THE

CIVIL ENGINEER & ARCHITECT'S

JOURNAL.

VOLUME TWENTY-NINTH. 1866.

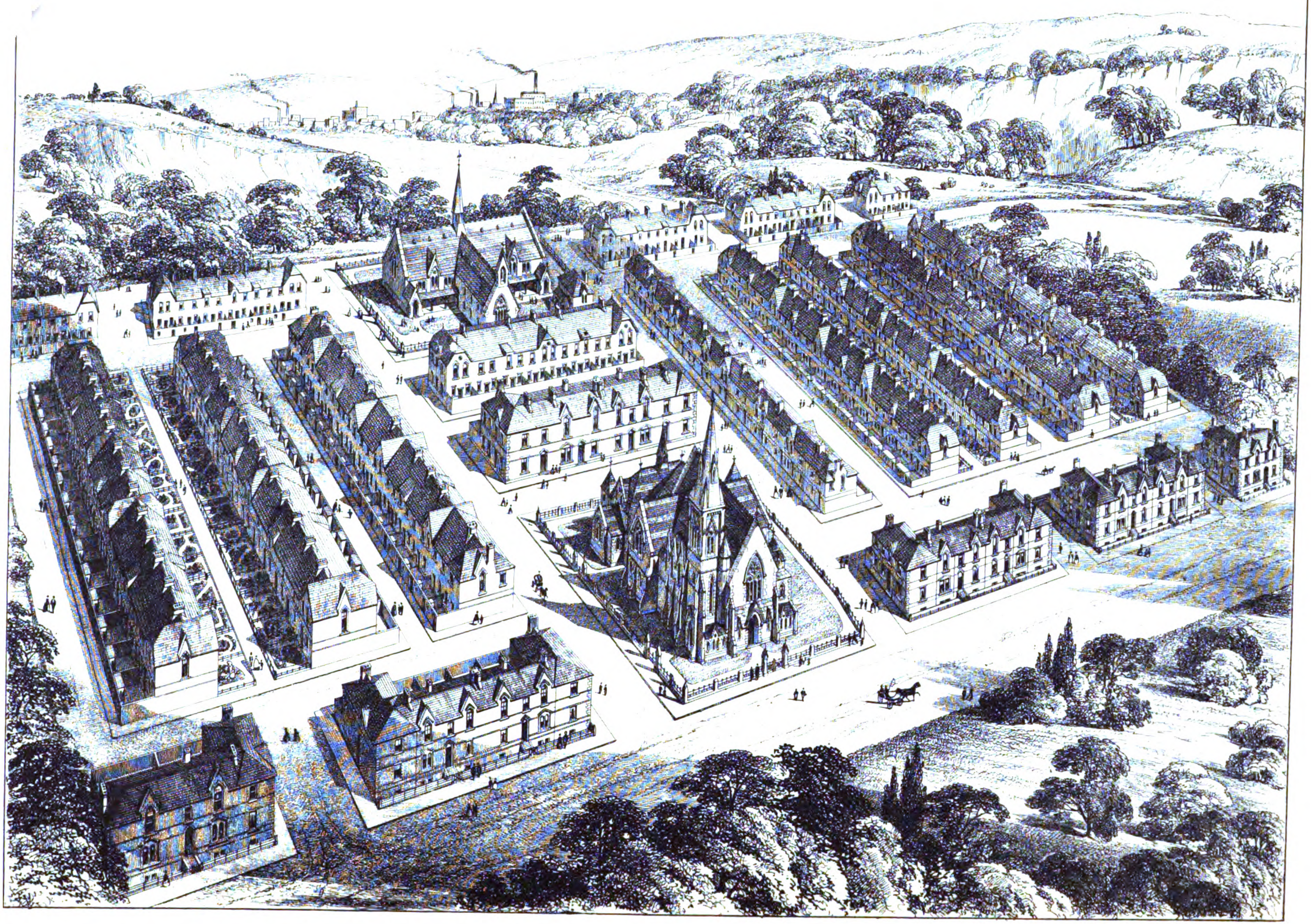
LONDON:
W. KENT AND CO., 23, PATERNOSTER ROW.

INDEX TO VOL. XXIX.—1866.

S.

T.

LIST OF PLATE ENGRAVINGS.

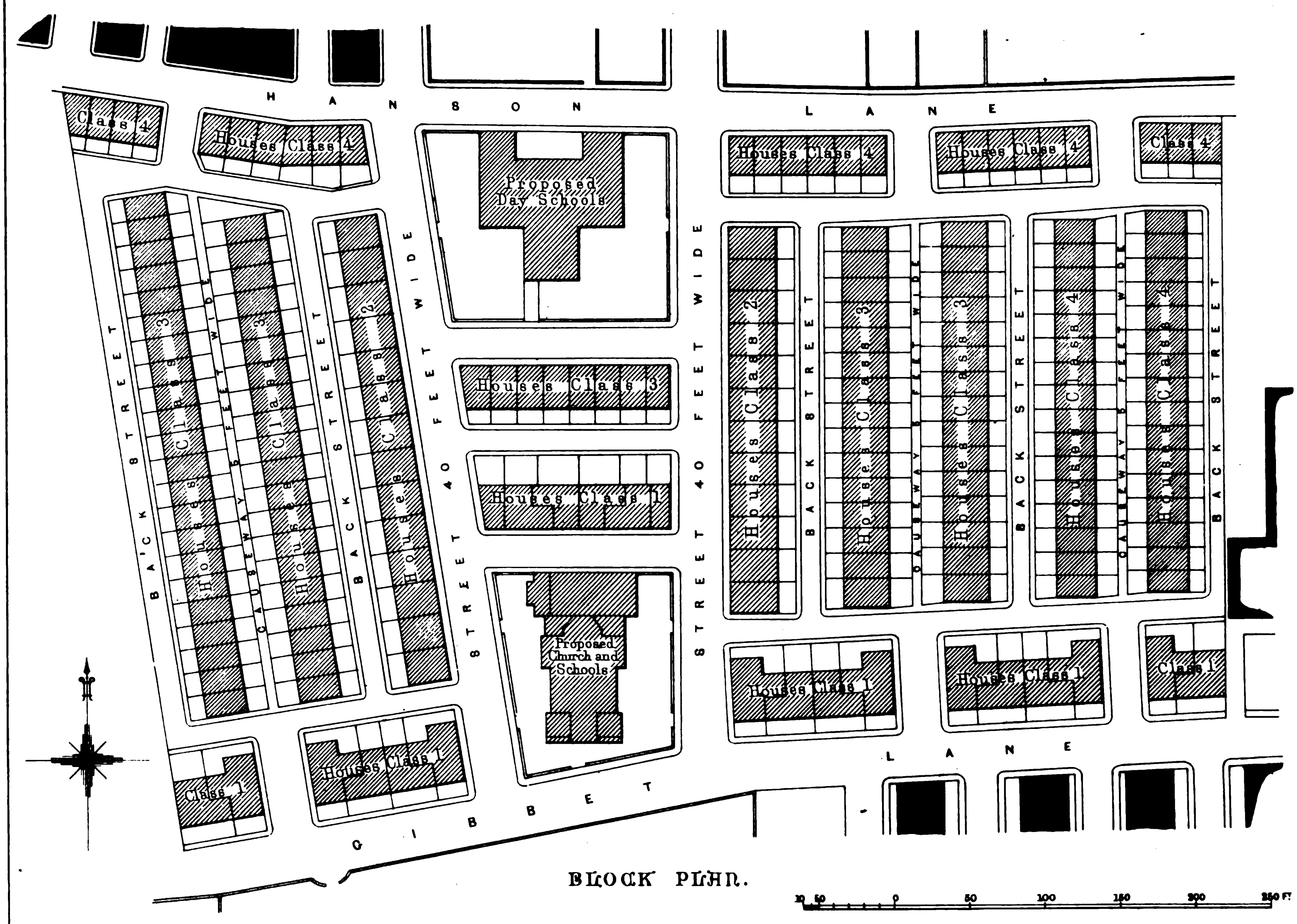


J R Jobbins

MODEL DWELLINGS FOR ARTIZANS, WEST HILL PARK, HALIFAX.

Paull & Ayliffe Archts Manchester

West Hill Park, Halifax.

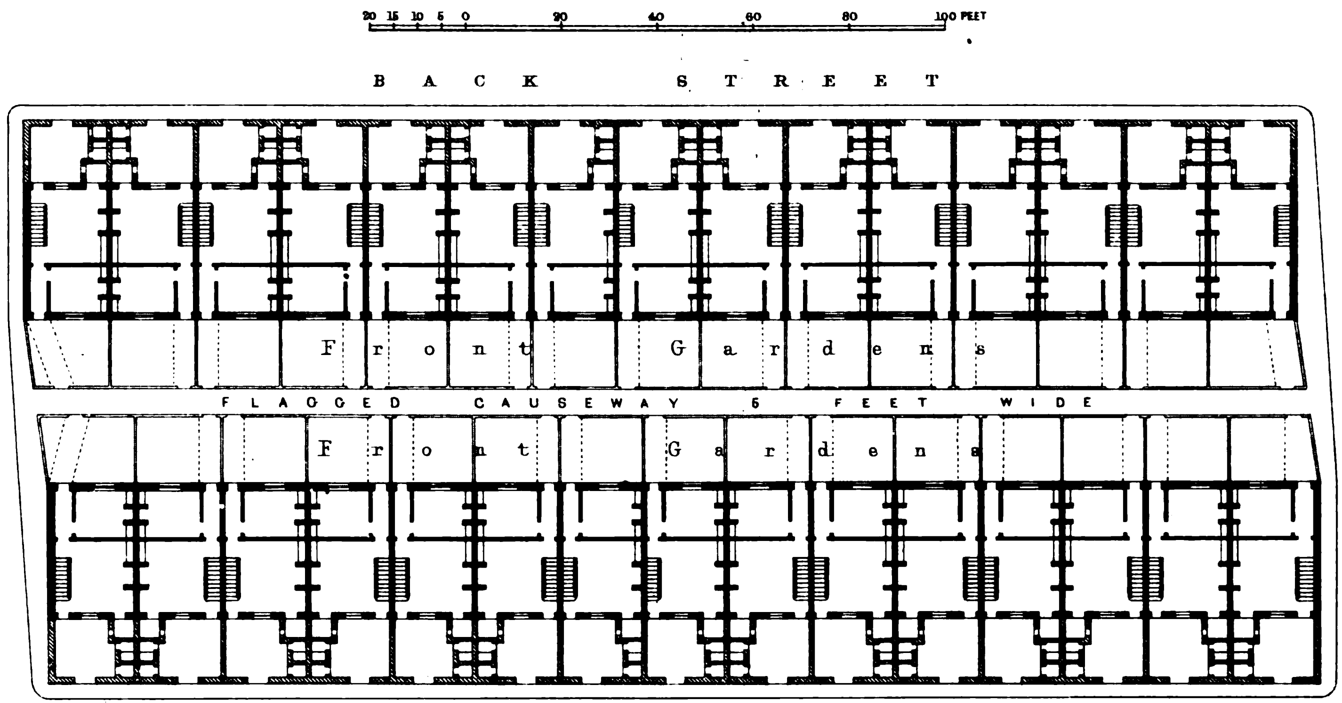


Paull & Ayliffe, Architects, Manchester.

J.R. Jobbins.

Artizans' Dwellings, West Hill Park, Halifax.

FRONT ELEVATION OF HOUSES IN CLASS 3.

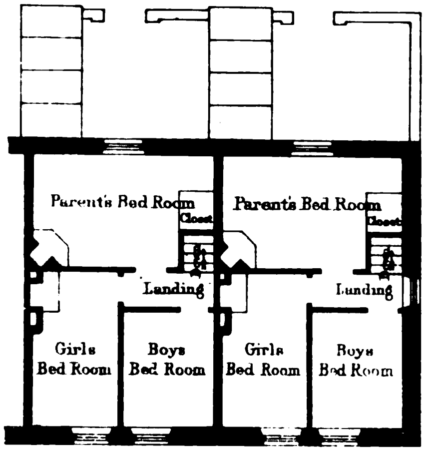


GENERAL PLAN OF TWO BLOCKS OF HOUSES IN CLASS 3.

Paull & Ayliffe, Architects, Manchester.

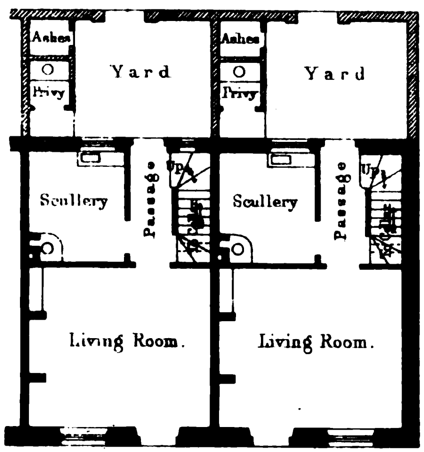
J.R.Jobbins.

Artizans' Dwellings, West Hill Park, Halifax.



CHAMBER PLAN.

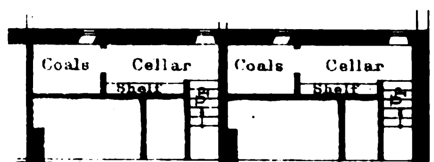
CLASS Nº 4



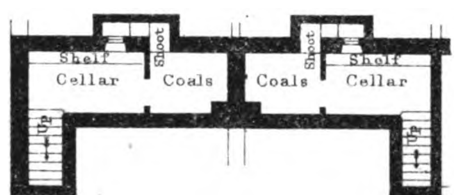
GROUND PLAN.

FRONT ELEVATION.

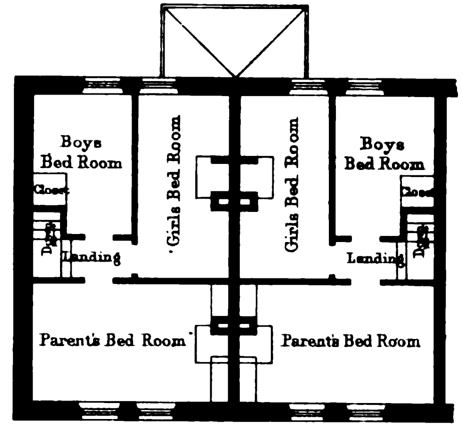
10 5 0 10 20 30 FEET



PLAN OF CELLARS TO HOUSES, CLASS 4.

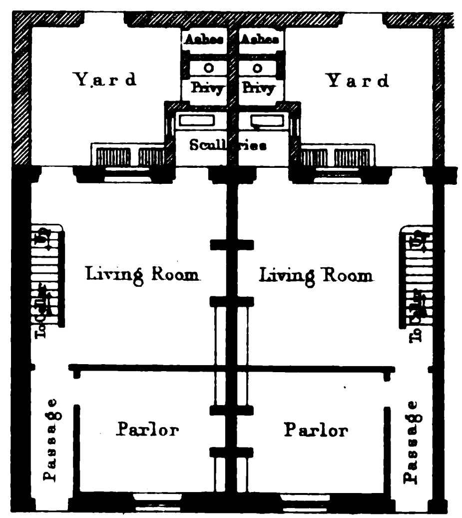


PLAN OF CELLARS TO HOUSES, CLASS 3.



CHAMBER PLAN.

CLASS Nº 3



GROUND PLAN.

Paull & Ayliffe, Architects, Manchester.

J.R.Jobbins.

THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

TO OUR READERS.

Upon commencing a new volume of this Journal, we beg leave to offer a brief statement relative to our past, as well as to our future labours. A glance at the index accompanying this present number will show the variety and importance of the papers, as well as the number of the illustrations, that have appeared in these pages during the last year, illustrating the engineering and architectural progress of the country during that period; and we hope it will be found also that we have neglected no opportunity of bringing before our readers subjects claiming their attention, and possessed of peculiar interest. The volume for the coming year will contain several new features, one of which will consist of a series of original sketches of early French Architecture, principally Ecclesiastical, that have not previously been published, and, to a great extent, from buildings of which no published illustrations exist. These we believe will be found of considerable value to the architectural student. Another feature will be the endeavour to give only such plates as will be of permanent value for reference for practical and professional purposes, and also to increase the monthly number of the plates. It is also proposed during the current year to give regularly the papers read before the Architectural Association, and a report of the proceedings at their meetings. Many of these papers have of late years been extremely valuable, and they have not always been reported in this, or any other professional journal.

From the first establishment of this Journal it has been made the repository of every class of information coming within the scope its title embraces, and to this we shall adhere.

The encouraging support that has for so many years upheld this work, we gratefully acknowledge, and we entertain the hope that it will be extended to us during the progress of 1866; and we trust that our Engineering and Architectural contributors will afford us a continuance of such communications as have been hitherto placed at our disposal.

WORKMEN'S DWELLINGS, WEST HILL PARK, HALIFAX.

(*With Engravings.*)

The proof sheets of a work on the eve of publication, under the sanction of the Society of Arts, entitled "*The Homes of the Working Classes,*" * by Mr. James Hole, have just reached us, rather too late to do justice to it; but, as far as we have been able to scan its contents, it seems to be one of great value, and just such a work as is now required to enable the public fully to understand the important question of the day, *the necessity of providing suitable dwellings, at reasonable rates, for the various grades of the working classes that require them.* In the work before us there is scarcely a point in connection with the subject but what our author has well considered: he points out most forcibly the many existing evils arising from limited space, bad ventilation, and want of drainage, with which those of limited means have to contend, and shows the advantages that will accrue to master and servant by affording healthy and suitable dwellings for the sons of labour. Many of our wealthy manufacturers are fully sensible of the unfit state, both as regards space and arrangement, of the residences of their work-people, and would, we hope, gladly lend a helping hand to better the condition of those whose industry brings their wealth, but the want of knowledge as to all the bearings of the subject, perhaps, prevents them; it is, we imagine, to bring the subject in a simple and unmistakeable way before capitalists and the public generally that Mr. Hole has entered upon this arduous task, which he has performed, if we may form a rather hurried opinion upon it, with great industry and consummate judgment. There are many gentlemen who have taken up the subject; but amongst the leading men of the day, none is more sensible than Mr. John Crossley, of Halifax, of the advantages that the manufacturer would derive from affording the artizan an improved and better state of things; for this great and praiseworthy end he has started a scheme, which is fully unfolded and illustrated in the work before us, for the erection of improved dwellings, called the "West Hill Park Model Dwellings."

Mr. Hole says the object is "to encourage thrifty artizans, clerks, and others to obtain freehold dwellings for themselves. In 1862 Mr. Crossley purchased a very eligible plot of land in the suburbs of Halifax, bounded by the parallel thoroughfares of Gibbet-lane and Hanson-lane. Invitations were sent to the local architects, and also to Messrs. Paull and Ayliffe, of India-buildings, Cross-street, Manchester, offering premiums for the best designs for laying out the land, and for the houses in each class of dwellings. The plans were publicly exhibited, and the first premium was unanimously awarded to the Manchester architects.

A reference to the 'block plan,' see Plate 2, will show the principle adopted in the laying out.* Streets with through communications pass at right angles from Gibbet and Hanson lanes each side of the land; therefore cross streets were made in connection with them. These are given in the centre of the plot, and are each 40 feet wide. The ground rises rapidly from east to

* The Homes of the Working Classes, with suggestions for their improvement, by James Hole, author of the 'History of the Mechanics' Institutes,' &c., 8vo. pp. 206. plates. London, Longman; and Baines & Sons, Leeds.

* In our next we shall give Plates 3 and 4, which will show the skilful internal arrangement of the West-hill Park dwellings.

west, but is nearly level crosswise; therefore the houses are chiefly disposed in long rows from south to north. The spaces between the fronts of the respective rows not being required for vehicle traffic, are appropriated to flower-gardens having a public causeway in the centre 5 feet wide, and neat iron fencing to enclose each garden. Opposite each end of each front space a street opens out into the highway, and gives facility for access by carts, &c. to the streets at the back of the houses. Public view of back streets is not desirable, therefore short blocks of houses are placed fronting Gibbet and Hanson lanes, which render them in this case comparatively private. By this arrangement the occupants of the dwellings have every inducement to keep the fronts of their houses neat and tidy—all unsightly but necessary operations being confined to the back, and shut out from the public eye.

It was originally intended that the houses in class No. 4 should be erected for about £100 each, exclusive of land, streets, sewers, and architect's commission. It was found, however, that the desired accommodation could not be obtained in substantial buildings for such a small amount as this; and the cost was therefore fixed at £130. Nothwithstanding their increased value, the idea of 'cottages' still attached itself to the dwellings in this class; and the arrangements were planned accordingly. A spacious family living-room next the front, and a good scullery at the back, a small cellar below, and three bedrooms above, seemed to furnish every requisite for an artizan's family; but now that the houses have been taken up and occupied, it is found that the inhabitants are of a higher class, and as a natural result the ground-floor arrangements have proved unsuitable. Two rows only of those dwellings have been erected—namely, at the east end of the land. The other two rows to the west of the last-named (marked class 3 on block plan, Plate 2) have been erected on a different plan. The area of ground occupied is considerably larger, the contents of each house, exclusive of outbuildings, being respectively 58 and 46 yards, but the dwelling-rooms in this case are placed at the back, and the front is used for a parlour and entrance-passage partitioned off. This arrangement gives great satisfaction, and the houses are readily taken up. These four rows, containing in all 62 houses, are all that are yet erected. Others will follow in due time.

It will be seen by the elevation that no attempt has been made to make these buildings architecturally fine. The few features introduced serve to redeem them from positive plainness, but that is all. Architectural effect is reserved for the houses facing the main thoroughfares, which will be for a superior class of occupants. All the building carried out so far has been substantially done, and the fittings and internal conveniences have been carefully attended to. The outside walls are faced with dressed 'wall stones' from the district quarries, backed with rubble stone, and lined with brickwork. The internal walls are of brick 4½ inches thick, except the 'party' walls, which are 9 inches thick. The roofs are covered with good Welsh slate, and pointed with mortar underneath. Ventilation flues are provided from the rooms, and steam flues from the sculleries. Over each doorway in the bedrooms there is an opening filled with perforated zinc to admit fresh air, and a similar opening communicates from each bedroom with the roof. From the roof there is an opening into a ventilating flue, which rises between the smoke flues up to the top of the chimney-stack. All the windows have sashes double-hung, and are glazed with good 16 oz. and 21 oz. sheet glass. Each house is well supplied with closets on both floors, and the cellars have stone shelves and every requisite. Water is laid on from the street mains to the sculleries, and gas is provided to each of the ground-floor rooms.

The net cost of the houses in class 4, inclusive of land, street, and sewer formation, and legal and architect's expenses, &c., has been about £160 for each house. The houses and land, &c., in class 3, will cost about £270 each. The internal finishing of these latter houses, and also the external treatment, are superior to those in class 4.

The houses in classes Nos. 1 and 2 will be of a still more expensive character, estimated to cost £320 for the houses in class 2, and £500 for those in class 1. These are intended for foremen and the higher paid class of clerks. Space is reserved for schools, &c. (See the bird's-eye representation.) The West-hill-park dwellings possess a great advantage: they are pleasantly situate in the upper part of the town, and close to a beautiful public park given to the town by Sir Francis Crossley, Bart., M.P.

To show how a working man may become the owner of one of these houses, through the aid of the building society, we will take the cost of a dwelling at £160, which has to be paid for on the completion of the building, when a complete conveyance of the property is given to each purchaser.

	£	s.	d.
The purchaser finds	£40	0	0
Building society	120	0	0
	160	0	0
For the advance of £120, subscription has to be paid at the rate of 5s. per week or £13 a year, for a period of 12 years, when principal and interest are paid. This makes	156	0	0
During this time there has been the saving of rent, say £8 8s. a year, which has assisted to make the above payments, and must therefore be deducted	100	16	0
	55	4	0
Amount furnished by purchaser	40	0	0
Interest at 5 per cent. thereon...	24	0	0
Amount of cost of dwelling	119	4	0

Thus he obtains for £119 a dwelling worth £160, besides the use of a superior dwelling twelve years sooner than he could otherwise expect to secure it.

The advantage is really greater than thus stated. In practice it would be difficult for a working man to invest £40 at 5 per cent. interest in any other way. He is not only enabled to do this, but to capitalise his future rent, and make each payment of it accumulate at compound interest.

We cannot conceive any more practical method by which employers of labour could raise the condition of the employed, than that adopted by those true 'Captains of Industry,' Edward Akroyd and John Crossley, in their organisations for realising to their workmen the ownership of their own dwellings. How vastly might the relation of employers and employed be improved, to the great benefit of both, if employers would take an enlightened and humane view of their duties to those dependent upon them. Assuming, for the sake of argument, that the old teachings of 'love your neighbour as yourself,' of 'doing unto others as you would be done unto,' are antiquated if not obsolete doctrines, superseded by the new lights of 'supply and demand,' 'buying in the cheapest market,' &c., we do not ask the capitalist to pay one farthing more wages than those fixed by the most rigorous competition, yet he might easily effect a vast improvement in the homes of his workpeople, and so in their general condition, by devoting a very little attention to that subject. His superior intelligence, especially his better acquaintance with the details of business, would enable him to assist his workpeople in obtaining dwellings of a superior character. It has been said by the author of the *Claims of Labour*, 'that the devout feeling which in former days raised august cathedrals, might find an employment to the full as religious in building a humble row of cottages.'

If a capitalist erect works in a new and sparsely-inhabited district, he is also under the necessity of building dwellings for his 'hands.' But if he erect works in or near a town, he very seldom thinks it necessary to make any such provision, but trusts to the existing supply; in other words, he is the means of drawing additional population to the place, and so of overcrowding the existing inhabitants. He throws upon others the responsibility of building houses for the new comers, if they think fit; but if they be not so minded, his hands must crowd into such lodgings as they can procure, and must suffer whatever evils in consequence befall them, and for which the employer is really as morally responsible as if he had directly caused them. It may be a very convenient arrangement for a capitalist to sink the whole of his capital in his mills, machinery, &c., leaving it to the speculative spirit of cottage-builders to find dwellings for his people; but is it just to those employed, or to his neighbours? Yet there are men who put down large mills, and yet never take the slightest thought whether their hands can find houses or not. That they leave to the laws of 'supply and demand.' And what kind of provision is thus insured the cottage districts of every manufacturing town can tell. Pecuniarily he is often a loser by this neglect. If his workpeople have to walk a considerable distance to their work, the mere loss of physical energy and effectiveness is considerable in the course of a year. If they are badly housed, he will lose much in their absence through sickness, and still more by their idleness and wastefulness, the result of their low moral feeling and want of self-respect. Large factory owners have often admitted that whatever they have spent in improving the education and social condition of their workpeople, has been a most profitable investment; and surely, among all the positive conditions of improvement, none are so powerful as a clean, comfortable, and healthy dwelling."

Want of space prevents our entering further upon the contents of Mr. Hole's work; in our next we shall endeavour to make our readers fully acquainted with its great value.

ENGINEERING IN AUSTRALIA.

The Williamstown Graving Dock.—Since the completion of the main trunk line of the Victoria railways, comparatively few engineering operations of importance have been undertaken either by the government or by private individuals; nevertheless, one or two works of magnitude have been commenced, one of the most noteworthy of which is, the Williamstown Graving Dock.

The want of a graving dock in the vicinity of Melbourne has long been felt, and many have averred that the interests of the port have suffered in consequence of vessels of large tonnage having to go to Sydney, or even to the United Kingdom, in order to effect repairs which, but for such a want, might with advantage have been conducted here.

This inconvenience is now about to be remedied, the colonial government having determined to expend a sum of about £100,000 in the construction of a dock at Williamstown. The site was chosen so as to render available, as a foundation, a mass of porous basalt rock known to exist there, which is much better suited to support the great weight of masonry than the shifting sands at Sandridge, on the other side of Hobson's Bay, are. The work is to be completed in several distinct contracts, and is expected to be finished in three years' time. The reason why it will take so long to construct is, that the work is to be a yearly progressive one, and its cost to be defrayed by a sum placed on each year's estimates sufficient for the purpose.

The first contract, which has been taken by Messrs. T. Glaister and Co., involves the construction of 100 feet in length of the dock (including the head wall), the amount of the tender for which is £23,000. The dock is to be 450 feet long, 50 feet wide at the bottom, and 80 feet at the top. The side walls are provided with seventeen courses of steps, each 18 inches high. The bottom of the masonry rests on a bed of Portland cement concrete, 2 feet thick; above this comes the invert in two courses, one 2 feet, the other 3 feet deep. The total height of masonry in the side walls is 32 feet, and all the upper courses are joggled together with 6-inch cubes of the same stone as is used in the construction of the rest of the dock.

The material with which the dock is constructed is that known in the colony as "bluestone," a hard, heavy, extremely durable basalt, easy to work, and geologically of very recent date. This material is extremely abundant, and can be obtained in good sized blocks, some of those used at the dock weighing as much as 7 tons.

Some difficulty has been experienced from the great influx of water from the sea, and this will probably become still more serious as the work advances sea-ward; at present a No. 4 Gwynne's centrifugal pump, actuated by a 12-horse engine (a Clayton and Shuttleworth's portable) suffices to keep it under by dint of working night and day. Another difficulty arises from the large clay-holes that occur in the rock on which this part of the dock rests. The entrance to the dock will require, before it can be commenced, the construction of a large cofferdam, and is intended, when the dock is completed, to be closed by means of a caisson.

The construction of the dock is being carried on under the supervision of the Public Works Department, and the plans were drawn by the gentlemen in that division of the public service.

It is worthy of note that the Williamstown Graving Dock is the first piece of work done in the colony, in the construction of which steam overhead travellers, now so common in England, have been brought into use.

MATERIALS MOST APPROPRIATE FOR LONDON EXTERIORS.

By J. DOUGLASS MATHEWS, A.R.I.B.A.

MEMBERS of the architectural profession are not unfrequently censured for allowing their noble art to degenerate into a mere fashion of the time, and its purity to be sacrificed to meet the questionable taste and caprices of those who are ignorant of its true principles. In reply to this accusation it should be urged that as population increases, trade and commerce also increase, that the necessities of the community must be considered, and that architecture as a creative art must be subjected to changes adapted to the requirements of the population, even though it be at the sacrifice of some of its characteristics. In no way can this be better shown than by comparing London of the past with London of the present. It requires no little stretch of the imagination, when we traverse the busy streets of the Metropolis, with the double lines of perfectly vertical houses, erected on the regulation principles laid down by the Building Act; to picture to ourselves the habitations of our forefathers some two centuries and a half ago—when each successive story overhung the one immediately below, so as nearly to obscure the clear light of day. To fancy the old quaint and picturesque half-timbered buildings, with their low-fronted shops, and with no better means for the display of marketable commodities than a board, which was made to do double duty—as a stall by day, and a shutter by night; or the principal story, with its small panelled wainscoting and its thick mullioned windows, the casements thereof filled with semi-opaque glass; and then to contrast all this with the Metropolis of the present age—when each newly-erected building is endeavouring to surpass its predecessor—and stone, metal, glass, and colour, are almost indiscriminately pressed into the service of the builder, in order to attract the attention of the passenger, or to serve as a publication of the importance or wealth of its occupier. It cannot be doubted that the houses of the olden time were as beautiful in the eyes of *their* architects, and as well suited to the requirements and circumstances of their owners, as those of the present time are to theirs; and however much we may be influenced by artistic feeling and Mediæval predilections, there are few that would consider the London houses of the seventeenth century fitted for the uses and habits of the present day.

Necessity often compels men to do much which their taste and judgment would condemn; and the architect is not always to be blamed for carrying up his building to an immoderate height, and apparently supported at its base by enormous plates of glass between slender piers, when, if left to follow the dictates of his fancy, governed by the true principles of art, he would limit it to a proportionate height, and give to it, not only the reality, but the appearance of stability—introducing such an amount of appropriate decoration as would give the emporium of commerce the lightness and elegance of the dwelling house.

At no period since the great fire of London, in 1666, has rebuilding been carried on to so great an extent as during the last few years and at the present time; and probably at no former period has the art of architecture been so greatly appreciated by commercial and mercantile men in their buildings as now, for there are but few who consider their capital well expended without their new buildings possess some considerable architectural pretensions.

The present value of ground in London, and especially in the City, bears no proportion to its value formerly. *Then*, the annual value of the building was determined by the cost of the erection, with a comparatively small addition for ground rent. *Now*, the reverse is the case, and the capitalist has to calculate the amount of rent he is likely to obtain by the occupation of every available portion of his premises (in height as well as surface), before he can venture to purchase or rent the ground upon which they are to stand; and a few hundreds spent in external display are found to be productive of a large increase to the annual return.

Perhaps there is no subject more difficult to an architect to design than many London exteriors, of which the following particulars may be taken as an example. The site has a very narrow frontage, and that in an equally narrow street, the adjoining and opposite houses having ancient light, which must be respected in order to avoid threatened injunctions, or claims for compensation for diminished light and air. As much light must be obtained in the building itself as is possible. Every inch of space must be economised; and as the Commissioners of Sewers scarcely allow an inch projection on the public way, there is little room for architectural projection.

In cases of this kind it is obvious that the truly orthodox Classic style (with the exception of the rigid Grecian, so prevalent about 40 years ago) would be inadmissable. The five orders placed one above another would be absurd; a bay of a Florentine palace, whose character is breadth and grandeur, would be inappropriate; the true Ecclesiastical Gothic altogether incongruous; and a reproduction of the dwellings of the seventeenth century but ill adapted to the requirements of this age.

What then is to be done? Light being so essential, the new building must have no extremely prominent parts casting their deep shadows over the upper portions of the windows, and thus the effect which is given to buildings situated in open spaces, and which contributes so largely to the author's design, cannot be obtained for him in a city street. The architect, deprived thereby of the opportunity of giving relief to his design by the contrasts of light and shadow, is compelled to resort to some means by which the otherwise extreme simplicity and plainness of the front of his building may be relieved, and which shall harmonise with the general design. This relief may be obtained by a judicious use of materials that not only possess, but retain pure and brilliant colours. The consideration therefore of the materials best adapted for London exteriors, both for durability and appearance, may well form the subject-matter of an essay at a time like the present; and in treating the subject we shall divide it into two parts, viz., constructive and superficial. In the former will be comprised those materials which form part of the structure, as stone, brick, wood, iron, &c., and in the latter, those which are applied after the building is erected, as cement, encaustic tiles, and other ceramic manufactures, mosaic, &c.

In stone most architects have a material which will generally satisfy them more than any other, and especially in London, where there is every opportunity of procuring stone of all kinds, the easy transit by rail and water offering great facilities. In its use an architect is left unfettered: he is not limited to a particular thickness in the members of cornices and other mouldings, which is the case with brick, and so frequently interferes with the correctness of his design; if he desires minuteness of detail, the material will readily allow of it; if he wishes to introduce variety in colour, he can have it in the glorious hues of the English stones. But while these are some of the advantages, there are others which prove disadvantageous to the use of stone as a building material; among these the principal are its cost, and the difficulty of procuring such stone as will resist the action of the weather and the London smoke. The obtainment of that boldness of design which is necessary to give grandeur and effect to a stone façade, is rarely to be met with in a London exterior.

Although stone may be had in London at a very moderate price, yet it cannot be an economical material unless its component parts are such that will stand the atmosphere; and the stones which alone can do this, are brought from a distance, and are so close and heavy, that the charge for carriage and increased labour in working, swells the amount so considerably as to prevent its universal use.

The stones mostly in use are the sandstones and limestones. The majority of the former are composed of quartz sand cemented together by some foreign compound substance; when this is silica, they will be almost unchangeable by the effect of the atmosphere, but more often with carbonate of lime and clay, which are easily worn away by the action of rain, and soon allow the stone to be disintegrated. Laminated stones are generally liable to decay, being composed of mixed grain, and formed in water frequently give off water in evaporation when exposed to the air, and absorb it again when rain comes, and are also very susceptible to frost. The Craigleith stone of Edinburgh is the most durable sandstone, and the Yorkshire beds stand next in order, while generally the red stones are the least durable, being frequently combined with carbonaceous clay. It is a matter of regret that sandstones should prove so treacherous, as there are few limestones that have the fine deep tones common to sandstones. Much of the enchanting character of ruins, so delightful to an artist and antiquary, is due to the use of sandstones; as however an architect is not required to build ruins, he must use stone on which he can depend.

Limestones are of two kinds: the carbonate of lime, and the carbonate of lime and magnesia. The former comprises amongst others the oolitic stones of Portland, Ketton, Ancaster, and Bath. The latter includes the stones of Yorkshire, Derbyshire, Bolsover, Mansfield, and others. If it could be ensured that in the magnesian limestones there were equal parts of carbonate of lime and carbonate of silica, they would be valuable, but for want of this they often prove very treacherous, as is evidenced by the stone used in the Houses of Parliament, which is from the Anston quarries in Yorkshire, and was considered to approach closely to the Bolsover stone in Derbyshire, which occupies a high place in magnesian limestone both theoretically and practically, but on account of the beds being too thin was considered useless in building the Parliament Houses. In reporting on the decay of the stone used, the committee appointed by the House of Commons states, "That it is obvious that, although some varieties of magnesian limestone are an excellent and durable material when not exposed to the deleterious influences of a London atmosphere, yet that in London it is subject to causes of decay which render it an undesirable and unsafe material for the construction of public buildings." The same committee in speaking of Portland, says, "It is equally obvious, that Portland stone well selected has been used in buildings in London from the date of St. Paul's downwards, and under circumstances of great exposure, and with most successful results. Portland stone is a material to be obtained in any quantity, in blocks of any size, beautiful in colour and texture, reasonable in price, not by any means as hard as Ancaster stone, and yet with a power of resisting the influence of the London atmosphere that leaves little to be desired. It must be remarked that Portland stone should be carefully selected, an operation which would be most satisfactorily effected by an agent at the quarries."

This latter clause suggests an important hint, and it should always be remembered that the particular bed as well as the quarry should be inquired into; this is readily seen by inspecting the river front of Somerset House, built with Portland stone by two different masons, the lower portion being perfectly black and sound, and the upper part very white and with scarcely a good stone. If the choice of the stone is entrusted to the mason he will frequently use the softest, as being the easiest to work and making the cleanest job when completed. Portland has not only the advantage of being the most lasting stone, but also in being capable of sustaining a greater weight than almost any other. Tisbury stone is a good limestone. Bath stone, although justly celebrated, is scarcely to be depended upon for London buildings. If it were possible for stones to be quarried, and worked some months before they are set, there would be far less decay, as the outer surfaces would so harden as to prevent the entrance of rain and frost to a considerable extent.

The chief reasons why the atmosphere of London is so destructive to stone and other materials, are, that a great quantity of carbon and sulphur is discharged by the lungs of the inhabitants, and by fires (the combustion of coals for the latter exceeding three million tons per annum in London); the soot readily adheres, and if not speedily removed, soon commences the work of decomposition. The removal is scarcely ever attempted, except by rain, which in its downward course is affected by the solid substances floating in the atmosphere, soluble in water, and generally containing carbonic gas, sulphuric acid gas, and sulphate of ammonia, which together form a coating which soon acts on the cementing medium of the stone. The more absorbent a stone is, the sooner it will decay, as in winter especially it holds the water, which soon freezes and in the expansion incident thereto breaks the stone to pieces. Much decay may be prevented by protecting the more exposed projections by lead, and in occasionally washing by the hose of a fire-engine, or otherwise, the more sheltered parts, which generally decay the soonest, as the sooty incrustation is seldom disturbed by the wind or weather.

The question of the preservation of stone, either by a coating of some substance which will form a species of waterproof, or so to modify the chemical condition of the surface as to make the softest stone as hard as an imperishable rock, is a very difficult one, and one which time alone can determine. Many means have been tried; any process whereby the stone is painted or otherwise disfigured should be opposed, as by being so treated, the truthfulness of the material is in a great measure lost, and cement would answer all purposes and be considerably cheaper. Ransome's process seems to be the best, and has so far proved successful: it consists of coating the surface with a solution of soluble silicate, and afterwards with a solution of chloride of calcium, by which an insoluble silicate of lime is formed in the body of the stone or other material.

In designing a stone building breadth should be studied as much as possible, as nothing looks more unsatisfactory than narrow stone piers, which at once denote apparent weakness in that material, which ought most of all to give the appearance of solidity and strength. Intimately associated with sand and limestones are those older and harder materials, granite, and serpentine, and also marbles, which lend so great a charm, and often brighten up a design that would without them be cold and cheerless, and which also offer so ready an escape for the evil just complained of, in using a narrow stone pier, by substituting a column of stronger material, whereby no room is lost, and a far more pleasing and satisfactory effect is obtained.

Granite is a material abounding in England, Scotland, and Ireland, and can be obtained of almost any colour. It has the advantage of being as little liable to decay as any material, being composed of crystalline matters, and almost unabsorbent and but little exposed to injury, it is capable of taking and retaining a good polish, which is evidenced by many specimens used externally in London many years since. The material being of such a hard nature, and therefore expensive to work, will effectually prevent its being ornamentally worked to any considerable extent. When ornament is introduced, it should be incised, as most suited to the material. A simple but very effective mode of obtaining ornament has recently been adopted at the new offices of the Royal Insurance Company in Lombard-street, where the mouldings round the principal doorway are of polished granite, and the ornament apparently worked afterwards, and left rough from the chisel. The cost of granite, considering the difficulty of working and its weight in transit, is not great, and doubtless, as it becomes more largely used and more machinery is brought to bear in cutting and polishing, the expense will be greatly reduced.

Serpentine is a material that is said to offer complete resistance to the London atmosphere. Its chief ingredients are silica and magnesia; being very close grained, it is capable of bearing an excellent polish by friction, which it is said to retain permanently. Like granite, it can be obtained in almost any colour, and of moderate size. Although its advantages render it very desirable for use where it can be closely inspected, it cannot be generally recommended for external use, on account of its heavy appearance, as street dust will soon accumulate and form a coating even on polished material, and this would soon obscure the beautiful but small veins with which it abounds. Its cost is somewhat more than ordinary granite.

It would be almost an impossibility to enumerate the marbles which are to be found in the United Kingdom. The Irish, Derbyshire, Staffordshire, Somersetshire, and Devonshire are those best known. A visit to the Museum of Practical Geology, in Jermyn-street, will give some idea as to the infinite variety of colour to be obtained by their use; there seems little reason why, with such beautiful materials so near at hand, Italian and other Continental marbles should enter so much into the construction and beautification of English buildings as at present.

Marble, as a rule, will stand the London atmosphere, although in some, especially the Derbyshire, there are small crevices into which the rain enters, and in time causes decay. It is not probable, however, that marble will ever enter largely into external decoration, as, although capable of taking a polish, it will not long retain it when exposed to the atmosphere; and the mere fact of using marble without being permanent and lasting (neither of which it can be for long without polish), is an useless expenditure.

Many experiments have, from time to time, been made, and patents obtained, for the manufacture of an artificial stone, by which science endeavours to make up the deficiency existing in nature; but these, with few exceptions, have to be fired, which renders the process expensive; and, unless great care is bestowed, the materials will be imperfectly burnt; and, when moulding and other delicate portions are required, are very liable to twist in the process.

M. Coignet manufactures an artificial stone, composed of sand, grey lime, and Portland cement, mixed with a little water, and allowed to consolidate in moulds. This material has been in use largely in France since 1859, and a church near Paris is said to be entirely built of it. This process seems a difficult one, and its success must depend on the proper slaking of the lime, and the purity of the Portland cement,—difficulties in London, at least, almost insurmountable.

The material, however, which seems to combine excellence with cheapness, is that patented by Mr. Ransome, called "concrete stone" (prizes for designs in which were offered by the Company to our Association last year.) It consists of sand mixed with silicate of soda and water in a mill, from which it emerges a thick paste: it is then immersed in chloride of calcium. A chemical combination at once takes place, which firmly cements the sand, and a true sandstone is formed impervious to the action of the atmosphere. Its colour is good, and it can be moulded into almost any form, and, if required, undercut as much as ordinary stone. It hardens very quickly, and is ready for use soon after it is made. The cost of manufacture is small, all the materials being close at hand; and this, with the addition of the strong opinions expressed in its favour by some of the most eminent chemists, cannot fail to bring it sooner or later into very general use. From experiments made, it is found capable of resisting a greater pressure even than Portland stone.

The material, however, which must occupy the architect's chief attention is *Brick;* for, great as may be the advantages offered by the foregoing and other materials, they are all more or less expensive,—a great cause for which is the cost of carriage; whereas clay abounds in and around London to an almost endless extent, and is easily converted into brick, in the manufacture of which it obtains the double advantages of being a durable and cheap material.

No manufacture is more ancient than that of brick, and it is worthy of remark that, in whatever country clay was found, its buildings were generally of brick rather than stone; and it is surprising, considering its extensive use, the art of brickmaking has not, until quite recently, taken its proper position among the arts and sciences.

Much has lately been done in the way of improving both the material and the setting, but there is still much remaining to be done; but at the present time, when such millions of bricks are being consumed by our great engineering works, it is probably too much to expect; but if some manufacturer could be found, willing to take up the matter as an art, he would find ample scope for his exertions, and would doubtless in time be crowned with success.

The advantages of brick are numerous, but care must be taken not to overrate them. While calling in its help to give colour in his façade, the architect must be cautious as to its use; and, while employing it ornamentally, must be careful that the ornament is adapted to the material. This is of importance, and warrants special attention. Some of the disadvantages of the bricks at present in use are their colour, size, and coarseness, and also the unevenness of their sides and edges.

Everyone must have remarked in passing through our streets the frequent failures in brick buildings from the want of harmony prevading them, and this is in a measure unavoidable; the limited colours which can at present be obtained frequently necessitate the employment of one colour throughout, or relieved sometimes by bands of bricks of a strong contrast, or by cutting up the surface into a variety of forms and of various colours, whereby all breadth, depth, repose, and harmony are lost. In the present day, when science and art work so harmoniously together, it is not too much to hope that ere long we may have bricks of a variety of colours, so that a correct polcyhromatic effect may be obtained when desired. The want of this desideration is much felt in London, perhaps more so than anywhere else; as in a narrow street red or dark colored bricks would be out of taste, and the only alternative, therefore, at present is cream or yellow as a facing.

The size of the bricks is a great impediment in design, for although most useful in carrying out the requirements of the Building Act as to the thicknesses of walls, it fetters the architect greatly in composition; and this is shown by the disproportionate forms adopted in many buildings, whereby the effect is sought to be obtained wholly by coloured brick. So long as this impediment is allowed to exist, so long will buildings lack that purity of form so distinguishable in those of the ancients. Correct form and proportion must be primary; ornament, colour, and decoration are (though important) secondary considerations.

While the Act of Parliament was in force restricting bricks to one size, we can readily understand why no endeavour was made to alter it; but now that it is altered, it is a matter of regret that other sized bricks, capable of being worked in with the common stocks, are not more generally manufactured. Bricks of about the thickness of tiles could be very advantageously used as bands, and often with better effect than an ordinary course of bricks. To borrow a suggestion from Mr. Harris, contained in a lecture before the Association, "Bricks 13½ + 9 or 9 + 9 would afford a good opportunity for a sunk ornament being stamped, and filled in with a clay of another colour, and burnt together;" or even stamped without the introduction of the filling, and in a variety of other ways.

One thing especially should have the careful attention of an architect in his London buildings—namely, detail. He has seldom the advantage of breadth, or the help of nature, to make up for plainness and coarseness of detail, which is often the case in the country, and he must remember that his building has only itself to rely on; it is not only that portion that meets the eye of the passer-by that requires the careful study, but also the upper details. This is frustrated, in a great measure, by the bricks at present in use, and especially where they are used decoratively as well as constructionally; and on this account many a design, good in itself, has been entirely spoilt by being carried out in a coarse material.

It is with great difficulty that a brick-front is worked neatly without the aid of tuck-pointing; this is, or ought to be, inadmissable, especially where colour is used, as it seriously cuts up the design, and destroys all breadth and harmony. When bricks are used as projections in string-courses, pilasters, &c., they ought to be first squared and rubbed, which, however, adds greatly to their cost, and does not, after all, make satisfactory work. In moulded bricks this is especially necessary on account of the inequality in burning. The coarseness of the surface, however, forms probably the chief ground of complaint. The roughness allows the soot and other matter with which the London atmosphere is charged to lodge on their face, which, instead of being washed off by the rain, becomes a paste, and fills the pores of the brick with the coating previously hanging on it; therefore, notwithstanding that a brick front may, when finished, satisfy the admirers of colour, yet after a time the whole effect is lost, the bricks soon losing their colour, and darkening unequally; this is especially observable where red bricks are used in combination with white or yellow malms—the former being frequently pressed, and consequently not so porous as the latter, retain their colour for a much longer period.

Induration is put forward as a remedy, by filling the pores of the brick with a coating impervious to the weather, and doubtless it does succeed to some extent; but the great want still is—a brick well, truly, and squarely made, with a slight glaze on its surface. Bricks of this description were in use in Nineveh and Babylon, and more recently in some of the older buildings at Harrow and its neighbourhood. Bricks with a very high glaze for wall linings, &c., are manufactured by Messrs. Minton; but both on account of their cost (upwards of 1*s.* each) and their high glaze will always prevent their use as an external material. It may be objected that buildings faced with glazed materials would have an unpleasant appearance when seen in any other way than in direct elevation, as their glaze would reflect the light; but it is a question worth consideration, which is the least evil? It has been said that the sun is never visible in London, and in some streets this is almost true; but at any rate almost every house is in the shade or fog more than half the year. If a glaze could be given to bricks similar to that on common stoneware, a great and lasting good would be accomplished, and nothing would do more to relieve the streets of London from their dreary, gloomy, and in some cases almost dejected appearance. While hoping that such materials will soon make their appearance, a little careful study in detail would not be thrown way. An hour's careful designing will often produce more variety in brick forms than is generally thought.

Terra-cotta forms a valuable adjunct to a brick building; being capable of receiving almost any amount of ornamentation, and having the additional advantage of being impervious to the atmosphere. The real meaning of the word "is burnt earth." Its components are chiefly clay, flint, glass, and fossils, the latter containing phosphate of lime. These are crushed and pounded together, and formed into a paste, with the addition of a little water; then ground in a mill, and afterwards thoroughly beaten. It is then modelled into the forms required, and allowed to harden; afterwards put into an oven, which is heated sufficiently to partially vitrify it, and then allowed to cool gradually, and withdrawn. Its manufacture has existed for many centuries, and its durability is evidenced by the remains frequently brought to light. The cost of the production of terra-cotta is small, but, like all other moulded articles, the chief cost is in the modelling. Its colour is a great recommendation, and harmonises well with brickwork. It has lately been used largely in construction, some examples being the buildings at the Horticultural Society's Gardens, the Charing Cross Hotel, a church near Manchester, and a portico in Cumberland-street, Hyde Park. It is stated that the entire cost of the latter work, including modelling, was less than if executed in brick and common stucco. If this be so, its cheapness will greatly recommend it; but as a general rule this must not be taken as a guide. There are, however, disadvantages in the employment of terra-cotta which should be borne in mind in employing it as an ornamental material. There is always a great risk in firing, owing to unequal contraction. In the case of continuous moulding and ornament this is a serious drawback, as it is well nigh impossible for the various blocks so to join that the true line may be kept. Terra-cotta is also a brittle material, which must prevent its use where strength is required, and especially if exposed to jarring. If used externally in a damp situation, it frequently receives an unpleasant green tint, giving it the appearance of neglect and decay. Mr. Blashfield, of Stamford, has of late given much attention to the subject, and has succeeded in an admirable manner. There is no doubt that, like most other manufactured articles, terra-cotta will improve as it becomes more generally used.

Notwithstanding that, as a rule, iron as an external building material is objected to by architects in London exteriors, its use is frequently thrust upon them. It is impossible to defend it in an artistic point of view, as its wiry lines ever give the appearance of weakness, notwithstanding its actual strength. The chief recommendations are—strength, the power of spanning large openings, and occupying less space than other materials, all of which are advantages that demand attention, especially where every inch of room gains additional rent, and every foot of window light proportionately reduces the gas bill. The present Building Act precludes its use to any considerable extent, but there are means of getting over this difficulty. It therefore becomes every architect to take the matter up carefully, ever bearing in mind that the fundamental principle in its use should be truthfulness. Cast-iron admits of much ornamental treatment, but all ornament should be suited to the material itself, and not mistaken for stone or other treatment. Wrought-iron may be ornamented to almost any extent, and, if desired, an iron structure may be so designed as to allow of the use of tiles, majolica, and other materials as panels.

PARIS IMPROVEMENTS.

The expenditure of the City of Paris, apart from that of the State, for works of public utility during the present year is given officially at two hundred millions of francs, or eight millions sterling. The application of this sum is as follows:—

	£
Public promenades and plantations	1,280,000
Water supply and sewers	1,320,000
Religious edifices, hospitals, municipal buildings, and public schools...	2,400,000
Road work	3,000,000
	£8,000,000

Of all the public works the sewers are beyond question the most important and the most difficult of execution, and the progress which has been made during the last few years, not only in the extension but in the improvement of the system of these great outlets of impurity is one of the most important facts in the history of Paris. It appears that in the year 1860, the total length of all sewers of the city was 15,386 mètres. The additions made since are as follows:—

	Mètres.
From 1800 to 1831 there were constructed new sewers equal in extent to ...	20,124
1832 to 1839	50,870
1840 to 1847	27,804
1848 to 1849	5,925
1850 to 1855	21,738

		Mètres.
In	1856	3,528
	1857	10,999
	1858	4,436
	1859	18,383
	1860	19,944
	1861	20,079
	1862	30,057
	1863	30,682
	1864	39,227
In addition to the above, the branches for the service of private establishments amount to		16,559

The whole amounting to 388,451 mètres, or more than two hundred and thirty miles in length.

Another new public garden is about to be formed in the fourteenth arrondisement of the city. The site selected is the plateau of Montsouris, an elevated spot commanding the valley of La Bièvre and affording a fine view of Paris and the surrounding country. The Parc of Montsouris, will be connected with the main boulevards of the city by a road forty metres wide, to be called the Boulevard Jourdan, and will be approached from other quarters by four other roads, two of twelve and two of twenty-two metres in width. The new park will cover an extent equal to nearly forty acres; the park of the Buttes Chaumont, now in course of formation, covers fifty acres, the Bois de Boulogne and the Bois de Vincennes are respectively 3000 and 3100 acres in extent.

Immense works are now under hand, with the special view to the improvement of the approaches to the Exhibition of 1867. The whole of the steep hill known as the Trocadéro, and which extends from the old village of Chaillot to Passy, is being cut dowr, and three new Boulevards will shortly pierce this hitherto inconvenient suburb, and connect it directly with the river and the Champs Elysées. The enormous quantity of rubbish supplied by these works is being carted to the Champ de Mars, to form a foundation for the new Exhibition building. In connection with this great work may be mentioned the widening of the Bridge of Jena, which will correspond with the main axis of the Exhibition building; the pathways are to be added to the roadway, and new footways constructed on each side of the bridge. Opposite this bridge, on the side of the Champs Elysées, will be a fine open space, called the Place Josephine, and in which will stand the statue of the Empress. There are six churches at the present moment under construction, two large structures, both nearly finished, in the heart of the city, and four in the outskirts.

Next to the new series of sewers, and infinitely more open to public appreciation, the new markets will probably be the most striking works which the municipal government of Paris will have to show the world in 1867. The great central halles, or market, with its broad streets all under cover, (which has already been described in the *Journal*,) is rapidly approaching completion, and will be certainly the finest establishment of the kind in the world; the market of the Temple and that of St. Honorè, situated in the very heart of the city, have been entirely reconstructed, four or five others have been greatly improved, and six new markets, to replace those which have been demolished, are now being erected in the same style as that of the great central market, that is to say, on columns of cast-iron, supporting lofty, well-lighted, and well-ventilated roofs formed of iron, zinc, and glass, with extensive cellars for the storage of stock and materials, and supplied with water and drainage in the most complete manner. Two other markets are also under consideration, and by the time the great Exhibition opens there will probably not be a specimen left of those assemblages of dirty huts which formed the old markets, and supplied refuges to myriads of rats, and so were many sinks of pestilence. Two of the six new markets now under construction, cover respectively areas of 2000 and 2700 square yards.

INSTITUTION OF CIVIL ENGINEERS.

Dec. 12.—The Paper read was on "*Experiments on the Strength of Cement, chiefly in reference to the Portland cement used in the Southern Main Drainage Works.*" By John Grant, M. Inst. C.E.

This communication related to an extensive series of experiments, the results of which were recorded in voluminous tables forming an appendix to the paper, carried on during the last seven years, with a view to insure as far as possible that only cement and other materials of the best quality should be employed in the Southern Main Drainage works, of which the author had charge as resident engineer.

As a preliminary step, samples of Portland cement were obtained from all the principal manufacturers for the purpose of experiment. The average weight of these samples were found to be 108·6 lb. per bushel, and they sustained breaking or tensile strains, at the end of a month, varying from 75 lb. to 719 lb. upon 2¼ square inches. A clause was then inserted in the specifications to the effect that the Portland cement to be used in the works should be of the very best quality, and ground extremely fine, weighing not less than 110 lb. to the striked bushel, and capable of resisting a breaking weight of 400 lb. upon an area 1½ inch square, equal to 2¼ square inches, seven days after being made, and after being immersed in water for the whole of that time. The standard was subsequently raised to 500 lb. on the same sectional area, which was that used throughout the experiments. During the last six years 70,000 tons of Portland cement had been used in these works, which extended over a length of 18 miles and had cost £1,250,000. This quantity of cement had been submitted to about fifteen thousand tests, at a cost of only five farthings per ton. The machine devised for showing the tensile strain was a lever balance, constructed by Mr. P. Adie (Assoc. Inst. C.E.), and its first cost was from £40 to £50. It was so simple that an ordinary workman could be trusted to test the cement, and the cost for labour did not exceed £80 per annum for each machine.

The manufacture of Portland cement required extreme care in the admixture of its two simple and well-known ingredients, clay and chalk, it being necessary to vary the proportions according to the quality of the chalk; thus, in white chalk districts, the clay formed from 25 to 30 per cent., and in grey chalk districts from 16 to 20 per cent. of the whole bulk. The manufacture was carried on almost exclusively on the banks of the rivers Thames and Medway; the clay, which should be as free from sand as possible, being obtained from the creeks and bays between Sheerness and Chatham. Long experience now enabled the clerks of works and others to detect the qualities of the cements by colour and by weight. Very strong Portland cement was heavy, of a blue grey colour, and set slowly, in fact, the longer it was in setting the greater was its strength. Quick-setting cement had generally too large a proportion of clay in its composition, was brown in colour, and turned out weak, if not useless. In the first schedule of prices 2*s.* 3*d.* per bushel was inserted; but this was far above its present market value.

But the tests were not alone sufficient. It was essential that constant supervision should be exercised to insure that only clean and sharp sand should be mixed with the cement; that the cement was only supplied with sufficient water to reduce it to a state of paste, which was best accomplished by means of a perforated nozzle at the end of a pipe or watering can; that the bricks or stones were thoroughly saturated with water, so that in setting the cement might not be robbed by absorption of the moisture necessary for its perfect hardening; and that a current of water was prevented from passing over the cement, or through the joints, during the progress of setting, as this would wash away the soluble silicates.

The results as a rule were the average of ten tests, the samples being immersed under water from the time of setting to the time of testing. The tables showed that, during the last six years, 1,369,210 bushels of Portland cement had been submitted to 11,587 tests, and that the cement was found to be of the average weight of 114·5 lb. per bushel, and to possess an average tensile strength of 608·6 lb. upon 2¼ square inches, being 51¼ and 21 per cent. in excess of the two specified standards. It was also ascertained that, provided Portland cement be kept free from moisture, it did not, like Roman cement, lose its strength by being kept in casks or in sacks, but rather improved by age—a great advantage in the case of cement which had to be exported. Experiments, conducted over periods varying from one week to twelve months, with Portland cement, weighing 112 lb. to the imperial bushel, gauged neat and mixed with varying proportions of different kinds of sand, showed that neat cement was stronger than any admixture of it with sand; that mixed with an equal quantity of sand (as had been the case throughout the Southern Main Drainage Works); the cement might be said to be, at the end of a year, approximately three-fourths of the strength of neat cement; that with two, three, four, and five parts of sand to one of cement the strength was respectively one-half, one-third, one-fourth, and about one-sixth that of neat cement. Other experiments showed that at the end of twelve months, neat cement kept under water in a quiescent state was about one-third stronger than that which was out of water, both indoors and exposed out of doors to the action of the weather; that blocks of brickwork, or concrete, made with Portland cement, if kept under water until required for use, would be much stronger than if allowed to remain dry; and that salt-water was as good for mixing with Portland cement as fresh water. Bricks of neat Portland cement, after being made three, six, and nine months, withstood a crushing force of 65, 92, and 102 tons respectively, or equal to the best quality of Staffordshire blue bricks; and bricks of cement mixed with four and five parts of sand, bore a pressure equal to the best picked stock bricks; while Portland stone of similar size, bore on its bed a crushing weight of 47 tons, and against its bed somewhat less, and Bramley Fall stone sustained on its bed 93¼ tons, and against its bed 54¾ tons. Portland cement concrete made in the proportions of one of cement to six or eight of ballast, had been extensively used for the foundations of the river wall and the piers of the reservoirs at Crossness, as well as for the foundations generally both there and at Deptford, with the most perfect success. It was thought that it might be still more advantageously used as a substitute for brickwork or masonry, wherever skilled labour, stone, or bricks were scarce, and foundations had to be made with the least expenditure of time and money. Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave only clean ballast. Roman cement, though about two-thirds of the cost of Portland was only about one-third its strength, and was therefore double the cost when measured by strength. It was, besides, very ill adapted for being mixed with sand.

In conclusion, the author, whilst recommending Portland cement as the best article of the kind that could be used by the engineer or architect, warned everyone who was not prepared to take the trouble, or incur the trifling expense of testing, not to use it; as, if manufactured with improper proportions of its constituents, chalk and clay, or improperly burnt, it might do more mischief than the poorest lime. Further experiments were desirable, on the strength of adhesion between bricks and cement, under varying circumstances; on the limit to the increase of strength with age; on the relative strength of concrete made with various proportions of cement and ballast; and on the use of cement in very hot climates, where probably extra care would be required in preserving the cement from damp, and keeping it cool until the process of setting had been completed. On these and other important points, the author trusted that all who had the opportunity would record their observations, and present them to the Institution.

The Annual General Meeting.

Dec. 19, 1865.—It was remarked in the Report of the Council, that the position which the Institution had now attained must be satisfactory to all its members, and eminently so to those few still living who, many years ago, when young men, laboured earnestly to secure for it a recognised place among the scientific societies of the Metropolis. They seemed to have anticipated that a time would arrive when, as a matter of course, every one in any way connected with the profession would belong to the Institution; for in the charter of incorporation granted in the year 1828, as well as in the bye-laws and regulations based upon that charter, the designation "civil engineer" was made to embrace every branch of engineering except that devoted to the military art. It was well that this should be constantly borne in mind, so as to prevent that which should ever be one united body being split up into sections. There seemed to be no reason why, at this time, any limitations should be introduced, or any restrictions be imposed, tacitly or otherwise, which might operate to render less comprehensive and complete the perfect embodiment of the profession in the Institution; and in that view efforts should be directed to consolidate all branches under one corporation, and thus to add materially to the power, influence, and importance of the profession at large.

There had been twenty-four ordinary general meetings during the past session, when twelve papers only, out of those submitted to the council, had been read, owing to the protracted and animated discussions to which they gave rise. Of these communications one-half had reference distinctly to foreign enterprises or discoveries, including—a description of Giffard's injector, probably one of the most ingenious and scientific pieces of mechanism of modern times; an account of the Docks and Warehouses at Marseilles, where the imports and exports were estimated to amount to three million tons per annum; a notice of the Chey-Air bridge, on the Madras Railway, and particularly as to the methods employed for raising the water out of the foundations; an account of the Drainage of Paris; and two Essays on the Decay of Materials in Tropical Climates, and the methods employed for arresting and preventing it. At home, the works for the Main Drainage of London and for the interception of the sewage from the River Thames, were fully detailed and illustrated; a description was given of the Great Grimsby (Royal) Docks, with a minute account of the enclosed land, entrance locks, dock walls. &c.; the particulars were recorded of a highly interesting experiment—the employment of locomotive engines, for passenger traffic, on the Festiniog Railway, a mineral line with a gauge of 2 feet only; the maintenance of Railway Rolling Stock was the subject of a useful communication, embodying the statistics for a period of thirteen years, of all the stock belonging to the North Eastern Railway Company; a careful and elaborate inquiry on Uniform Stress in Girder work, suggested by a previous discussion at the Institution, and by which it was sought to be maintained that uniform stress was perfectly consistent with the utmost economy of materials; and a description of the river Tees, and of the works upon it connected with the navigation.

It was stated that arrangements had been made by which Volume xxii. of the Minutes of Proceedings would be in the hands of the members in February next, Volumes xxiii. and xxiv. in the months of May and August following, and Volume xxv. for the present session before the meetings were again resumed in November, 1866.

In the belief that many members and associates of the Institution were in the habit of making observations and experiments, on subjects connected with engineering science, which were seldom published, but remained as notes in memorandum books, and in time were lost, the council urged the members to contribute results of this kind, for the purpose of forming an appendix to the minutes.

About three hundred volumes had been added to the library during the year; and a portrait of the late Sir William Cubitt, past president, by Mr. Boxall, R.A., had been received from his son, Mr. Cubitt.

The tabular statement of the transfers, elections, deceases, and resignations, showed that the number of elections had been 142, of deceases 21, of resignations 5, and of erasures 8, leaving an effective increase of 108, and making the total number of members of all classes on the books on the 30th of November last, 1203. This was an increase of nearly 9 per cent. on the present number in the past twelve months.

The deceases announced during the year had been:—Sir John William Lubbock, Bart., Honorary Member; Colonel Frederick Blom, Frederick Braithwaite, John Isaac Hawkins, Captain Gustaf Lagerheim, John Lewis, James Beaumont Neilson, Jacob Perkins, Frederick Walter Simms, and General Alexander Wilson, Members; George Abernethy, John George Appold, Matthias Wolverley Attwood, William Henry Richard Curll, William Johnson, Edwin Marshall, Benjamin Oliveira, Sir Joseph Paxton, John Francis Porter, Andrew John Robertson, and Douglas Sutherland, Associates. By the will of the late Mr. Appold, whose interest in the welfare of the society was unflagging, provision was made for a sum of One Thousand Pounds being conveyed to the Institution on the decease of Mrs. Appold.

An examination of the statement of receipts and expenditure showed that, during the year ending the 30th of November last, the receipts from subscriptions and fees alone amounted to £3950, as against disbursements of all kinds of £3511; while the income account was further increased by the dividends upon trust funds amounting to £353, and upon other investments (not being in trust) of £400, as well as by miscellaneous receipts to the extent of £350. Twelve years ago, in the annual report for the session 1853-54, the total income of the Institution was estimated to amount to £1923, and the expenses exclusive of the minutes, to £1649. In the interval the receipts had been increased from subscriptions and fees more than twofold, and from dividends and other sources more than seven times; on the other hand, the disbursements, exclusive also of the minutes, had in the last year been £2086 only, against the estimated sum of £1649 at the former period. The realised property of the Institution now comprised:—I. General Funds, £12,510 3s. 6d.; II. Building Fund, £2502 5s. 5d.; III. Trust Funds, £9970 12s. 7d., making a total of £24,983 1s. 6d. as against £22,541 5s. 6d. at the date of the last report.

The Benevolent Fund established in connection with the Institution, twelve months ago, had since been fully organised, and a committee of management appointed, who would in due course have to report to the subscribers of the fund. It might, however, be stated, that the donations actually received had amounted to £22,782 17s., and the annual subscriptions for 1865 to £712 16s., being in the former case a little in excess of the sum promised, and in the other an increase of 30 per cent.

A private bill to be submitted to parliament in the ensuing session, and for which plans had been deposited and the usual notices served, appeared calculated to affect very seriously the interests of the Institution. This was in reference to that part of a project entitled "Houses of Parliament Approaches," which contemplated the compulsory purchase of all the property on the north side of Great George-street, including the house occupied by the Institution. The council felt it to be their duty to direct attention to this subject, believing it to be one which demanded serious consideration.

After the reading of the report, Telford Medals and Telford premiums of books were presented to Messrs. J. W. Bazalgette, C. Reilly, E. H. Clark, and Capt. H. W. Tyler, R.E.; Telford Premiums of Books to Messrs. T. Hawthorn, E. Fletcher, E. Johnston, G. O. Mann, W. J. W. Heath, and J. Taylor; and the Manby Premium in Books to Mr. H. B. Hederstedt.

The thanks of the Institution were unanimously voted to the President for his attention to the duties of his office; to the Vice-Presidents and the other Members and Associates of Council for their co-operation with the President, and their constant attendance at the meetings; to Mr. Charles Manby, Honorary Secretary, and to Mr. James Forrest, Secretary, for the manner in which they had performed the duties of their offices; as also to the Auditors of the Accounts, and the Scrutineers of the Ballot, for their services.

The following gentlemen were elected to fill the several offices on the Council for the ensuing year:—John Fowler, president; Joseph Cubitt, Charles Hutton Gregory, Thomas Hawksley, and John Scott Russell, vice-presidents; James Abernethy, William Henry Barlow, John Frederic Bateman, Nathaniel Beardmore, James Brunlees, Thomas Elliot Harrison, George Willoughby Hemans, John Murray, George Robert Stephenson, and Charles Vignoles, members; and Joseph Freeman and John Kelk, M.P., associates.

ON THE PROPOSED NEW COURTS OF LAW.*

By THOMAS WEBSTER, Q.C.

SITUATION AND AREA OF SITE.

WITHIN the district bounded on the north by Carey-street and Lincoln's-inn, on the south by the Strand and the Temples, on the east by Bell yard and Temple-bar, and on the west by New-inn and Clement's-inn, is the site on which the Palace of Justice is to be erected, and the Courts and Offices of Judicature are to be concentrated. Its clearance will be commenced forthwith. The approaches and appropriation of the site are the questions in which the public and the profession are now most interested. The site, when cleared, will be found to be about 20 feet higher on the north, or Carey-street, than on the south, or Strand side, and to have a gradual inclination from the north-east, at the corner of Bell-yard, towards the south-west, at the church of St. Clement Danes,—a circumstance not to be disregarded in considering the approaches to the palace, as it is from the south-west side alone that we must look for an approach terminating in the Palace of Justice, and presenting a *coup d'œil* worthy of the subject. It is too much to hope and expect that this opportunity may not be lost, but that the fullest advantage may be taken of it,—that the noble example of the Emperor of the French may be followed; that, while the citizens of Paris rejoice in seeing their principal buildings placed at the end of newly created and imposing thoroughfares, the citizens of London may not be denied a similar satisfaction. The approaches from the north and north-east, though capable of great improvement, cannot be adapted to an approach of the kind suggested, without an interference with a property already exclusively devoted to the profession, and extremely valuable; as, for instance, Lincoln's-Inn, the New Record Office, and Rolls House; Serjeant's-inn, the Law Institution, and other buildings in Chancery-lane. A good access to the Palace of Justice from the level of Chancery-lane for carriages, and over and under Chancery-lane for passengers, may be obtained; but a grand approach, such as may be presented on the south-west, is pecuniarily impracticable on the north-east side; and its attainment would render the site a great thoroughfare for traffic having no occasion to resort to the Palace of Justice. The difference of 20 feet in the levels of the ground between the north and south may be taken advantage of to afford an extra floor on the southern portion of the site, and a saving of 20 feet in the ascent to the principal story—the floor of the Great Hall of the Palace of Justice—from the northern and western side.

LEVEL OF THE SITE AND OF THE THAMES EMBANKMENT.

The relative levels of the site and of the Thames Embankment present advantages not to be disregarded. The Strand at St. Clement's may be taken to be about 30 feet above the level of the roadway of the Thames Embankment, below which, at the depth of say 20 feet, are the Metropolitan Railway and the Low-level Northern Sewer.

SUBWAYS UNDER THE STRAND, FLEET-STREET, AND HOLBORN.

Thus access may be obtained to the basement of the Palace of Justice, and by an easy incline to the level of Carey-street, by a subway under the Strand in the neighbourhood of St. Clement's Church, and the traffic to and from the Palace of Justice may be separated and isolated from the traffic between the level of the Strand and other parts of the Metropolis. Thus the great stream of traffic using the Thames Embankment *en route* to or from other places than the Palace of Justice, and the traffic to and from the Palace of Justice, may be rendered independent the one of the other, and prevented obstructing the approaches to the Palace of Justice from the north-west, north, and north-east. Such approaches from the Thames Embankment may be connected with the approaches from the west and north on the western side of Lincoln's-inn-fields; from Covent-garden on the west, and Holborn on the north; they would remove one of the greatest plague-spots in the Metropolis, lead to the purification and improvement of the district of Clare-market, and the territory almost unknown, except to those who pass between Lincoln's-inn and the west, lying between Great Queen-street, Lincoln's inn-fields, Drury-lane, and Clement's-inn.

APPROPRIATION OF THE SITE.

The appropriation of the site must depend on various considerations, amongst which the area to be dealt with, and the requirements of the courts, are the most prominent. The area of the site may be taken at 7½ acres. The difference of levels of Carey-street and the Strand will give an extra floor of about one-half that area, without extra excavation. Let us start from the level of Fleet-street and the Strand, at the Temple-bar entrance to the Palace, and assume the basement of the building to be 20 feet below that level, or 10 feet above the level of the road of the Thames Embankment, or 30 feet above the level of the rails of the Metropolitan Railway, and of the Low-level Sewer in that embankment. This basement of 7½ acres (without deducting the space necessary for areas for lights and passages) has been proposed to be appropriated to strong rooms, for the preservation of original wills and other documents of value. For the wills alone it has been said that upwards of three acres will be required. To this basement access may be had by subways under Fleet-street and Chancery-lane, so as to connect it at once with the Temple, Serjeant's-inn, the Rolls and New Record Office. The basement will have a depth of about 40 feet next Carey-street, or on the north side, should it be thought expedient to carry it throughout at that level; and if Carey-street can be relieved of the through traffic by which it is now encumbered, by reason of the obstruction at Temple-bar, the arch of which is too low to permit the passage of the high-loaded vans and waggons, a portion of that street may be made available to widen the area for the lights to the basement. The ground-floor of the Palace, or that on the level of Fleet-street at Temple-bar, would be about 20 feet below the level of Carey-street; and assigning 20 feet for the height of the rooms on the ground story, and 20 feet for the height of the next, we arrive at the level of the floor of the Great Hall, about 40 feet above Fleet-street, and 20 feet above Carey-street.

ARRANGEMENTS OF COURTS AND OFFICES ABOUT THE GREAT HALL.

In the arrangement of the courts on the sides and at the ends of or around the Great Hall, the principles of separation and isolation are essential for the convenient and economical administration of justice. In this respect it may be well to imitate the arrangements of the new Assize Courts at Manchester, in which those principles are applied to the extent there required.

The precise arrangement of the courts will be matter of detail for after-consideration, but the general principles may be indicated.

For the purpose of illustrating the arrangement of the courts and offices in connection with the Great Hall, let us suppose a series of four concentric circles, the inner representing the Great Hall; that in the space between the circumference of the first and second circles are arranged the courts and offices immediately connected with them; that the space between the second and third circles is a passage or corridor for communication with the courts and offices arranged between the first and second circles; and that the offices are located between the third and fourth circles. Access to the courts will then be obtained from the Great Hall on the one side, and from the corridor between the second and third circles. Access to and from the Great Hall will of course be open to all, but access by the corridor will be strictly confined to the judges, officers, jurors, professional men, witnesses, and parties actually engaged in the business of the courts, or passing to and from the offices located between the third and fourth circles.

Thus the general public and parties engaged, or whose attendance is necessary to the conduct and progress of the cause, may be separated and isolated from each other, but able to intermingle in the Great Hall, and entering and leaving the courts by different routes.

The courts, and offices immediately connected with the courts, as the retiring-rooms of the judges and the jury, will be arranged in the space between the first and second circles, each court with the offices immediately connected with it presenting substantially the same arrangement, but differing only in details according to the requirements of the business to which it is devoted. The interval between each court, or each set of courts, will be available for access between the Great Hall and the great corridor, by rising, as in the courts at Manchester, to a level above the level of the floor of the Great Hall. This elevation, of say 4 feet, will give the means of access to the bench and the retiring-rooms of the judge, and to the jury box and retiring-rooms for the jury, while a descent of 4 feet will give access to parties and witnesses engaged in the cause, and afford the means of separating the witnesses on either side from each other, in convenient waiting-rooms immediately accessible to the court. This level of the floor of the

* Paper read at the Social Science Congress.

judges' rooms, which may be conveniently designated the level of the bench, forms a most important feature in the new courts at Manchester, and in the arrangements hereafter mentioned, especially in reference to the suggested entrances to the courts. The indiscriminate manner in which the witnesses on either side are permitted to intermix, during the progress of the cause, with each other and the general public, and the difficulty with which they are introduced into, and withdrawn from, the witness-box, are serious defects in our administration of justice; and any scheme for the courts in which this was not amply provided for would be most seriously defective. It is of the greatest importance also that the jury should be provided with accommodation wholly independent of the access to the public, and that their retiring-room should be convenient for communication with the judge.

The offices of the masters of the several courts should be in immediate connection with and contiguous to the several courts, and it may be sufficient to have indicated and illustrated by imaginary circles situations suitable for their location on the level of the Great Hall and courts, while the floors immediately below that level will afford space for the Writ and Record Offices, with convenient accesses to the offices of the masters of the respective courts. The contiguity of the several Writ, Record, and Judgment Offices to the master or the courts is of less importance than bringing them all into as close contiguity as possible with each other, with the view of a general consolidation and concentration of such offices for all the courts.

INTERNAL ARRANGEMENT OF THE COURTS.

The construction and internal arrangement of the courts would appear to have received little consideration, many being most inconveniently large or small, and none presenting that separation and isolation by which the convenient administration of justice may be so much facilitated. In many, the position of the witness-box is so inconvenient as to lead to its abandonment, and to placing the witness in some new position more convenient for the judge and jury and counsel, but most inconvenient to the witness. The inconvenience of ingress and egress, and the manner in which all parties are intermixed with each other and with the public, is matter of universal complaint whenever circumstances of interest give rise to a crowded court.

To the relative position of the judge, with a jury-box on either side of the court, arranged with three seats holding four each, and of the counsel, no exception can be taken. The great defect is in the position of the witness-box, and the difficulty of ingress and egress for the witnesses, professional men, and others necessary for the progress of the cause. Accommodation for jury-men in waiting, for students, for short-hand writers, and reporters, must form an essential part of the arrangement. The witness under examination naturally turns to the counsel by whom he is examined; the reply to the question will be naturally addresed to the same counsel, and consequently, according to the arrangements adopted in many of the courts, from the judge and jury, by both of whom the witness should be heard and seen. The witness, if placed near to, and a little below and on the right hand of the judge (assuming the jury to be on the left of the judge), that is, on the opposite side of the judge from the jury, will speak across the judge, be seen by the jury, and heard equally by the jury and examining counsel; from whom he will be about equally distant. The position of the witness-box in the Courts of Queen's Bench, Common Pleas, and Exchequer, is an illustration of this; but the witness might with advantage be nearer the judge than in any of those cases. If the witness be placed between the judge and jury, his back will generally be turned on one or the other, and he will sometimes get engaged in conversation with some of the jury, a most objectionable and inconvenient practice. None of these courts present convenient or isolated ingress or egress for the witness, who must struggle and be intermixed with the general crowd, with whom he is intermixed both before and after his examination. Nor are the jurors, counsel, attorneys, or parties any better off, as the experience of those attending the courts at Westminster, and other courts in the Metropolis, will affirm.

This may be wholly avoided by a passage under or on either side of the seat of the judge. Assume the floor of the judicial bench to be 4 feet above the level of the floor of the court, by steps descending to the level of 4 feet below the floor of the court, ingress and egress may be obtained under the bench, and communication effected with suitable separate waiting-rooms, in which the witnesses of either party prior to their examination may be kept together, ready to be called as required. The witnesses, after examination, may be permitted to pass into the court by a passage under the upper seat of either jury-box, and intermix with the general crowd. This ingress and egress under the floor of the bench may also be made available for counsel, attorneys, and other parties immediately engaged in the cause. The floor of the court between the bar and the bench would afford (the witness-box by which it is usually encumbered being removed) ample space for short-hand writers and reporters, with seats and small desks under the jury-box; the centre part being kept clear for ingress and egress and the exhibition of models and plans, in the introduction and exhibition of which great inconvenience is frequently experienced. The seats reserved for students might be immediately behind the bar, the access to the first and second row of bar-seats being from the floor of the court under the bench, and to the third and other rows at each end next the jury-boxes by passages under the upper seat of the jury-boxes, or direct into the Great Hall; the seats for the public being behind, at either angle, with entrances only from the Great Hall. Thus the angles of the rectangular courts would be utilised, and the hearing improved; and I would suggest whether the shape of the courts should not be rectangular and hexagonal in all cases; the part occupied by the bench and jury-boxes being rectangular, and the other part three sides of a hexagon. The seats for the bar and the public should be slightly raised, so that every person may be able to see and hear without difficulty; for, unless this be the case, it is almost hopeless to attempt to preserve the quiet of the court.

LIMES, CEMENTS, MORTARS, AND CONCRETES.*

By CHAS. H. HASWELL, Engineer, N.Y.

(Continued from page 267, vol. 28.)

CALCAREOUS MORTAR, being composed of one or more of the varieties of lime or cement, natural or artificial, mixed with sand, will vary in its properties with the quality of the lime or cement used, the nature and quality of sand, and the method of manipulation.

Mortar.—Lime, 1; clean sharp sand, 2·5. An excess of water in slaking the lime swells the mortar, which remains light and porous, or shrinks in drying; an excess of sand destroys the cohesive properties of the mass It is indispensable that the sand should be sharp and clean.

Turkish Plaster, or Hydraulic Cement.—100 lb. fresh lime reduced to powder, 10 quarts linseed oil, 1 to 2 ounces cotton. Manipulate the lime, gradually mixing the oil and cotton, in a wooden vessel, until the mixture becomes of the consistency of bread-dough. Dry, and when required for use mix with linseed oil to the consistency of a paste, and then lay on in coats.

Exterior Plaster or Stucco.—1 volume of cement powder to 2 volumes of dry sand. In India, to the water for mixing the plaster is added 1 lb. of sugar, or molasses, to 8 imperial gallons of water, for the first coat, and for the second or finishing, 1 lb. sugar to 2 gallons water. Powdered slaked lime and smiths' forge scales, mixed with blood in suitable proportions, make a moderate hydraulic mortar, which adheres well to masonry previously coated with boiled oil. The plaster should be applied in two coats laid on in one operation, the first coat being thinner than the second. The second coat is applied upon the first, whilst the latter is yet soft. The two coats should form one of about 1½ inch in thickness, and when finished it should be kept moist for several days. This process may be modified by substituting for the first coat a wash of thick cream of pure cement applied with a stiff brush just before the plaster is laid on. When the cement is of too dark a colour for the required shade, it may be mixed with white sand in whole or in part, or lime paste may be added until its volume equals that of the cement paste.

Khorasser, or Turkish Mortar, used for the construction of buildings requiring great solidity, ⅓ powdered brick and tiles, ⅔ fine sifted lime. Mix with water to the required consistency, and lay on layers of 5 and 6 inches in thickness between the courses of brick or stone.

Interior Plastering.—The mortars used for inside plastering are termed Coarse, Fine, Gauge or hard finish, and Stucco.

Coarse Stuff.—Common lime mortar, as made for brick masonry, with a small quantity of hair; or by volumes, lime paste (30 lb. lime) 1 part, sand 2 to 2½ parts, hair ⅙ part. When full time for hardening cannot be allowed, substitute from 15 to 20 per cent.

* From the Journal of the Franklin Institute.

of the lime by an equal proportion of hydraulic cement. For the second or "brown coat" the proportion of hair may be slightly diminished.

Fine Stuff (lime putty).—Lump lime slaked to a paste with a moderate quantity of water, afterwards diluted to the consistency of cream, and then allowed to harden by evaporation to the required consistency for working. In this state it is used for a "slipped coat," and when mixed with sand or plaster of Paris it is used for the "finishing coat."

Gauge Stuff, or hard finish, is composed of from 3 to 4 volumes fine stuff and 1 volume plaster of Paris, in proportions regulated by the degree of rapidity required in hardening; for cornices, &c., the proportions are equal volumes of each, fine stuff and plaster.

Stucco is composed of from 3 to 4 volumes of white sand to 1 volume of fine stuff, or lime putty.

Scratch Coat.—The first of three coats when laid upon laths, and is from $\frac{1}{4}$ to $\frac{3}{8}$ of an inch in thickness.

One-coat Work.—Plastering in one coat without finish, either on masonry or laths, that is, rendered or laid.

Two-coat Work.—Plastering in two coats is done either in a laying coat and set; or in a screed coat and set. The screed coat is also termed a floated coat. Laying the first coat in two-coat work is resorted to in common work instead of screeding, when the finished surface is not required to be exact to a straight-edge. It is laid in a coat of about $\frac{1}{2}$ an inch in thickness. Except for very common work, the laying coat should be hand-floated. The firmness and tenacity of plastering is very considerably increased by hand-floating.

Screeds are strips of mortar 6 to 8 inches in width, and of the required thickness of the first coat, applied to the angles of a room, or edge of a wall, and parallelly at intervals of 3 to 5 feet all over the surface to be covered. When these have become sufficiently hard to withstand the pressure of a straight-edge, the interspaces between the screeds should be "filled out" flush with them, so as to produce a continuous and straight, even surface.

Slipped Coat is the smoothing off of a brown coat with a small quantity of lime putty, mixed with 3 per cent. of white sand, so as to make a comparatively even surface. This finish answers when the surface is to be finished in distemper, or paper-hangings.

Hard Finish.—Fine stuff applied with a trowel to the depth of about $\frac{1}{8}$th of an inch.

Estimate of Labour and Materials for 100 *square yards of Lath and Plaster.*

Materials.	Three Coats Hard-finished work.		Two Coats Slipped work.	
Lime	4 casks	$4·00	3⅓ casks,	$3·33
Lump lime for fine stuff ...	⅝ „	·85		
Plaster of Paris	⅛ „	·70		
Laths	2000	4·00	2000	4·00
Hair...	4 bushels,	·80	3 bushels,	·60
Common sand	7 loads,	2·00	6 loads,	1·80
White	2½ bushels,	·25		
Nails	13 pounds,	·90	13 pounds,	·90
Masons' labour	4 days,	7·00	3½ days,	6·12
Labourer	3 „	3·00	2 „	2·00
Cartage	...	2·00	...	1·20
Cost of 100 yards,	...	$25·50	...	$19·95

Concrete or Beton, is a mixture of mortar (generally hydraulic) with coarse materials, as gravel, pebbles, stones, shells, broken bricks, &c. Two or more of these materials, or all of them, may be used together. As lime or cement paste is the cementing substance in mortar, so is mortar the cementing substance in concrete or beton. The original distinction between cement and beton was, that the latter possessed hydraulic energy, whilst the former did not.

Hydraulic.—1½ part hydraulic lime measured when unslacked, 1½ part sand, 1 part gravel, 2 parts of a hard limestone broken. This mass contracts $\frac{1}{5}$ in volume. Fat lime may be mixed with concrete, without serious prejudice to its hydraulic energy.

Various Compositions of Concrete.—Forts Richmond and Tompkins, U.S.—Hydraulic.—308 lb. cement=3·65 to 3·7 cubic feet of stiff paste. 12 cubic feet of loose sand=9·75 cubic feet of dense.

For Superstructure.—11·75 cubic feet of mortar as above, and 16 cubic feet of stone fragments. In the foundations of Fort Tompkins, about one-twelfth of its volume was composed of stones from $\frac{1}{4}$ to $\frac{3}{4}$ of a cubic foot in volume, rammed into the wall as the concrete was laid.

Sea Wall.—Boston Harbour.—Hydraulic.—308 lb. cement, 8 cubic feet of sand, and 30 cubic feet of gravel. The whole producing 32·3 cubic feet.

Superstructure.—308 lb. cement, 80 lb. lime, and 14·6 cubic feet dense sand. The whole producing 12·825 cubic feet.

Total Cost of Labour and Materials Expended in laying Concrete Foundation at Fort Tompkins, during the year 1849.

LABOUR.

Wages of sub-overseer, 42·2 days, $2 per day		$ 84·40
„ mason, setting planks 82·8 days at $2 per day		165·60
„ labourers (assisting), 153·6 days at $1 per day		153·60
„ labourers transporting and ramming concrete, 2971·8 days at $1 per day		2971·80
Total cost of labour		$3375·40

MATERIALS.

4,096 casks cement at 85 cents	$3481·60	
12,288 „ sand at 3 cents	386·64	
20,480 „ broken stone at 8 cents ...	1638·40	
		$5488·64
Total cost of labour and materials		$8864·04
Total number of cubic yards of concrete laid, excluding the stone masses rammed in		$3606\frac{1}{27}$
Cost per cubic yard of pure concrete		2·46
Deduct for stone masses rammed in		·20
Cost per cubic yard as laid		2 26

Cost of Masonry, of various kinds, per cubic yard, and the volume of Mortar required for each.—(General Gilmore, U.S.A.)

Masonry.	Volume of Mortar.	Lime required, no cement used.	Cement required, no lime used.	Difference of cost of Masonry with cement mortar and lime mortar.	Cost. Lime mortar.	Cost. Cement mortar.
	Cu. ft.	Bls.	Bls.	$ cts.	$ cts.	$ cts.
Rough, in rubble or gravel, from $\frac{1}{8}$ to $\frac{1}{16}$ cubic foot in volume,	10·8	·565	1·22	·90	4·10	5·
Blocks, large and small, not in courses, joints hammer-dressed, ...	8·1	·423	·92	·62	7·	7·62
Large masses; headers and stretchers dove-tailed; hammer dressed; beds and joints laid close, ...	1·	·05	·11	·08	9·	9·08
Ordinary; courses 20 to 32 in size, ...	1·5	·08	·17	·12	5·70	
Ordinary; courses 12 to 20 in size, ...	2·	1·05	·22	·16	2·19	
Brick, ...	8·	·42	·90	·66	5·70	6·20
Concrete, good, ...	11·	·54	1·75	1·21	2·19	3·20
„ medium, ...	9·	·41	1·06	·65	1·56	2·21
„ inferior, ...	8·	·37	·97	·60	1·45	2·05
Rubble, without mortar,	...	...	...	...	3· to 3·30	

Cost of materials assumed as follows: Cement, $1·20 per barrel; lime, $1; bricks, $4·25 per M.; sand and gravel, 80 cents per ton; granite spalls, 55 cents per cubic yard; labour, $1 per day. For walls less than 2 feet in thickness the cost is increased.

OBSERVATIONS FOR CONSIDERATION, PREVIOUSLY TO THE LAYING OF ANOTHER ATLANTIC CABLE.*

By T. SEYMOUR BURT, F.R.S.

The first Atlantic telegraph cable was actually laid between the shores of Ireland and America, in the year 1858; and by what means was it so efficiently laid without on any occasion, if I err not, its breaking or separating throughout any portion of its length, so as thereby to require the difficult, if not fatal, operation

* From the Journal of the Society of Arts.

of hauling it in again to cut out the faulty part, and to effect its repair? How was it laid?—Why, by making use of two ships instead of one, viz., the English Agamemnon and the American Niagara, which ships, each conveying out half the cable, having joined the ends of the same, and spliced them in central Atlantic ocean, steered away for their respective countries, which they satisfactorily, if not simultaneously, reached, after having deposited these two halves of the cable in the bed of the sea, as well as having connected the other two ends with the ends of the coils proceeding from the two opposite shores. Well, this fact shows the possibility, or rather the practicability, of laying a cable between this country and America or Newfoundland. Then why has the operation not succeeded in the second instance?—Simply, because one ship only has been employed in the performance in the latter instance, instead of two ships. For, if two ships managed so well to lay a long cable in the first instance, why should only one ship have been employed on a second operation, and one, indeed, which has so specially failed? As time represents nearly everything with respect to the chances of storms occurring to disturb the equable paying out of the cable, it is manifest that if only one ship be employed in the operation instead of two, there must be four chances to one against the one ship escaping a storm in double the time, to that of the two ships escaping a similar calamity or inconvenience in half the time, as required for the voyage; besides, the two ships, before parting in mid-ocean, on depositing their joined ends of the cable in deepest water, being nearer one another, can help one another in the most difficult portion of their course, or that were—if the cable should break at or over the central (or assumed) deepest part of the ocean—they would both remain, or separating, would return to meet again, and so constantly to assist each other in recovering the escaped end of the coil. Whereas the one ship alone has no help at hand but its own. I should be disposed therefore, to advocate the use of two such ships again, instead of one, in the operation of relaying the Atlantic cable.

But there is another argument against the use of one ship only. That ship must, like the Great Eastern, necessarily be of immense size, in order to be sufficiently capacious to contain, or stow away, the whole main length of cable, which consists of 1900 or 2000 miles or more. Now, the greater the size of the ship the greater the stress exerted upon the cable when she raises her bow above the surface of the water—like as a giant pulls more strongly than a child. A smaller ship's haul or strain exerted upon the overhanging cable would not so tend to rend that cable (notwithstanding its tendency to rise to the wave to a greater height than the bow of the larger ship) as would the terrible dead weight and rise or stress or strain of the huge ship itself, the resistance of the cable being unnecessarily overpowered by the superior momentum of the latter vessel, and being thereby caused to be rent in twain, from the effect of the increased tension, which serves to break it like a piece of thread. And therefore, probably if a very small ship or steamer could be steered in advance of the Great Eastern, on her next attempt, and could then be made to receive the descending part of the cable after it has left the latter ship, and, next, to deposit it directly over its own bow into the deep, the cable would be less liable to be torn asunder than if the big ship should pay it out alone and at once over its own bow directly into the abyss.

But why did the cable which had been first laid fail? A reply to this momentous question is printed in Part I., Vol. III., of my Miscellaneous Papers on Scientific Subjects, London, 1861, pp. 32-8, in a letter addressed to the late Viscount Palmerston, whilst Prime Minister, dated July 23, 1860.

I repeat the question. Why did the first-laid cable fail, after having been properly laid from end to end? It failed simply because one-half of the length had been twisted (in manufacture) to the right hand of the line of its axis, whilst the other half had been twisted to the left hand of the same line or axis. How was this done? One of the halves had been manufactured on the banks of the Thames, the other half in another locality, the name of which I forget. Yet, strange to say, this fatal defect was considered, it appears by the *Times* of the 13th of May, 1858, to have been remedied or "overcome" by joining the the two ends, in midway Atlantic, to certain "rods of iron, loaded with a weight in the centre," which it was hoped—for it could could not have been believed—would rectify the fault. And so the cable failed—and, yet not even a trial beforehand was made of the two pieces—pieces contrarily twisted, be it remarked, and known to be so—by joining them together, I mean the half cable twisted, to the right hand and the other half twisted to the left, in order to ascertain the effect of a heavy strain exerted upon those two halves when so joined. The consequence was that the so-joined coils, each consisting of one-half the whole cable, soon began to unwind and gradually to untwist themselves, until the electric pulses or pulsations, passing through the gradually attenuated core or copper wire, upon which the entire strain or stress was now thrown, became weaker and weaker, until they shortly afterwards, like my Uncle Toby's pulse in "Tristram Shandy," fluttered, stopped, beat again, and then entirely ceased! Nor was this effect to be wondered at. Let any person of average common sense try the effect himself with two sets of small wires (or threads), three or four threads in each wire; one set twisted to the right hand the other set to the left hand of the axis of each coil, and then let him, after having joined one end of one coil to one end of the other by a firm knot, or even a "curved bar of iron," and after having stretched the whole coil in a straight line, with a stress bearing upon it, state from his own experiment, proof, and experience, what he considers to have been the main, if not sole, cause of failure of the first-laid Atlantic Telegraph Cable.

It matters not with a cable manufactured in but one direction, *i.e.*, with the helix to the right or with the helix to the left, whether it be cut and then joined again either at the surface of separation, or at the opposite ends, or with the cut end of one portion joined on to the worn end, or to the furthermost end of the other portion, because the helix or twist would remain the same in any mode of junction throughout the entire line; but, I maintain that if one portion of the other half be of a different twist to any portion of the other half, both portions of the coil situated near the point, or rather surface of junction, will, on tension being applied, immediately begin to unwind themselves; and thus will transfer the tension they are intended to resist from themselves to the central copper wire they are intended to support, which latter will consequently become so attenuated from that powerful cause, as at least to separate itself into two detached parts, besides being more or less laid bare by the opening up (or out) of the outer helix, consisting of coils of wire and other substances placed for its protection. Let anyone try the effect of the experiment, as I said before, and the result must confirm the entire correctness of this assertion. Therefore, I assume it to be absolutely necessary, in order to avoid certain failure, that all parts of the cable, shore-ends as well as others, should be manufactured of one uniform helix or coil.

The point now, however, for consideration is, how to lay the cable again after the occurrence of two not altogether unexpected failures? or, rather, how to lay a new cable, and that, if possible, without having to "haul in" again any portion of it after it has been "paid out," in order to discover the whereabouts of its faulty insulation, and with a certainty of weakening the chain or cable on every occasion that it is cut and again spliced. Now, this difficulty may be partially obviated by not having so very many splicing places in the original cable; for it must be evident that the greater the number of splicings or junctions in the same the less the chances of its efficiency. The parts "spliced" together cannot possibly be so strong or so closely connected, or the central wire (the vehicle of the electric message) so intimately adhesive in all its fibres, as the one originally manufactured in its integrity. What a large number of splicings or junctions there must have been in the late Atlantic cable; first, there was the batch of splicings required to join each of the several lengths sent down at different periods from Messrs Glass and Elliott's workshops by each vessel that shipped a length to convey and join it on to its predecessor on board the Great Eastern. Then a splicing was required for each of the tanks when filled, or at any rate for two out of the three tanks in which the cable was stowed on board the leviathan ship Next, the "splicing the main brace" to the end at the Irish shore, and "yet another" splice would have been required at the junction with the land side on the American shore. "I'll see no more," as Macbeth says, almost dreading this long account of splicings in the late cable, and trusting it may be possible to avoid some of them in the new one. The first laid cable was not so cut and so joined, it is to be presumed, as the second one, and yet the former was undoubtedly laid the whole distance, and for the moment successfully so—a message having been transmitted from end to end—from America to England, and this without the occurrence, that I am aware, of any breakage or separation of the coil (save one), in consequence of a mishap. How was this done? By the employment of two ships. And would not the cable have continued its insulation for a reasonable time—not expecting, of course, that it would have solved the problem of perpetual motion—had not its two halves been coiled, unfortunately in two contrary directions; and had they not still more unfortunately been joined together with that sad and fatal fault existing; although the fact was known at the time, or beforehand, certainly before the 13th of May, 1858, without a trial being made to ascertain whether the cable would, when so joined, succeed or not, and when such a trial would have caused but a few hours' delay in the commencement of so great and glorious an undertaking.

In recommending, as I have done above, that two ships should be employed in the performance of this great work instead of one, I do not mean to infer that the operation cannot be completed by the Great Eastern herself, providing a smaller accompanying vessel can be steered but a little way ahead of her, for the reception of the descending cable as it descends from her bow, and before it is allowed to enter into the deep sea, as before explained. I would only desire to be understood as generally advocating the use of two ships instead of one in the execution of this vast undertaking, in the completion of which we all as Englishmen must feel so deep an interest.

One great means of control, however, should exist in the paying-out apparatus, which should be made by means of springs and wheels, or other self-adjusting arrangements, to apportion, at the required velocity, a sudden supply of slack cable, whenever a great and sudden rise of the ship's bow happens to take place, and to require the said supply as from a feeder, so that the amount of strain upon the cable should, if possible, be neither more nor less than a constant quantity. Upon this most important arrangement a great deal of the success of the work must necessarily depend; whereas a different principle will involve but little chance of such a desideratum.

STUDY AS A PREPARATION FOR PRACTICE.*

By T. Roger Smith, F.R.I.B.A.

Study as a preparation for practice is a subject of more than ordinary interest for the members of a society like this, which consists almost entirely of students, either commencing practice or preparing for practice as architects; but is also a theme presenting more than ordinary difficulties to anyone desiring to treat it fully and fairly. I have felt it impossible to do what I consider justice to the subject, and therefore I must trust to your forbearance and indulgence while I lay before you this attempt, an attempt which I felt was almost called for in order to complete the views taken in two papers which I have in previous years had the honour of reading before you—one "On commencing Practice," the other "On the Conduct of Business."

At the outset I must apologise if I appear to assume a dogmatic tone. If this is so, I must plead as my excuse that you will hear but little to-night except things of the truth and importance of which I am very fully convinced in my own mind; yet in pressing my views on your attention I desire to refrain from seeming to do so with that positiveness which he might well assume who was conscious of having as a student done all that I recommend you to do, and been all which I desire each of you to become. If parts of this paper are written with a consciousness of advantages gained, other parts are written with a desire that you should escape mistakes and supply omissions of which the speaker is keenly sensible; and throughout I hope that your own judgment and good sense, and the experience of those best able to advise you, will be brought to bear upon the suggestions made to you.

One very great difficulty in treating of the conduct of your studies is the certainty, that I can hardly offer any hints that will be of service to one, which may not prove valueless, and possibly even injurious, to others, supposing my recommendations to fall in with inclinations to which such happen to be already giving way too much. Perhaps the best remedy for this will be, if I take the advice of one of our most valued members, and ask each of you to pay most attention to that part of my paper which pleases him least.

As an example, I may just point out that with regard to most of you there is nothing so likely to be useful as something which will induce you to work far harder than you do; yet there can be no doubt some few of you are already working too hard, and that every additional spur to you is an injury. Again, in the case of a large part of you, I might, no doubt, do more good by simply and solely urging you to draw more, and draw better than you do, than I could by anything else. But there are sure to be some of you to whom any other work than drawing is distasteful, and who would like nothing better than to be told never to do anything else but draw, forgetting that, though drawing is by far the first thing, yet that architect's education who can *only* draw would be miserably deficient alike in knowledge of construction, materials, history, or the conduct of business. In this difficulty you, gentlemen, must help me by listening with judgment and discrimination. Do not run away with that half of what is said, which you like best, and treat the other half as of no importance to yourselves; but, on the contrary, treat with as much attention that part of what I say which may seem to bear on what you are conscious, in your own heart, is a weak point in your character or the defect in your training, as you are willing to bestow on whatever may fall in with the bent of your genius, inclination, or opportunities. A perfect character is only to be obtained by the correction of errors and defects,—and the cultivation of gifts and acquirements. I trust that you will take pains to educate yourselves as architects in both these ways.

I propose this evening to view the ordinary circumstances of an architectural student in this country, (and in several respects they are tolerably uniform for all of us,) not as matters for discussion as to whether or not they are the very best possible—though I may allow myself one or two words in passing on that head—but as fixed definite conditions under which I have studied, and you have studied, and in all probability our successors for several generations are likely to have to study. These circumstances we cannot in our own cases alter, and shall not be able, perhaps shall not wish, to alter in the case of those who are to succeed us; we must therefore accept them, and our grand object this evening will be to discover how to make the best of them.

What then is the position of a young Englishman who is studying architecture with a view to the practice of this art as a profession? In most continental states he would be either pursuing a course of drawing and of studies under various professors in an academy, or doing much the same thing, but under the eye of one teacher, in an *atélier*. In either case he would be engaged in a way more or less similar to the manner in which his school or college days have been spent, only with the special subject of architecture taking the place of the classics, mathematics, philosophy, and so forth, which have been the subjects of his previous studies. In this country he is sure to be in the office and among the assistants of an architect in practice, ordinarily without systematic instruction, often entirely without defined teaching, and in many ways in a position widely different from the one he left to enter the profession. On the Continent he is an Academy Student. In England he is an Articled Clerk. And it is simply to point out to you the best way, so far as I know it, of turning the English system and your own spare hours to the best account, that I now address you.

Almost all youths who have a fair prospect of being able ultimately to practise, are in circumstances which enable their friends to pay a premium with them, and article them to a practitioner. I am aware that many enter offices in other ways, and obtain knowledge enough to enable them to act at least as architectural draughtsmen, and that of these some advance far enough to practise on their own account. Such may find much that I have to say apply to themselves, but the class that I specially contemplate is that of architectural pupils who have friends of some connection or position, or who, from some other circumstance, are so placed as to look to the exercise of their profession as architects on their own account, and not to any less responsible position, as their final aim, and who are the recognised pupils of some architect. And in passing I may say that I think it undesirable for a youth to become a pupil unless he has a reasonable prospect of being in time able to practise.

Those who enter the profession ought, if possible, to do so fully prepared by their previous education, that is to say by their acquirements, and their habits of industry and their general training, for making the best use of their time as pupils,—especially now that time is customarily so short. What has occurred in the case of each one of us cannot be altered; but any or all of us may be able at times to influence the course of young men proposing to join our ranks, and therefore I may be excused for

* Paper read at the Architectural Association.

pointing out what is, in my opinion, desirable before a pupil enters an office.

He who desires to become an architect should be naturally, and by training, a gentleman, with application and tenacity of purpose; he should possess ingenuity, a natural turn for the pencil, good sense, and, if possible, some spark of genius.

If he is not one of nature's gentlemen, and well-bred, that is to say, not honest and brave, gentle and courteous, he will find the general conduct of his profession beset with infinite difficulty, and will bring discredit upon his calling. If he want application and tenacity of purpose, the large amount that there is to learn, and the great deal there is to do, and the serious difficulties there are to surmount, will overpower him, and he will fail of success. If he have no ingenuity and contrivance he will fail to meet the difficulties of construction, arrangement, and architectural treatment which constantly spring up.—For architecturul practice is little more than a series of contrivances for the overcoming of a constant series of emergencies.

A natural turn for the pencil is most of all essential. We learn, we think, and we express our thoughts as architects, through the pencil; and no man without considerable natural talent for drawing ought ever to think of our profession.

Without good sense, which is partly a natural gift as well as an acquired habit, an architect would go astray at every turn; and whenever you get into a circle of successful architects you will be struck, I think, with nothing more than the atmosphere of straight-forward good sense which surrounds you. A rash, a foolish, or peevish lad will never make an architect, unless good sense can somehow first be worked into him.

Lastly, an undefined something, known as genius—the spark to set the whole on fire—is of infinite value, when it can be had, yet few boys or youths can be said to show it strongly, even when in after life they develop it. Perhaps it is as well this should be so, for a precocious genius often breeds an overweening conceit, and makes a man quite too proud to be taught, almost too proud to learn. And a man of talents and industry, even though of but little genius, will not fail to rise.

Such youths as I have attempted to sketch are not so rare but that one may very fairly require that all the few characteristics named, except perhaps the last, genius, should be forthcoming in our young aspirant for architectural life. Let us now inquire how ought he to have been educated to give him the best chance of future success? My own desire would be that the architectural student should have had an university education, but should have had before him his future profession during a part, if not the whole of his college career. It is very much to be regretted, and were it not that all architects are travelled men, it would be still more to be regretted that the number of Oxford and Cambridge men in our profession is so small as yet. At present, at any rate, the possession of a degree is a distinction of no small lustre among us. For the bar and the medical profession an university career is considered almost an essential, yet the learning, knowledge of the world, good connections, and polished bearing, acquired at an university are quite as telling advantages in an architect's favour, and to the full as needful to him as to the physician or the barrister.

The absence of anything like an artistic education from our public schools and colleges is no doubt a main reason why architecture as a profession has fewer attractions for university men than other callings. But there may be other reasons. The entrance to practice is not guarded yet, though the time is coming when it will be, by an official examination; its highest prizes are nothing approaching what are obtained at the bar; and perhaps our average incomes are not so high, and our social status less indubitable, than in some other professions. Still in most of these respects a rapid and notable improvement is on foot; and let us mark that the more studious and accomplished each of you becomes, the more will he advance that movement; while the delightful nature of much of our work, and the cordiality subsisting among the members of the profession, render it one of the most attractive a man of culture and education can choose.

Lastly, the circumstances under which men ordinarily obtain practice are such as to make it no real loss of time to devote the requisite years, after leaving school, to an university education; or some similar course of scholarly and gentlemanly training, in fact, if he be also an artist. I believe that, within anything like reasonable limits, the later a young man enters our profession (supposing his time to have been well spent previously), the better will be his chance of success. If he enter an office at sixteen he will, it is true, be fit to receive a salary as a clerk three years earlier than if he entered at nineteen; and this is in many cases so important an object that there is nothing to be said against it; but I believe that of two men, the one entering at sixteen and the other at nineteen, having well spent the intervening three years, the latter would be likely to be the most forward by the time they were both thirty or thirty-five.

Where an university education is not attainable, a good classical, mathematical, and general education, the best possible, is most desirable, and in this no special branches of study need be singled out. I want the young student to be generally cultured and instructed, and if he be so, history, the mathematics, and modern languages, which are all technically desirable, almost essential for him, will be among his acquirements.

Of special culture, the chief, perhaps the only points to be insisted on are *drawing*—not architectural, but of the figure and landscape—and general culture of taste for and knowledge of the fine arts. This I should like to see carried very much further than is ordinarily attempted, before a student begins his life as an architectural pupil; and I believe that in many cases a youth who has left school in order to become an architect would gain time by devoting the whole of one year to nothing but drawing, under good instruction, except so much time as was requisite simply to keep up his other attainments, in place of going at once into an office. It would not be too much to expect that a student should be able to draw the figure well from the round, well enough for example to procure admission to the Antique School of the Royal Academy, and should be able to sketch landscape subjects from nature in water-colours with freedom and finish: ornament, and mechanical drawing, and perhaps perspective, I think he had better not study till he begins as an architect, but in the figure and landscape, and let me add modelling, if practicable, it is hardly possible to do too much or to fix too high a standard. To this a general acquaintance with the fine arts of painting, sculpture, and music, ought to be joined; and the earlier both drawing and general art are begun the better. If a man has been during many years educated, and is highly cultured in literature solely, it seems unlikely, and I believe in fact rarely happens, that the fine arts will take a strong hold upon his mind; and of course, of the two, a man who has artistic feeling and power, with even very restricted general culture, will succeed better as an architect than one highly cultivated in other matters, but deficient in artistic skill. I could point to instances of both classes of men in abundance; and therefore I say unhesitatingly, let us have the highest, best, and most extensive culture we can, only along with it a sufficient amount of art-culture, and extended over a long enough period of years to preponderate over everything else, making the man an artistic scholar—not a scholar merely.

The majority of young men do not enter the profession with such advantages fully developed—and to such I have only to say, that they are not therefore to despair. They enter, it is true, at a disadvantage, but by resolute well-directed effort this disadvantage may be overcome, although it is true that scholarship and draughtsmanship may be ordinarily most conveniently and completely acquired *before* begining the career of a pupil. There is nothing really to prevent anyone from gaining all the attainments I have named during the time of his architectural studies if he be so minded, or from supplementing, to a very great extent, his deficiencies; though I cannot deny that such a task will prove an arduous one. It is however greatly to be desired that, whatever these deficiencies may be, they should not be failings in draughtsmanship, or let me add, failings in gentlemanly breeding and bearing. The ranks of the architectural profession as it is now constituted, are no place for a youth who is clumsy or ignorant, either in his general dealings with men, or in his special dealings with the objects of his art; and if there be any failings in these two respects no pains should be spared to correct them.

A young man who enters an office for the first time, whether he finds himself the sole occupant of a lonely room, or the junior among a crowd of clerks, will find much that is novel in what surrounds him. Let him start with the conviction that everything which is new to him is something for him to learn, and I think he will have the best guide to his conduct in an office that anyone could give him; nay, I feel sure that, if I could but be certain that this rule would stick fast in your memories, I need hardly say one word more about office life. I will put it in the briefest way—*learn all that you find new*; and I will begin with the caution that getting accustomed to things is not what I mean by learning them. There may be some few things that one learns tolerably well by getting accustomed to them; but they are very, very few, and are none of them known intelligently. It is this in fact that I have chiefly to warn you against. At first there is such a multiplicity of unaccustomed things doing and passing before him that an office appears, to the new comer, a remarkable, often even an enjoyable change. But it usually happens that while one or two of these novelties are inquired into, mastered, and so to speak learned, the majority of them are simply acquiesced in, the pupil gets accustomed to them, perhaps he even bears a hand in them, and yet he never learns them; possibly, after the first blush of his curiosity has gone off, he never even so much as recognizes that there is anything to learn in the majority of them, till years after he comes to find that he is deficient in an elementary knowledge which he might, had he so pleased, have easily picked up while in his articles.

I could give a hundred instances of this, any one of which I am sure almost all of you would admit to be true. Take an example at random—you are told to work out a staircase on a plan and section, and that the risers are to be seven inches and the treads ten; with some contriving you do it, and the drawing is approved, and you go home well contented at having learned all about staircases and how to contrive them, when in truth, for the most part, you have only been getting accustomed to them. Why is the riser to be seven and the tread ten? Supposing there was not room for your staircase, how could you make it steeper; supposing you wanted a broader step, what sort of a riser would be right then; or, with a steeper riser, what tread would you require? Or again, your master comes, and says there is not headway—alters the plan, and leaves you to put it in ink. If you are seeking to learn, you will not rest till he tells you, or better still, till you find out what "headway" means, and what dimensions it requires. If you are merely stupidly getting accustomed to your work, you will quietly ink it in, as altered, without any intelligent understanding of what you are doing. Or suppose he alters the width, the pupil who wants to learn sets to work, his attention being awakened by this hint, to convince himself what is a handsome width for stairs and what not, he looks at the next three or four staircases he sees, takes measurements of them, and so learns for himself the proper width of stairs of a given class. Or if he is still desirous to learn, but not very thorough, he simply asks his master or a fellow-clerk, gets an explanation, forgets most of it, and in so far as he remembers it learns something of the subject. But if, as I said, he is not at all intent on learning, he simply inks in what is put before him, or accomplishes his other task with as little expenditure of thought as possible, and goes home at the end of the day no wiser than he was at the commencement.

There are a dozen other points in which a staircase might illustrate what I mean, but the truth is, that not a drawing goes through a pupil's hands, not a paper does he copy, not a letter does he endorse, hardly a message does he put down in the call-book, but if intelligent and observant he may learn something of his profession from it. Of course such technical things as complicated drawings will not give up all their treasures at once. A plan speaks to the veteran in a language of which the tyro is but picking up the letters and the spelling, but where all is so full of novelty, every person truly desirous to learn, whatever may be the degree of technical information to which he has advanced, may learn from it something.

You will gather perhaps from the spirit of the above remarks that in my opinion there are better ways of learning what one does not know than being told it. The truth is that the knowledge which we really find out for ourselves, it is which truly becomes incorporated with us, and really is an enduring possession; much of what we are told we forget, therefore, as far as you can do so, prefer to find things out; but in the numberless instances that will occur where finding out is not possible, without more information than you possess, ask some one who knows.

I would suggest as an excellent rule for any pupil entering an office, and desiring really to benefit by the opportunities it offers to him, that he shirk *no* part of the work. Some young gentlemen, because a premium was paid with them and they think themselves "swells," will not strain a sheet of paper, or print to a drawing, and will hardly speak to a stranger. Of these, and all other duties of the office, let me say that first, as a junior member of a little community, a new comer ought cheerfully to take such a share of them as falls to his lot, knowing well that if he is able to make himself properly proficient at higher things, the rudimentary work will very soon naturally drop off his back and descend to some one else. Secondly, that part of a thorough knowledge of architectural practice, is a personal acquaintance with every detail of office routine. And thirdly, that some of these are more useful than they seem, especially the seeing strangers who come on business, and putting down messages correctly. This work, which pupils are very apt to think derogatory to their dignity, is very good training, and often the only training that will come in your way for years in that most necessary accomplishment, the conduct of business interviews.

Conform to the regulations with respect to punctuality in attending, and if the customs of the office allow, as is the case in many offices, a certain amount of licence to pupils in respect of absence during the day, let me urge you seldom, if ever, to avail yourself of this permission, except for things which more or less directly bear on your studies—such as going to visit the museums, the galleries of pictures accessible, any works in hand within reach, and all the good buildings, ancient and modern, you can find.

By-and-by, little by little, the young architect will find the chaos shaping into something like order: he will begin to understand drawings, and buildings, and office work. At this stage common construction is the portion of the work which it seems to me invariably, or all but invariably, takes the principal share of the attention of young men in an office, supposing they have begun to use their instruments freely (for it takes many months to master this thoroughly, I think few men who have been less than two years in an office would ink in a set of drawings and leave all the straight lines straight and firm, and all the circles round). By common construction I mean the ordinary routine of putting a building together, how trimmers are managed, how arches are turned, how walls are plastered, and so forth. This is all well; master it all, but let me entreat you, at as early a date as you feel yourselves getting the rudiments of office work into your heads, to aim at the highest parts of your profession. As for construction, master all that is simple, but do not rest content with the simple work if anything unusual, difficult, large, or complicated is going on in the office. Do not consider that such work is for the senior clerks to do all by themselves, but seek to be permitted to join in it. You may be unable to do any of the work, but try to make yourself master of the principles, check the calculations and understand the contrivances. One difficult thing so mastered is worth, and in fact will teach, many minor matters.

Make it a rule however, that whatever construction enters into your drawings done in the office you well understand it all, and put it down correctly. This will involve giving a certain amount of trouble to fellow-clerks or pupils, and may here and there introduce delay into things which you might wish otherwise to hurry; but be obstinate if necessary, both with yourself and others, on this point, for without it the habit of shirking difficulties instead of mastering them will be formed, your work will be slip-shod instead of thorough, and your progress will be apparently perhaps rapid, yet in truth not real.

But mainly and chiefly set it before you as your principal object to learn all the art you can from the works in the office. From the first try that your very simplest drawings shall have something draughtsmanlike about them, and take every opportunity to get such artistic work to draw, or especially to ink in from others pencilling, or at least to trace, as you can secure. Do all the detail drawings anyone will let you do, and strain every nerve to do them well. If by-and-by some little work is entrusted to you to work out the drawings, and draft a specification for the principal's eye, let no pains be spared, no effort omitted, to make your work as good as it can be, and especially in as good taste.

Even art-work however, must not occupy all your time in an office; take a share in all the business that goes on, especially if there be a little practice in estimating to be had. Perhaps there may be land-surveying, perhaps levelling, perhaps surveys and estimates for dilapidations, perhaps some other subsidiary work in the office. If so, try to see enough of it to understand the principles on which it is done, and to get a general practical acquaintance with methods of procedure, so that if such work comes to you to do at any future time you may not feel quite strange to it.

One other and most improving occupation connected with office life I must specially pass on your notice. I mean visits to works in progress. If there is a good building, in fact, if there is any building being done by the architect whom you are with, within reach of the office, go to it as often as ever you can, and be all eyes and all ears when you are there. Make friends of the clerk of works, the builder's foreman, and some of the artificers of every trade, and ask all manner of questions, make all manner of investigations, remember all you can, sketch all the construction as it goes on, and put down in a memorandum book all the principal matters you learn. Watch narrowly the effect of any details, the drawings for which you may be familiar with in the office, as they are worked on the ground, and again as they are fixed in place. Get a notion of actual size—that is to say, try to understand what a foot in height or a foot projection will look like near the eye, twenty feet up, fifty feet up, and so forth; and strive if you can to know the building as an artistic work from beginning to end. Learn it also as a structure, find out which is good and which bad of the materials. Coax the mason to show you which is the bed-way of the stone, and the bricklayer how to bond each thickness of wall; watch the mixing the mortar, the throwing in the concrete, the various steps of the work, and keep notes and sketches; and above all things sketch, as it is going on, all construction that is to be covered up, and all contrivances that are unusual. After all, buildings are the right thing. Our profession is not that of makers of drawings, but makers of buildings, and it is on the scaffold that you will best learn the practice of your profession.

I do not think I need go further in order to show that a young man entering an office has (if there is any work going on in that office) abundant opportunities for learning and innumerable things to learn. He may feel oppressed at the total want of system in this mode of acquiring knowledge as compared with the way in which all school studies are systematised. I know this is to some trained scholars a painful difficulty, but to some extent it may be overcome by establishing for one's-self a system. Say you have three or four memorandum books. One for materials, one for construction, one for arrangement of buildings and art-work, and another for office-work, surveying, measuring, and estimates. Whenever you learn anything fresh make a short note of it with illustrative sketches, in whichever book it belongs to; and with a little practice and a little systematising, the contents of each book will accumulate enough to prove to you that you are mastering your subject in an orderly manner.

The student, whether he goes to work in this manner or not, will ordinarily have no director but himself, but he will have many helpers. His relations with his master will vary very much with the temperament of that individual and the degree to which he is occupied; but if he gets no attention, it is in nine cases out of ten his own fault mainly. It is seldom that a practising architect has it in his power to devote more than a few minutes at a time, at uncertain intervals, to any one pupil, and he cannot attempt to frame anything like a course of study for him; and many pupils are hardly aware that anything short of such a course can be with advantage given them. It is however no small privilege, if the office be at all a good one, to be introduced to the profession through it, to have the run of the office and the works in hand, and to be sure of remaining in a good office for a considerable time, and to be recognised as being there, not simply to do the work and be made use of, but to learn. The pupil, because he is a pupil, will find many a little piece of information placed at his disposal, which would not be so readily accorded to a clerk who might need it quite as much, if he will but look out for it among his seniors in the office and on the works. A pupil has however a right to more than this; he has a right to have his difficulties explained, his work made pleasant to him, his private reading and work aided; and for all these things he should from time to time address himself to his master, not taking the busiest moment of the day, or in some other clumsy manner making his application inopportune, but doing the thing with judgment and propriety; and if it be clear that he is really desirous to understand his profession, it will give his master great satisfaction to aid him. It would be specially gratifying sometimes to know what sort of work a youth would enjoy to have put in his hands, and above all things to know that opportunities of any kind either for getting good work in the office or for seeing buildings would be prized. Pupils have undoubtedly a right to any reasonable privilege or assistance which they feel would aid them in any way; and I strongly urge those of you who are pupils, and who feel that either there is something you cannot get on with, or something you want to do, to make a friend of your master in the matter.

There are however numberless points on which you can learn better and more appropriately from your companions in the office, from the foremen or workmen on the buildings, or from friends in such a society as this, than from your master. Lay them all under contribution, and strive early to ascertain what kind of knowledge you can get from each. Make sufficient notes of most of the things you learn, marking the sources from which you derived your information, and the dates, and keep these notes in as orderly and accessible a form as you can.

Thus much for office life in its earlier stages. Pupils are now mostly articled for short terms, such as three or four years. I think, if it is a good office, that a youth may remain, as he generally has an opportunity of doing if he likes, a year or two in the same office with advantage after the expiry of such a term; but it will be of great advantage after from four to six, or at most seven years, to change, and spend a little time in each of two or three other good offices, so as to become accustomed to diversities of system and management, and to see different styles of work, before attempting to practice.

The points which in an office, and from the work going on under his eye, a youth may be expected to learn *thoroughly*, are I think, these:—the entire routine of an office, and its drawings, documents, and books; the entire system of preparing drawings for buildings, from the first sketch to the last detail; the mode of representing on a drawing or a set of drawings, such as could be worked from, any thing of any sort whatever that can be built; the preparation of specifications. The things of which he may be expected to learn the greater part, and more or less completely, are perspective, and colouring; the conduct of business correspondence and interviews; the preparation of reports on buildings; the superintendence of buildings in progress, and the regulating the accounts; the preparation of estimates, rough, and in detail; measuring and valuing work; dilapidations; surveys of other sorts; land agency business; land surveying, levelling, and other sorts of special work.

In the office alone, however, but a very incomplete education can be obtained; even so simple and necessary an accomplishment as perspective, for example, cannot always be picked up there—much less any complete scheme of the art and science of architecture. What supplementary aids then can we call in to our help? In London we have more public facilities than the country presents, and I will try briefly to enumerate the principal of these facilities. First of all, in too many cases, a youth enters an architect's office, not altogether without a turn for drawing, but seriously deficient in the cultivation of his talents. As this is the most serious of all deficiencies under which he can labour, I cannot but think that to it his first attention should be devoted, and if he spends all or most of his evenings for six months, and three evenings a week for six months more, at a good evening drawing-school, learning to draw the figure, he will never regret it. Landscape is only one degree less important to him, and any leisure which the other study leaves will be well spent over landscape drawing.

I am almost inclined also to suggest, if he have the misfortune to be deficient in his knowledge of French, that working at an evening French class will be desirable. The best architectural works are French, and the best travelling language is French—and as I want all students to read much and travel far, there seems to be here two very good reasons for cultivating this language, if it have been neglected.

The next matter to be attended to is the desirability of obtaining a good systematic acquaintance with the history and the general forms of past styles of architecture, and the theory and practice of construction. Fortunately, we have had for many years in London excellent courses of lectures on these subjects from a most learned and accomplished professor, whose perfect knowledge of his subject was only equalled by his ability to teach it—need I name Prof. Donaldson?—and no less fortunately is it that, now that he has withdrawn from the chair, perhaps the best qualified man who was available of the whole profession has succeeded to it. All students should attend Prof. Hayter Lewis's courses of Lectures at London University College. To these they will require to devote two evenings a week for the winter months of two years, and no inconsiderable additional portion of leisure beside. These lectures will be most advantageously attended after one or more years have passed in an office, and should hardly

I think, be commenced quite at the beginning of pupilage. Another course of lectures, on the Arts of Construction, is also delivered annually, at King's College. Of the ability of the professor, our well-known friend, Prof. Kerr, I need not say a word; and I should heartily recommend that these be also attended. In the days of Prof. Hosking it was generally supposed that this course was not intended for architectural pupils, so much as for those who were to be military or civil engineers, but I feel sure that in the present professor's hands the course will be of advantage to any or all of us who can attend.

At this Association students will find opportunities of self-improvement, such as will be of essential service. The most important features to men of two or three, or four years' standing will be, I take it, our old established Class of Design, with perhaps our more recent Voluntary Examination Class and Life School. The meetings and papers will also become thoroughly interesting the better they are known, though many of them will from the first be liked. But the Class of Design is the institution that I most cordially recommend the young pupil to enter as soon as he has got a smattering of the rudiments of his art. It will do much for him that no other society can, and above all things it will fix his aims upon that artistic part of his profession which I am so anxious he should keep prominently before his mind. Our life-class will give him an excellent opportunity of keeping up and improving his draughtsmanship; and our Voluntary Examination class will give him a very thorough insight into some practical points, and at least an acquaintance with many others. This class might with propriety be called the Class of Construction and Practice, as distinguished from the Class of Design; and if you will only join it in numbers sufficient when it starts next session, very shortly to commence, you will find yourselves well repaid. It is one of the most valuable and pleasant features of the good old Architectural Association, that here a student makes friends. Few are so constituted that they can do without some companionship in their work, and here many friendships have been begun which have proved of great advantage during studentship, and of permanent value through afterlife. Let me then cordially invite, and sincerely advise, any who may be present to-night only as visitors, to join us without delay, if it be only for the sake of securing companionship in study.

The next public institution deserving notice is the Royal Academy. The advantages offered to students are not great, but they are by no means contemptible, and they are entirely without fee. They include the use of an excellent library; lectures (those on architecture, when any are given, being uniformly valuable), a course of instruction in perspective, which those who have attended it speak of as excellent; admission to the exhibition of paintings; the opportunity of competing for medals, and ultimately the possibility of obtaining a travelling studentship. The chief advantage, however, to the young student, I hold to be the stimulus of making a design for the purpose of obtaining admission; and this I know to be so valuable, that, while I would not wish any to try whose draughtsmanship and powers of design are not sufficiently matured to give a fair chance of success (for it is always unwise to court disappointment, however willing we may be to bear it bravely when it meets us fairly); I think every pupil who enters an office should make the Academy part of his programme. The period for trying will vary much with the student's proficiency; his third or fourth year ought ordinarily to see him advanced enough to command admission.

Occasional courses of lectures on such subjects as chemistry, mineralogy, geology, artistic anatomy, and other kindred subjects are given at the King's College, at the School of Mines in Jermyn-street, and at South Kensington. Some of these are very valuable.

The last public body I have to notice is the Institute. That body has students, who pay a small fee and have certain privileges. These I think are not sufficiently appreciated, and I should be glad to know that more gentlemen of this Association availed themselves of them. Independent of this however, the Institute has done what ought to be of the greatest service to students, in putting into their hands a compendium of the books and subjects they are likely to gain good from—in publishing a specimen examination paper, to show what sort of acquirements they consider a proficient student ought to have made, and what further acquirements ought to be possessed by one who should be admitted to be distinguished; and above all, in holding the Voluntary Architectural Examinations, to afford students an opportunity of satisfying themselves that they have made good use of their opportunities, and of declaring to the world their attainments. This examination ought to be in the mind and before the eyes of everyone as a thing to be prepared for and gone through. It would have been of the greatest possible service to the present speaker had such an examination existed when he entered the profession as a pupil, and had such a list of books and sketch of examination paper been put into his hands.

The curriculum held out to me by my first master, a well-known practitioner of the old school, not now living, was a simple one: the Office—the Royal Academy—Italy. They were all good as far as they went; but a little guidance in some other respects, from some source or other, would have been of immense help. This guidance is now in many ways available, and I shall hold it a proof that young men at the present day are far more averse to hard work than architects ought to be, if in the course of a few years the examinations are not attended by large numbers of students.

Among public aids to study, I must mention libraries and museums. The best library for your purpose is the library of the Institute, accessible to you—either as associates, students, or temporary students. A fairly good one is that of the Royal Academy, accessible to students of that body. A very good one exists at South Kensington, accessible on the payment of a very moderate fee. All these are open on certain evenings as well as in the day. The British Museum library is for some purposes unsurpassed, but almost too unmanageably large for an ordinary student. It is open only in the day, by reading ticket, obtainable on the recommendation of any known professional or reading man. The library of the Commissioners of Patents—open perfectly free, but only in the day—includes many architectural books. At Sir John Soane's Museum there is an architectural library, but of its value I am not able to speak; and lastly, the library of the Architectural Association, if not extensive, and lacking many very necessary books, excels all others at least in its system—for it is a lending library—the only one, therefore, from which the student can get help in his work at home.

Of museums, the Architectural Museum at South Kensington together with the immense art collections availablethere, is by, far the best. The best collection of architectural *casts* accessible is however, I think, at the Crystal Palace. The British Museum has many good objects of art—especially in sculpture. For the general study of the arts, South Kensington and the National Gallery present excellent and constantly increasing means; and the various private collections in London, if you can gain access to them, or if you can see their riches in the loan-museums formed occasionally, are among the richest in the world. Finally, the different annual exhibitions, not forgetting the Architectural Exhibition, are all of them to be prized as means of artistic culture.

We have now considered office opportunities and such public facilities for study as London offers. It remains that we consider what the young architect may do with his own time, in his own room, or on his sketching tours, in order to fit himself for those branches of his professional practice the necessary knowledge of or skill in which is not to be obtained at the office or from public lectures. In order to make the best use of his time a student should systematically economise it; he must be as systematic as he can, as constant as he can, and as regular as he can; he must not pore too much over one thing, but on the other hand he must avoid distracting his attention among too many studies at once, or in other words, having too many irons in the fire. Above all, he must not work too long, especially at night: health and eyesight will ultimately suffer, and he manages matters very injudiciously who finds that when he has completed his studies he has rendered himself unable to put them to any practical use. I never however heard of morning work doing anyone much harm, and if any of you are energetic enough to rise betimes to study and draw, I believe you will never regret doing so.

There is a great deal to be learned that cannot be learned in an office. I have already referred you to courses of lectures as a most valuable means of acquiring much of this knowledge, but some cannot attend such courses, and those who can require to know many things for which it would be idle to depend upon them solely or mainly. The student must therefore make up his mind to devote a large portion of his leisure time for many years to various studies and pursuits requisite for his purpose.

I believe many minds are embarrassed, in the prospect of attempting so large and various a mass of acquirements, by the apparent intricacy as much as, perhaps more than they are overwhelmed by the amount of the work to be done. They cannot tell where to begin, and what to be at first, and they possibly yield to a kind of despair, oppressed by a difficulty to which they have failed to find the clue. Now it often really happens that, though the field be very vast, the part of it actually open to a student is but moderate. If so, his duty is very clearly to occupy what lies before him; for example, suppose he has but few buildings available, but has access to one church of good original workmanship, and has time to make some careful studies, but the style is Perpendicular, while he understands that twelfth and thirteenth century work was the finest. What of that? Perpendicular is, among the things to be known, studied, and drawn, and if he masters it now he will be all the more at leisure to study Early Pointed examples when he meets with them. Or as to books, he has only a few, and they not the most modern. Master them nevertheless, for though modern observation has extended our field, it has left the bulk of what was already known unchanged. In architecture, whether you consider history, science, art, or material, you cannot establish in any a proper and unchangeable sequence of things. You may either begin, if the history for example is your study, with the practice of the present day and our own country, and work back; or you may begin the history in the middle, and work downwards, and upwards, and sideways; or you may begin at the commencement of all time, and follow as best you may the stream of events. Either plan has its advantages. Similarly, you may with equal readiness commence the art by that of a foreign country and come homewards from that starting-post, or begin at home and spread outwards.

I think then it is sound advice to say, that if anything within the range of your proper studies offers itself, either through your happening to possess peculiar facilities for its study or through its presenting itself to your mind as desirable, seize it, and begin by it. Knowledge gathers like a snowball, from a very small nucleus, and will gather pretty nearly as well upon any genuine nucleus; indeed, nothing is more surprising than the way in which, when any part of a subject is thoroughly well known, other things range themselves before and behind it, and attach themselves to it. For example, to recur to the instance I have already suggested, the opportunity of studying one ancient church. The man who has really and completely done this has made a vast stride towards the study of the whole of English church architecture. You cannot know the characteristic mouldings of one jamb or one mullion, without gaining some insight into the principles upon which all mouldings are designed. You cannot become familiar with those points which are specially marks of date, without learning something of how what preceded and what followed was treated; and you could not understand one bay of a vault or one tracery window without finding that you had gone through the worst part of the difficulty of studying all vaulting and all tracery. Whenever at a loss then to decide what to begin with, remember that to begin with what is most within reach, is ordinarily not only easiest but wisest.

There may however be those who, having fairly the opportunity of selection—a good library available, a good set of photographs or casts or engravings at command, or in some other way a means of choice at hand—cannot exactly be said to have any one thing offering itself to their notice more prominently than another, and are forced to make a selection and to form something of a plan of study for themselves. In this case it can hardly admit of doubt that the wisest thing is to begin with some portion of the highest and best part of the profession—the art. Always put the art first, and let even such all-important studies as the history of architecture, be subsidiary to the knowledge of the actual artistic and structural forms, and the power of drawing them, and of designing and grouping similar forms. But where in the large extent of varied periods and styles of architecture should the study of the art be begun? If possible, I think, with the architecture of one of the best periods; if one can be found free from great complication and extreme elaboration. As therefore the earliest phase of Christian art in Europe unites all these characteristics, and is moreover, pretty fully illustrated in the best hand books, especially the French ones, and in many photographs, I should be disposed to say decidedly, begin the art by making yourself familiar with the forms and general aspect of what is termed Romanesque architecture. This architecture, especially the French variety of it, is very beautiful, yet very simple; ascending from it you go back in a clear course to the art of Rome, Greece, Egypt; and descending you come down through all the varied styles of Christian art to the present day. Study it chiefly with the pencil, and as far as you can from existing examples and plaster casts, when these fail, from photographs, engravings, and books. After you have got to know the English Norman, and how far it differed from the cotemporary and earlier work of France and of Italy, and have drawn some of the most interesting features, such as doors, west fronts, cloisters, you will find an inexhaustible mine of wealth in the enrichments, especially the capitals, of which good casts are very easily obtainable; and I really think that if you take my advice in this particular, and master the Romanesque work of Europe, from the earliest churches of Rome or Ravenna to the transition of Norman into Early English, that you will not need any further advice as to progress so far as the later styles are concerned. In picking out your examples from the various books you will have learnt half of what they have to tell as to the later developments of Christian art, and your course downwards will be easy enough.

I should like however strongly to urge the desirability of going backward as well as downward, and learning what was that Roman architecture from which sprang the Romanesque, and learning to know and to venerate that refined and yet vigorous Greek art from which sprang most of whatever we have that is good. Study also the development of Roman into Renaissance, and learn to know something of the meaning of an "order," a "module," and the other formulæ of the Italian masters, and this equally whether you have entire sympathy with it or not. It is disgraceful for a man who professes to decide against a school of art to know just nothing about it.

The leading study of all these things should be drawing them, trying to draw things like them of your own design, and reading and making notes about them, but mostly drawing. Notice how they were put together (or construction), as well as how they were shaped and combined to satisfy the eye (or design). Early commence to try making designs, and if you adopt my advice, and begin your study of architectural forms with the art of one period, as for example French Romanesque, and confine your study for many weeks or months to that, you will of course during the same period do well to design also only in the same style.

I think the arrangement and mode of constructing our Class of Design, make it a capital opportunity for a young man of cultivating the very necessary art of designing. I believe it quite worth any student's while to join the Association for this class only, and I very strongly urge it upon the attention of you all; adding to my hearty recommendations that you should join it, the one caution that you should in working out its subjects embrace every opportunity of showing the plans and some of the details as well as the general outline of your design, not contenting yourselves with a showy sketch, but working it more or less as though the drawing were to be built from.

The competition for the various prizes offered by this Association, the Institute, and the Royal Academy, will from time to time offer you opportunities of trying your strength with the advantage of a stimulus to your exertions in the shape of a prize. I cordially recommend you to try them, and when more advanced I believe you will find it, as I said more at length in my paper "on Entering Practice," a highly advantageous mode of study to compete for actual buildings. All these competitions give you an opportunity of exercising yourself in the arrangement and adaptation of your building to its requirements and intended uses, an art not to be picked up just at once, but requiring to be gained by repeated efforts.

Just as I have advised you to proceed in learning the elements of architecture as a fine art, I would advise you to some extent to learn it as a constructive art. If from any accidental circumstance any special material or any special branch of construction offers itself to your notice or attracts your attention, seize it, and pursue it as far as you can. If nothing of the kind occurs there, take one branch and master its elements, and afterwards take up another. I am inclined to recommend carpentry as a good branch to begin with, next bricklaying and masonry, then joinery, and then iron construction. But you ought, as far at least as the rudiments go, to be learning the first rudiments of all these arts, except perhaps iron-work, pretty much at the same time, from your office work and your visits to buildings; and I do not think you can go wrong in considering all these arts under the general head of construction, and regarding them as one study, so far as your ordinary office and building observation (taking Dobson's Art of Building as your hand-book) will carry you. This mu t be going on at the same time as the rudimentary study of the art, and the cultivation of draughtsmanship. The subsequent systematic pursuit of the less elementary portions of the different constructive arts which I have named, taken up one by one, ought to go on at the same time as your designing and your more advanced art studies. Before we can advance at all in architecture as a fine art, we require to know at least something of building as a technical art, and before we advance far, we require to know much of it, for all true architectural art is the out-growth of sound construction, and stands to it in something the same relation that poetry holds towards prose, or painting towards descriptive geometry; and though the simpler features and forms of architecture, such as doors, windows, columns, and arches, can be understood and mastered without any profound constructive knowledge; the case is different as you go on and begin to learn, or to try to design entire buildings, or the more complicated parts of them, such as vaults and roofs. You will find that you require to understand these before you can observe, measure, or draw them with advantage; and above all, before you can design them so that they look well, or would be likely not to fall down if they were built.

This part of your studies will be very much advanced if you spend some time at the joiners' bench or the masons' banker, or if you take the post of clerk of works on a good building. The objection to entering a workshop, unless you know all about the place you are going to, is that you are liable to hear bad language and see bad conduct. This risk is run everywhere to some extent, but it is most undesirable for a very young man to be more exposed to it than necessary; so that special care should be taken to know what the habits of the men are among whom a youth is placed before he be sent into a workshop, but I believe it to be most beneficial, and to promote a more thorough knowledge of the minutiæ of construction than any other process. When you make a thing with your own hands, you can hardly fail to understand it.

Employment as a clerk of works would be, I think, readily obtained by most skilful well-trained office hands of some years' standing if it were sought. The duties afford an admirable opportunity of learning both how a building is constructed from first to last, and how an architect ought to conduct his business. Every weak point in the plans and specification becomes known to the clerk of works—every unexpected occurrence of whatever nature on the works comes under his notice; and if any of you on my recommendation or otherwise get a twelvemonth's occupation as clerk of works on a good building, I will engage to say that at the end of the time you will feel as if you had never learned so much in the same space of time before. I may also fairly say that, if such engagements are useful to yourselves, I should fully expect them to prove on the whole more useful to your employers than the employment of average clerks of works, judging, however, in this expectation rather perhaps from what I hear, than from my own experience.

After the two broad and very comprehensive subjects of the leading forms (and principles of composition) of the main European styles of architecture, or most of them, and of materials and construction, there come a large number of other subjects, of which it is desirable to know some; but of which few (if any) know all. I am not now going even to attempt a complete enumeration of them. You will find most of them enumerated or referred to in the Institute programme of examination and list of books; and as a general rule, I may say broadly that any knowledge you can get on any of these subjects is desirable; and that some of them are indispensable.

Of the indispensable subjects, I may briefly enumerate warming and ventilation, drainage, and some outline of the laws relating to contracts and to buildings. As examples of less essential though most highly desirable acquirements, I may cite mineralogy, geology, chemistry, the laws of light and sound, heraldry, botany, and mechanics.

As examples of the other studies or arts bearing on the fine-art part of the profession, I may name as essential the principles and something of the practice of decorative colouring, and the chronology of architecture, which is indeed the history in minute detail, and which, as far as English Architecture is concerned, you will learn best by gaining a very intimate acquaintance with all the details and all the dates of a few good buildings extending over a long period of time. Other acquirements are the art of modelling or carving, special acquaintance with stained glass, metal work, jewellers' work, enamel work, mosaic and other inlaid work, landscape gardening, etching, lithography, antiquarian research, and such special branches of it (as for example ecclesiology) as bear upon buildings, or decorative art. An excellent statement of the nature and claims of all these branches of art may be found in Mr. Scott's paper which he read before us two years ago, and in one which, a short time previous to that, he had read at the Architectural Museum.

In these studies, in fact in all the studies I have urged on your notice, great help is to be got from good books. A few of the best books of reference ought to be part of your earliest acquisitions. The Institute list supplies the names of most of the most useful ones, but its list makes a much larger library than you will be able for many years to hope to acquire, or would indeed need to possess. Gwilt's Dictionary is one of the most universally useful books we have; Dobson's Art of Building, and a few others of Weale's Handbooks enumerated in the Institute list, are desirable and not expensive. Next to these I should place (if you read French) Viollet-le-Duc's 'Dictionnaire;' or, if that be too costly, De Caumont's 'Abécedaire.' Rickman, 'The Glossary,' Paley's Mouldings, and some of Pugin's books are among the best known handbooks for English Gothic; and the best guide that I know as to how to study English Gothic buildings is Sharpe's 'Parallels;' Nesfield's book, and Shaw's, are good examples of draughtsmanship, but very far inferior to Sharpe in analysis and arrangement.

For Classic styles, Chambers, and a compact edition of Stewart and Revett's Athens, are good to start with, and to these you can add some of the best French and Italian books as you go on.

As you go on of course many authorities and books of all sorts will have to be consulted. I have merely named the above, that you may have some idea of what to turn to first; but besides books of reference and books of engravings, you will find it interesting to peruse some of those works which treat of our art, or of portions of it, in a critical manner, histories, biographies, and general works on art. As examples I will cite the historical articles in Viollet-le-Duc's Dictionary; Mr. Pettit's books; Mr. Ferguson's Handbook, and other works; Street's 'Brick and Marble Architecture;' Scott's 'Westminster Abbey,' and his 'Domestic Architecture;' above all the early portions of Ruskin's 'Stones of Venice,' together with, for more miscellaneous reading, the best of Ruskin's other works, Sir Joshua Reynolds' 'Discourses;' Cellini's 'Autobiography;' Roscoe's 'Lorenzo di Medici.' All these, as soon as you have acquired some facts and want to know more, will be read with pleasure and profit. But mark me, till you find they give you pleasure these books will yield very little profit, and had better be left unread.

For purposes of study, I doubt if photographs are so useful as moderately good engravings. They are it is true wonderfully faithful, but their effects can only be approached by a draughtsmanship more finished than most students can boast; and I believe studies from prints and plaster casts will oftener be found instructive, partly owing to their being less disheartening to make, and partly owing to their being selected subjects, which in the case of prints are given in the shape of studies, and in the case of casts are in the most advantageous state for being studied. But photographs will serve better than most things, the very important purpose of assisting the student to surround himself with good architectural forms. I hold it of the greatest importance that there should be some beautiful objects about in your room, upon which your eye may daily fall and constantly rest, so as to correct some of the deadened perception of beauty and vitiated taste which we cannot hope wholly to escape, living as we do in a city replete with the base and the hideous, and in an age when almost every common article of furniture, of dress, and worst of all, of ornament, is either utterly worthless, or far worse than worthless. A few good photographs, two or three good casts, and some bits of good Japanese, Chinese, or Indian colouring, in papering or screens, or a bit of carpet, need not cost much, and they may save your eyes and your taste from ruin.

Let no scheme of study be so arranged and prosecuted as to become a weariness and to excite disgust. You can hardly become tired of drawing if you only select good subjects; nor can you well draw too much. But of most other sorts of work you *can* do too much; beware, therefore, of this, and be especially careful to include in your reading those books which interest the reader, which enlarge and elevate his view, and which are written with enthusiasm.

If, however, all this be pursued with diligence and success in your own rooms, or in libraries, or by the help of lectures, there remains to urge upon you yet one more thing, without which your book-learning will lose half its effect. I mean the study of *buildings themselves*. You must draw from entire buildings, and you must draw from separate portions of buildings, if you are ever to make good buildings yourselves.

London presents few fine subjects for such study, but still enough to be of the greatest value. Of the style which I recommend you to begin with, there are very few examples here, but in the chapel in the White Tower we have one of the purest and simplest specimens of Romanesque work that England contains. A few fragments may be found at Westminster, and a little good work by going as far as Rochester, but there are excellent casts at South Kensington and Sydenham. Of all the succeeding styles, however, Westminster Abbey presents examples of the highest value; nor is St. Saviour's, Southwark, to be overlooked. Leave to draw in the Abbey is easily got, and in the summer mouths leisure to go there will usually be readily granted by any master *to any pupil found making good use of it*. Avail yourselves of this privilege to the utmost, and transfer a large part of the Abbey, especially of its interior, to your sketch-books. Of Italian work we have some excellent modern examples in the Pall-mall club-houses, and earlier ones, but with less accurate detail, in St Paul's, and Wren's churches.

Of Greek and Roman and Oriental architecture we have no specimens visible, except some fragments of architecture, and many noble works of sculpture, in the British Museum; but both of these and of other styles we have the most extensive, complete, and classified series of casts which the world ever saw, in the Crystal Palace. It is an excellent place to see and to sketch in. Leave to draw there is readily obtainable, and it appears to me extraordinary that so few persons avail themselves of so complete a series of architectural examples. The Architectural Museum casts are readily accessible, and among them you will find much to work from. But at once the pleasantest and the most useful mode of studying buildings, is to join some friend, if a little more experienced in such matters than yourself so much the better, in an architectural walking tour, and to spend your summer holiday in that manner, or, if it suits you better, to go alone. No more pleasant way exists of blending recreation and improvement, and nothing can do so much to keep alive and increase your own interests in your profession, and to waken in you that enthusiasm for it, without which you cannot hope to reach the highest eminence in it, as this mode of study.

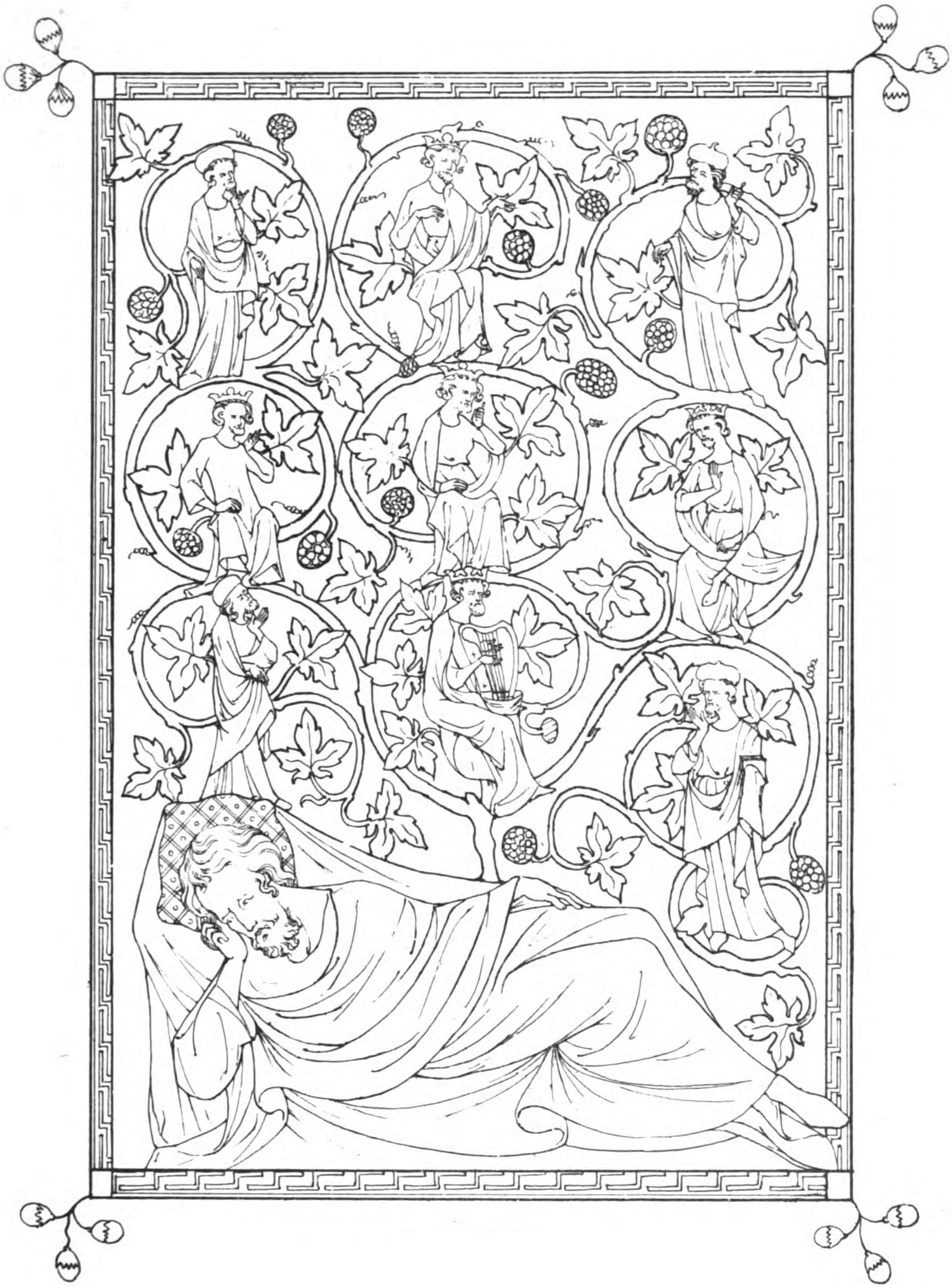
At some period, probably after not less than four years—and it may be after a great many more—the student should make a long journey, principally on the Continent. This is happily a tolerably well-recognised custom. It is one which cannot be safely omitted. I do not think it necessary here to spend much time upon indicating routes and places to visit, only let me urge that plenty of time be given to Italy, not only for architecture, but because there you are are more thoroughly steeped in an atmosphere of fine art of all kinds than elsewhere. For Gothic work France far exceeds Italy in value to the student, but the time in Italy will be felt to have been of greater value, in making him an accomplished student of art in all its branches. If possible, some time should be given to Greece and Egypt, and Asia Minor.

Perhaps I ought to say something here about *how* to study a building, and first let me say, that if you can approach it with some previous knowledge of what you are to find in it, you will gain more from it than if you come to it quite a stranger, and if this is not practicable, the assistance of a skilled observer, familiar with the building, and who will draw your attention to its remarkable points, will help you very much in your observation of it. The sort of sketches you should take will be determined to some extent by the nature of the buildings. Some are more appropriately used as studies of detail or ornament; others, and these the best, are also as useful, as teaching general design. These last you can often best study by first making a rough plan, if there be any peculiarities of plan, and then one or more sketches in perspective of interior or exterior, or both. But I am disposed to recommend beginners to make the principal part of their sketches, for some time to come, *geometrical*, and not in perspective. This mode has the following recommendations—it is the mode of working to which they are most accustomed, it produces very practically useful drawings, and, most important of all, it cannot be done without the student's devoting some amount of thought to the work. I should therefore recommend the attempt, especially with moderate sized portions of buildings, to reduce them back—in studying them—to the same drawings which you may suppose would have been needed to be made for the original construction of them. Take for example an east-end of a chuch, studied from outside, the sketcher having a block, a two-foot rule, a small T square, and a bow pencil. I should first roughly measure or pace out the width, and, then retiring a little away, carefully compare the width and height, aiding myself by holding my two-foot rule at arm's-length, alternately horizontal, as parallel to the building as I could get it, and vertical, hanging perpendicularly. This tells approximately what height and width I have to provide for, and consequently, to what scale I must work in order to get it all in on my sheet of paper. I should then measure and draw to scale with as much care as was requisite the plan of my east end, putting it at the bottom of the paper. Then I should rule up the vertical lines, and, as far as I could reach them, measure the heights. Whenever I could, above the points to which I could reach, I should ascertain additional heights by any such means as counting courses of bricks, or (if there be such) counting uniform courses of stone, or by measuring the height of quarries, or the distance apart of saddle-bars in windows, and calculating the dimensions by the number of repeats. In this manner you will get up some way; for the remainder a trained eye, and the careful use of your two-foot rule hung up at arm's-length, as a scale by which to compare ascertained dimensions with those not measurable, will give you all your heights to within a very few inches. I should turn in the curves, should try to add a section by the side of the elevation, and should afterwards proceed to draw very carefully, as separate studies, the profiles of the mouldings, sections of mullions and tracery-bars, and caps and bases; and in fact, as many details as time allowed, or as there seemed need for, whenever possible, getting up to the mouldings with ladders, &c. I am persuaded that this plan pursued for some time will help the student thoroughly to understand the buildings he has to draw in the early stages of his out-door studies, and also thoroughly to understand the nature of geometrical drawing.

As proficiency advances, you will feel more and more able, and more and more inclined, to draw in perspective, and this is the mode of study most natural and most pleasant to the advanced student; but you should always bear in mind that it is more possible to miss the peculiarities which give rise to an architectural effect, when you are working in perspective, and drawing the effect itself as you see it, without being obliged to satisfy yourself as to how it was produced, than when you are studying in the analytical method I have just described. In perspective work you will find a camera lucida very useful. Occasionally a finished outline of a very difficult subject may be completed under it, often, perhaps usually, its use will best be confined to the first quarter of an hour; in which time you can mark lightly the position of every object on the paper, and rough in the shapes and relative sizes, completing your work by eye alone.

Details of ornament should be sketched as large, and with as careful an attention to peculiarities of character as possible. Profiles of mouldings should be carefully, very carefully studied, accurate profiles full size being obtained when possible by one or other of the modes recommended by Paley in his 'Manual of Gothic Mouldings', and the student, when he does not work full size, should if possible ascertain the dimensions of the mouldings and figure them, and make a memorandum on the sketch of how many feet above the ground level such mouldings are placed. He should also observe the effect, the light and shadow, the air of breadth or of intricacy, of richness or of simplicity, of strength or of weakness, which each group of mouldings possesses, and should note, as far as he can find it out, what causes produce the effects he observes.

Lastly, structure, such as the jointing and coursing of masonry, the framing of joinery, &c. should be shown as far as it can be found out, and always shown with a scrupulous regard to accuracy, and, as a rule, these sketches should not be touched after leaving the building, so that they should form trustworthy memoranda for all future reference of what you saw while you were looking at the building. Structure, let me observe, may often be admirably studied in a ruin. You learn much from trying to find out why one part has stood while another has fallen; and you have a famous opportunity of seeing how the old men put their work together, when you see it coming to pieces under your eyes.



These studies will mostly be made in pencil, but, if the student can colour, he should make coloured sketches from nature along with his other work. If you acquire the habit of sketching standing, which is easily learned, it will save you, when working in a town, from much annoyance, for you are much less readily seen, and it being much more difficult to look over your shoulder, you are much less liable to be molested by the curious than when you sit down.

It is an advantageous plan also to make the attempt from time to time to describe a building in writing; this may fill up an evening sometimes on your tours. You should make such description exact and accurate, but at the same time somewhat picturesque, emulating such descriptions as those in the books of Street and Pettit. Such descriptions will be found unexpectedly, perhaps, to be of great value to you when you consult them in your journal. The making of them will be of great use at the time.

I ought perhaps to say something about measuring. I am not of opinion that the making hasty and perhaps inaccurate sketches and figuring them with careful dimensions is so useful, if that be all, as making a careful sketch either to scale or in perspective. But if you draw out the buildings as you measure them, then you get a more perfectly drawn authority than in any other way is obtainable, and you work the building more completely into your head than by any other plan. I would, therefore, only measure choice examples; and when they are measured take care not to neglect the working out the drawings.

I have now gone through the leading outlines of what can be learned in the office, what on the scaffold, what in the lecture room and your own study, and what in your sketching rambles. It only remains to add a very few concluding remarks. The first is, that if what I have enumerated seems formidable in amount, you must remember that it is the work of a life-time. You have not chosen a trade or a handicraft that can be learned in a few years, and then you have done with learning for the rest of your days; happily you have a profession where the oldest practitioner will find something new in science, something in art, something in practice, as long as his faculties retain their power. Don't always be looking at what yet remains to be done, or what seems beyond your reach, but concentrate your attention on what you are learning now, and what *is* within your reach. None ought better than an architect to understand the proverb, "Rome was not built in a day"—yet Rome *was* built, and so will your education be accomplished if some part of it is done daily.

If then you are fully occupied, and that with architectural work, feel content, make the best use of the work that is under your eye; and remember this, that *one* good building thoroughly understood—so that you feel you could design it all *de novo*, both as to arrangement, structure, and architecture, could write its specification, direct its erection, judge of all its materials, profile all it mouldings, measure all its extras and omissions, conduct all its correspondence, and, in short, make it, pull it to pieces, analyse it, do with it what you will,—one building thus completely mastered will go very far in making you an architect.

I feel that I must pause for a moment to inquire, Have I drawn too favourable a picture of the acquirements attainable under our present much decried system? I think not, and the best answer I can give is that very many skilful, educated, accomplished architects exist at the present time in England, who have learned all they know in the manner I have described to you, except only, that few of them have had the advantage of the lectures, the classes, the public libraries, and the Institute examinations. Yet of course a large number fail to profit—some of them, if there were a schoolmaster over them to hold their noses to the grindstone, would learn more and perhaps do better, but these are not the best class of men. The peculiar advantage of the English plan is, that it brings the student very early into contact with actual work, and throws him to a great extent on his own resources. These are just the circumstances under which a genuine English nature thrives best. At the time when one of you is preparing actual working drawings, and visiting actual buildings, and improving his leisure as seems best in his own eyes, a French or German student would be working exclusively on themes propounded purely as exercises, and arranging his studies as directed by his instructor. Each plan has its advantages, but I am quite sure that the English plans suits English natures the best, if they be but genuine hard-working ones.

I should, however, heartily welcome the prospect of such a school as Mr. Scott sketched out in that admirable paper he read to us, and as the Institute partially prepared to establish. In recommending to you our classes here, I feel that their work would be far better done with the larger means which such a school would bring to bear, while they would be as far from binding you in the trammels of an academy or of an *atelier*, as Prof. Kerr or Prof. Hayter Lewis's lectures are now; and I cannot forbear expressing my hope that the year of Mr. Beresford Hope's presidency of the Institute will be graced by the establishment of this much looked-for school of architectural art.

Meantime, let no one consider that he has any time to wait. Those who are waiting for the diploma before they offer themselves for examination, are not the men of our contemporaries who will hold it when it is given. Those who have come to the examination period, and gone in and passed, will get it. Those who wait for it will find their time otherwise occupied when the diploma is available. So with Mr. Scott's school, so with every other good that is to be. Seize the best advantage that lies before you, within your reach, under your hand. Come to *our* classes if those upstairs are not ready; follow what path is open, if the one you would like to pursue is not free to you. Above all, do not stint your labour. Avoid injury to health, eyesight, and vigour, but, securing enough leisure, enough recreation, and enough sleep, give all the rest of your time to the study of a profession which, whether you look at it as an art, a science, or a business, will well repay your zeal.

Looking on architecture as an art, the true pleasure felt by a real artist in his mastery of his work cannot be yours without long and patient study. Looking on it as a science, the security of all you do, the mastery over all your obstacles, nay, the possibility of faithfully doing your duty by the valuable property and the more valuable lives entrusted to your care in erecting buildings, is attainable only by study; and taking the humbler view of your profession as a calling in life, it is only after the most diligent study, and with the most careful attention, that you can hope so to carry it on as to uphold its dignity and your own reputation, and to conduct successfully the affairs it will impose upon you; and let me add that, however private connections may increase the chances of obtaining work which some of you will have, it is only the architect who is master of professional routine, of scientific construction, and of artistic design, who can turn those chances to account, and who will be able to gain honour and profit from his business.

As you sow you will reap; as you study now you will practise by-and-by; and I therefore earnestly urge the devotion of all your leisure and the exertion of all your energy in a pursuit well worthy the best efforts of all of us. More than all else, I would desire to fix your attention on the paramount importance of a thorough mastery of the pencil. I will give draughtsmanship any prominence which may be secured for it by recurring to it as I close this paper, and I will try to illustrate its value by reminding you of a well-known speech of Demosthenes, the great Athenian orator. Of him it is told, that one asked him what was the first essential of an orator, and he said Action; and what the second, Action; and what the third, still Action, was his reply. Just so, and in the same sense, I would say that the first essential of an architect is Drawing, and the second Drawing, and the third Drawing.

Reviews.

Illustrations of Old Testament History, from the Royal MS. 2 B. vii. British Museum. By N. H. J. Westlake and W. Purdue, Architects. London: Masters. Oxford: J. H. & J. Parker.

The above production of Messrs. Westlake and Purdue will be hailed with much interest and gratification by all concerned in the study of Mediæval art, or associated with re-introductions drawn therefrom, as placing within easy reach a very valuable and highly suggestive original source from whence to gather its proper spirit and to secure its characteristic sentiment and expression.

It is an especial desire, indeed necessity, of the present day, that reference should be had to such authorities as are here exhibited, and it is therefore unnecessary to enlarge upon the fact of how much good service he performs in the field of art who, in however small a degree, disseminates, or to use an ordinary phrase "popularises," the knowledge of the treasures we possess of this kind. Messrs. Westlake and Purdue are eminently entitled to thanks on this score, and not alone that their contribution is by no means a limited one—on the contrary, must have entailed an amount of labour and untiring perseverance which those only who have tilled on similar ground in like manner can form any just conception of—but that it is one also which especially heralds the proper direction for our thought and study, and points to the true and legitimate standards by which to hold and regulate our course.

Having premised so far, it may be necessary that we now take a more particular view of Messrs. W. and P.'s publication. It is in fact, a copy, so far as outline and chief character and expression is concerned, of the principal contents of the well-known MS. Reg. 2 B VII Musei Brittanici, commonly called Queen Mary's Psalter, a work attributed by competent authority to a date corresponding with the best periods of Mediæval art. The contents of this celebrated MS. comprise a series of illustrations of Scripture history, each with its appropriate glose, commencing with the fall of Lucifer, and ending with the death of Solomon—a beautifully illuminated calendar—a similarly enriched Litany—a Psalter and Hymnal—and several very interesting and highly coloured delineations of the prophets and saints. The first mentioned were, with the Litany, in part brought before the public by Mr. Westlake in 1858, and have since been completed by Mr. Purdue.

In the original MS. the illustrations, in the case of the histories, are but sparingly touched with colour, chiefly a kind of purple and a dull lake with green, confined, for the most part, to the dresses of the figures. For the faces and unclothed parts a kind of sepia brown is used. Each picture is enclosed within a border, coloured bright red, which is continued round each page of the book, and finishes at each angle in a spray of three leaves, shaded like the figures, and outlined in black.

It is, perhaps, to be regretted that the colouring here mentioned does not appear in Messrs. Westlake and Purdue's work. It would have been very useful, as showing how far considerable additional effect and character can be obtained with comparatively little labour. On the other hand, we perhaps see the drafting capability of the mediæval limner more clearly, thus divested of the aid derived from the coloured finish. Another omission is also to be regretted. In addition to the Bible Histories, at the bottom of each page of the original are a number of very curious grotesque subjects, such as are represented in the Bestiaries, and the MS. illustrations of the Sports and Pastimes of the period. Some of these are highly interesting in treatment, and the variety and originality of design is very extensive and instructive. As in the case of the Calendar also of the original MS., where the head-piece of each page contains a representation of the employments of the months, the Signs of the Zodiac, &c., they are particularly worthy of attention and study, and would have added considerably to the general value of the book, viewed as an authoritative example for like introductions.

As regards those subjects, however, which we have represented to us, with so many calling for notice on account of their general treatment, or other more specific merits, it is not easy to make choice. We may refer, nevertheless, to Plate XIV. of the series, for the grouping of the five figures on the right of the centre tree, "The men of the law" wondering at the act of Abraham breaking the false gods "en despyt;"—the similar grouping in Plate XXVIII., where Joseph's brethren exhibit his cloak stained with blood to their father;—the four figures in plate LXXIII., where Sampson shows Delilah to his father;—the Plate CXIII., where, in the upper picture, Solomon is directing the building of the Temple, and, in the lower, receiving the visit of the Queen of Sheba,—in both of which the arrangement of the draperies in the figures is remarkably well conceived and rendered. To Plate CXVI. we would also—passing over several others hardly less worthy—particularly draw attention. This is a most interesting and well-designed and drawn Radix Jesse, differing from the later and more general representations by the absence of the figure of the Blessed Virgin, which usually terminates the series. The principal figure, as is commonly the case, is the reclining Jesse, his head resting on an embroidered cushion, a rising tendril issuing from behind, enclosing in its convolutions nine figures. There are no names attached to these latter. David is, however, identified by his harp as occupying the centre compartment of the first range. Our readers will be able to judge for themselves of the suggestiveness and value of this example from the illustration (Plate V.) which accompanies this notice.

The plates which follow the Jesse, and which are highly illuminated in gold and colour in the original MS. contain, in the one case a series of single figures of apostles, and the three Mary's, preceded by a seated figure of the Saviour in majesty, and accompanied by a very beautiful picture of the blessed Virgin holding the infant Jesus, similar to, indeed, almost identical with a painting of the same subject still (that is to say, a few years ago) existing in one of the windows of Cliffe Church, in Kent; and in the next of a similar series of figures, but here placed in pairs and forming a juxta-posed, or paralleled arrangement of the holy personages of the Old and New Testaments, each holding a scroll inscribed with a text, Jeremiah being companioned by St. Peter, David by St. Andrew, Isaiah by St. James major, Zechariah by St. John, Hosea by St. Thomas, Amos by St. James minor, and so on for twelve other figures, ending with Ezekiel as coupled with St. Matthias.

It would be possible to dilate, to much greater extent than we have here done, upon all that may be derived from a reference to the work before us, and from a careful study of what it presents. We must however be content with what we have already said, and to rest in the hope that it may be sufficient to secure for it such a consideration as its real worth would fairly entitle its producers to expect, and should, properly viewed, ensure.

Art Foliage. By JAMES K. COLLING, F.R.I.B.A. London: published by the Author, 150, Hampstead-road.

The work before us is a valuable addition to our knowledge of art-decoration, and likely to be of great use to stone and wood carvers, as well as to all those any way engaged upon foliated ornamentation. Mr. Colling has gone deeply into the subject, and has very clearly enunciated the principles which should guide the art-workman in the treatment of natural foliage for artistic purposes, which as he explains must, more or less, always be made geometrical, and arranged with symmetry in accordance with its situation and purpose. One of the first things to be studied is the arrangement of the branches which constitute the leading lines. These constitute the skeleton upon which the whole is formed, and they should be made such as will best harmonise or contrast with the architectural or other lines which surround the composition. In the second place, the forms of the leaves and flowers have to be considered, and to be altered or adapted from nature as circumstances may require. In the third place, and one of the most important points, requiring great study and consideration, is the effective arrangement of light and shade. Then there is the position it is intended to occupy, whether internally or externally; whether it has to be placed close to the eye, or at a height; and, lastly, the material in which the ornament has to be executed.

These various points the author has carefully and systematically examined in the body of his work, and has most ably illustrated by a series of boldly designed enrichments of a very varied character, consisting of examples of coloured decorations, wall papers, inlays of marble and of wood, carved diapers, and ironwork, besides many examples of carving both in stone and wood, as spandrils, panels, bosses, string-courses, cornices, enriched mouldings, capitals, corbels, finials, crockets, and brackets.

The commencement of the work is devoted to what Mr. Colling calls "an Analysis of Form," which is both interesting and highly useful, for a person who intends applying himself to the study of ornamentation, should examine the nature of form of every species when reduced to its first and most simple principles. This Mr. Colling exemplifies in a series of ten plates, tracing the use of geometric form from its most simple elements to its more complicated, and divides geometric ornamentation into three divisions, treating them under their separate heads of Diapers, Borders, and Centres. We consider this a most important part of the book, containing as it does a large amount of original matter which it is most necessary should be known to every ornamentist, no matter upon what material he may be engaged. To our manufacturers especially engaged in the ornamentation of woven fabrics, this portion is likely to prove exceedingly useful and highly suggestive for new combinations of forms. It will materially aid them in relinquishing old conventional and worn-out ideas, and lead them to adopt a greater range of beautiful combinations.

In illustration of his subject, Mr. Colling has not limited himself to style, but has sought for examples among the Egyptian, Assyrian, Indian, Chinese, and Japanese—as well as the Greek, Roman, Italian, Byzantine, Romanesque, and Mediæval. Besides this there are constant references throughout the work to leaves, flowers, and other objects in nature which are adapted to the use of the ornamentist, and the book concludes with a series of plates, consisting of some valuable examples of natural buds, ferns leaves, flowers and fruit, which appear to be selected with great care, and to contain excellent suggestions, if worked out and studied in the same spirit as Mr. Colling's own designs from nature. Nothing, however, requires greater care than the art of adapting forms from nature; for, as the author truly says, "Natural foliage, however well rendered or cunningly carved, if merely copied from nature, without being translated by the mind of the artist, will fail entirely in its purpose, and be less effective than the literal copyism of the foliage from any of our architectural precedents. This cannot be too strongly insisted upon, because, if we tell our artists that they should not copy from old examples, but simply say, as it has often been said, that they should 'go to nature,' we should soon be so deluged by literal representations of natural foliage, that this system of copyism would become worse than the first. In the rendering, then, of natural into decorative foliage, there must be study and thought with life and beauty. It must be the creation of the artist's mind, and not a copy of this plant or that flower.

Mr. Colling has evidently gone into his subject *con amore*, and with the earnestness of one who understands the subject upon which he is treating; and has consequently produced a book which we have little doubt will be highly appreciated. We have no work that so fully explains the application of nature for the purposes of ornamentation, and coming at a time when so much is being done by the carver and ornamentist in the various new works of great importance all over the country, we anticipate for it a most marked and deserved success.

A Handbook of Formulæ, Tables, and Memoranda for Architectural Surveyors. By John Thomas Hurst, C.E. London: Spon, Bucklersbury.

This book contains, in a convenient form for the pocket, a considerable and varied collection of memoranda useful in surveying and the allied branches of business. Such a work has long been required, presenting as it does in an accessible form a very large proportion of those details which, though they may be required at any moment, cannot easily be retained in the mind, or traced in the large works which are standard authorities in the several branches of science. We have here tables of the strengths of materials, and formulæ for calculating the strengths of beams and trusses of different kinds and scantlings of timber and iron, as usually applied in building; memoranda relating to water supply and capacity of pipes and sewers, with tables; thicknesses of walls and retaining walls; weights of materials; proportions of staircases; formulæ for calculating the efficiency of the mechanical powers; mensuration of superficies and solids, with tables and gauging. Then follows the measurement of builders' work; memoranda as to building materials; constants of labour; schedules of dilapidations and fixtures; architects', surveyors', and valuers' charges, and tables of weights and measures. There are also notes upon the valuation of property and reversions, with tables of interest, and the value of annuities, &c. The author does not lay claim to originality, and in many cases acknowledges the sources from which the information is derived, the omission of this is however in some cases to be regretted, as, although the sources may be generally known, a book of this kind may usefully guide the student who is in search of fuller information. The work seems to have been carefully prepared, and, from the outline of the principal heads of information which we have given, it will be seen to be of great utility to the architect and surveyor.

CUT-OFFS.*

The controversy between the United States Navy Department and the builders of the Algonquin, enlivened by the trenchant letters of the constructor of her engines, has forced on public attention the subject of expansion by cut-offs. The sympathies of many practical men are with the builders. They endorse their confidence in the superior qualities of the engines, and their defiance of official opponents. Still the principles of physics, on which the result depends, are inexorable, and insensible to moral suasion or censure. There are those who think the mighty agent, upon which progress depends more than on anything else, has passed through every form and phase of trial, and that its value as a motor is exhausted in modern engines; others, with more reason, believe that, so far from our knowledge being complete, much of importance is yet to be acquired. Unacquainted with the parties contending and their experiments, without a shadow of interest in cut-offs, or the slightest prejudice in favour of or against them, I think it has happened to them as to other devices to which credence has been given without due examination and opinions taken up on trust. At the risk of having the remark applied to myself, I think they are imperfectly understood. The following thoughts are thrown out with the sole view of aiding in the discovery of the truth.

To economise steam by expansion has been a desideratum for well-nigh a century, and nothing conclusive has been attained. Conflicting opinions are still rife, and the government has charged a commission of experts to solve the problem by a fresh set of experiments. I have no faith in doubtful or hazy explanations of mechanical matters, nor is there any reason why anyone should. Whatever is uncertain vanishes when thoroughly looked into, and every man of ordinary talent and persistence can do that. Such is the case with steam.

Although the leading element in the civilisation of our orb, and one in all probability never to be superseded, the properties of aqueous vapour are as palpable and plastic as those of other bodies. As complete control of it may be had as of them. It is weighed in the same scales, and its quantities ascertained by the same vessels of capacity as liquids and solids. A pound of it is a pound of water vaporised. The mode of using the measures is somewhat different than with liquids, but not less rigid and correct. One holding a cubic foot of water has to be emptied and filled afresh until the required number is made up, whereas with steam several feet are commonly contained in the space of one, the number being indicated by the pressure. Hence *pressure* and *quantity* are complements and explicatives of each other. As volume increases, pressure diminishes, and *vice versâ*, the quantity remaining the same. The smaller volume may contain the larger: five cubic feet whose pressure is 40 lb. on the inch, contains 10 feet of 20 lb., or 20 feet of 10 lb., all three being equivalents in cost, quantity, and power. The knowledge of this is essential to a correct appreciation of cut-offs, since as much, or even more steam may be let into a part of a cylinder than would suffice for the whole.

It will be understood that I speak here of *natural steam*, not of that doctored by heat and more or less decomposed after actually or virtually leaving the boiler,—steam, of which every cubic foot contains, in round numbers, a cubic inch of water, and in the using of which nothing is left in doubt—nothing to mystify or perplex,—steam, whose power is increased by increasing its quantity, just as more heat is obtained by consuming more fuel, more light by turning on more gas, more wind power by enlarging sails to catch more of it, as the force of a gun is increased by adding powder to the charge, and that of men and animals by increasing their numbers. To double the power of steam, the fluid must be doubled. Such we take to be the only reliable theory of forces, whether the motive agent be an elastic fluid, a liquid, a solid, or a living body. Yet vast amounts of time, talent, and money, have been and are still being spent to prove steam an exception. Superheating it may, in certain cases, be found useful to prevent premature condensation, but that its value as a prime mover is thereby increased has yet to be established. It adds nothing to the substance of the fluid. Another query is, whether any alleged gain does not cost, all things considered, as much or more than it is worth.

If a sluice-gate be arranged to deliver more water on one part than on another of an overshot wheel, no more power could be got from it than from the uniform discharge of the same quantity upon it. The power would be in the weight of the liquid, and that would be the same in both cases. So with steam; it is the quantity let into the cylinder that determines the power, not the mode of letting it in. This is, however, questioned. Advocates of cut-offs insist that when the whole force or charge is opened on the piston in the first part of the stroke, and left to expand and follow it to the end, a better effect is obtained than from an equal (or even greater) charge let in regularly from the beginning to the end, or near the end of the stroke.

* From the Journal of the Franklin Institute.

It has been thus accounted for: "By the momentum given to the matter which the engine is moving—it may be the fly-wheel, or the steamboat itself, or the train of cars, all of which, when once set in motion, will not suddenly stop, even though all power were suddenly suspended from driving them, and which therefore will continue to go on under the diminished pressure of the expanded steam. Thus you see that, when the steam is cut off from the cylinder, that which is in it continues to push on the piston with diminished force, but still with some force; and as the piston cannot stop, it absorbs, and through the wheels which it drives gives out again to useful effect whatever pressure is thus spent upon it, just as your watch will run all day, although the spring which drives it grows weaker and weaker as it is relaxed. The gain which can be obtained from the use of expansion is measured by the extent to which you carry it; or in other words, how short you cut off the steam in the cylinder. Ten expansions will do three times and a third as much work as no expansion, using the same amount of fire and steam."

Progressive movements dependent on varying momenta abound in every department of nature. Animals that go forward by springs or leaps are examples. The path of some birds through the air is a succession of ascents and descents—a series of undulations or curves—rising by the action of their wings and descending without it. The principle of thus applying force is therefore a sound one, and the question is, its adaptation to artificial machinery and propulsion. We find it confined by the Great Engineer to organisms specially fitted for alternations of leaps and stops, and whose functions are incompatible with uniform speed. Neither the locomotive organs of natural machines, nor the conditions under which they act, are applicable to ours, nor ours to them. There is not a rotary propeller in nature, while we have in the wheel the most equable and perfect instrument of progression. Its supreme excellence is its complete adaptation for receiving and transmitting continuous motion without jarring the masses it moves, and consequently without a varying momentum. With cut-offs there is of necessity an inequality of pressure on the pistons, and therefore an inequality of motion in bodies impelled by them,—an effect fatal to stability and durability. If the second proposition in the quotation is to be received, the laws of force and resistance would seem to be at fault.

The next dictum is specific, and not to be misunderstood. Could it be proved, a chief niche in the world's Walhalla would be due to its author. That by the same quantity of steam more than three times the work can be performed with a cut-off than without one is incredible, and if true a miracle almost as great as making three gallons of water out of one. If the resistance were greatest at the beginning of the stroke, and fell down to zero at the end of it, there might be cause for some gain, but so far from that, it may be considered uniform in bodies moved by steam, whether ploughs, ships, cars, or manufacturing mechanisms. Whatever may be said to the contrary, we must continue to believe, till controverted by facts, that there can be no saving of steam power by substituting a succession of impulses for continuous pressure, except in cases where the resistance rises and falls with the piston's movements. Whether there are such cases we know not, but it is certain that sudden changes of force and velocity are not the things for steam machinery, no more than are springs and leaps (sensible or insensible) for bodies moved by it.

The popular idea is illusive. It is the impression of many that when the cut-off acts at half-stroke, half is saved; at one-third, two-thirds; and at one-fourth, three-fourths. They forget that pressure indicates quantity. Engines with cut-offs of necessity use steam of greater tension than others, and the less the charge the greater the tension. The only difference is that one class uses small volumes of high pressure, and the other large volumes of lower pressure, the requisite quantity being the same in both. An engine is worked with steam of 100 lb. on the inch, and cuts off at half-stroke. The mean pressure of the latter half is, therefore, 75 lb., and that of the whole stroke 87 lb. on the inch. Observe that twice the force is expended on the first half than suffices for the latter half, and (the resistance being the same) twice the amount required. Where then is the difference in the amount consumed between charging the cylinder with 87 lb. steam, and with it varying from 100 to 50 lb. In every case as much of the fluid must be admitted as will push the piston to the end of the stroke, whether soon or later cut off. Another engine has a cylinder of the capacity of 12 cubic feet; and requires steam of not less than 12 lb. per inch pressure. This does t work without a cut-off. Suppose it be determined to apply and cut off at half-stroke, would not the tension have to be rai to 24 lb. on the inch; if cut off at one-third, to 36 lb.; and i one-fourth, to 48 lb.? In fine, does it not follow that theoretic there is no more to be gained by cutting off at a quarter tha half-stroke, and no more by that (unless in special cases allu to) than with no cut-off at all. To determine how far prac conforms to theory there is a conclusive experiment—apply same quantity of steam used with a cut-off to the same cylin without one.

THE ARCHITECTURAL ASSOCIATION.

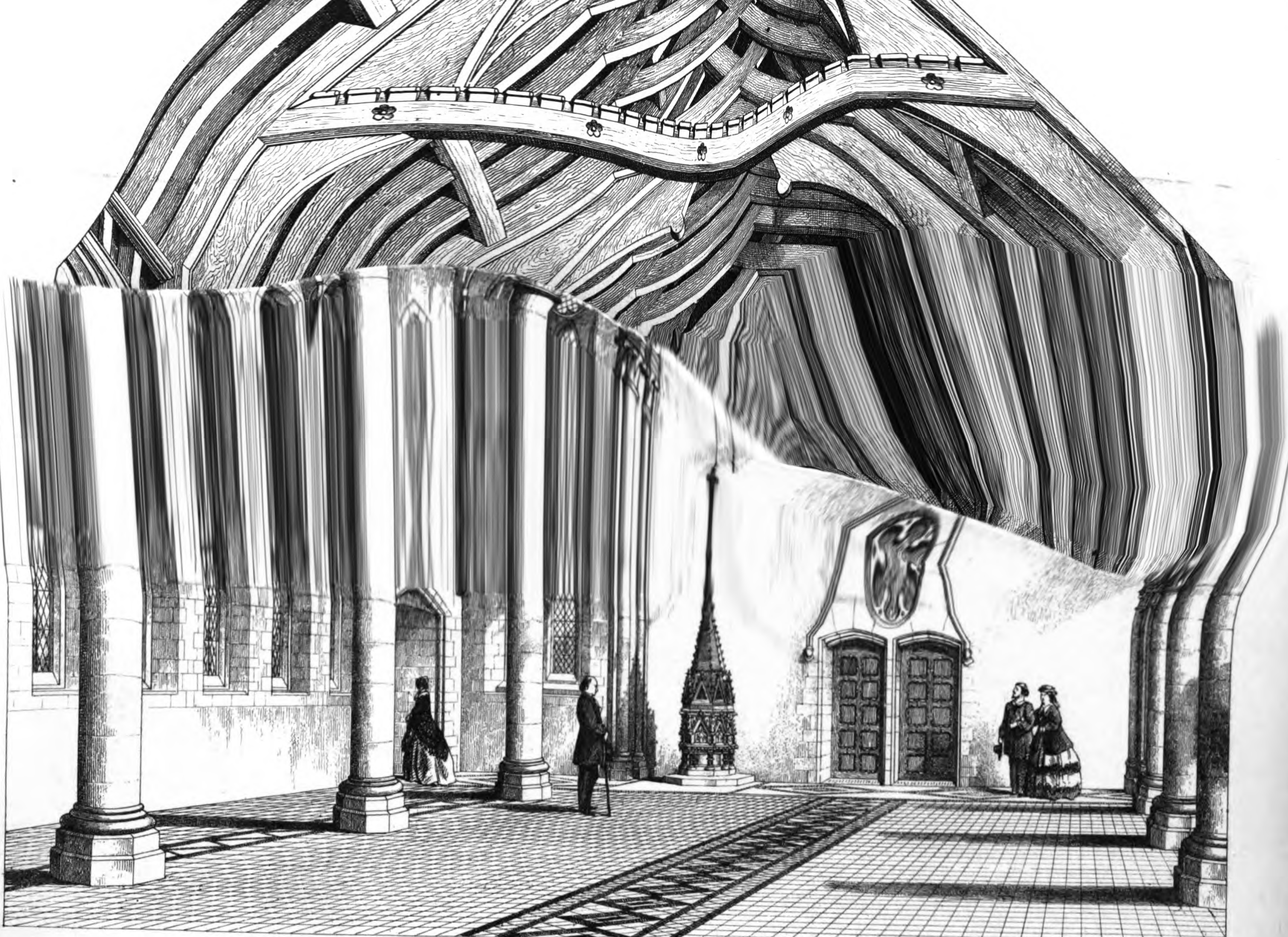
At the ordinary meeting, held 22nd ult., Mr. Robert W. E in the chair, the minutes of the last meeting were read confirmed. Messrs. Chas. T. Whitley and J. W. J. Kenn were elected members of the Association. The following gen men were nominated for membership, to be elected at the n meeting:—Messrs. Edward S. Harris, Edward V. New, John Cross, Chas. H. L. Wilday, George Lot, W. H. Hawe, Ph Condy, Frank Palmer, John H. Spanton.

The report of the sub-committee, appointed on the 24th Nov ber to make inquires as to the publication of the transactions of Association, was read. The report stated that satisfactory arran ments had been entered into with the Editor of the *Civil Engi and Architect's Journal*, whereby the Journal would con authentic reports of the papers and discussions thereon. Lemon proposed, and Mr. Faver seconded, the adoption of Report, which was carried.

Mr. Riddell announced donations to the library. The ch man then called on Mr. J. Douglass Mathews, hon. sec., to read Essay for which the prize of the Association had been awar to him. Mr. Mathews' Essay will be found reported in ano part of the present number of this Journal.

Manchester Architectural Association.—The annual mee and conversazione of this society was held on the 20th ult. gathering was very successful. The contributions of draw and models were very numerous, and generally exhibited g ability. A series of three pictures, by Mr. J. Redford, f sketches taken upon the spot, illustrative of the rise, culmi tion, and decline, or, as it was termed, "the morn, noon, night" of architecture were displayed, and indicated ca study on the part of the artist. Singularly, for the perio "night" was employed a scene taken from the river Ir which will be familiar to anyone acquainted with the ne bourhood of Blackfriars Bridge, Manchester; the "Palace Gold," in Venice, which is a masterpiece of constructive i nuity and colouring, being selected as the epoch when science was at its "noon;" and a Canadian log shanty, with solitary settler, represented "morning." A collection of splen photographs were shown, representing various scenes in C fornia. Amongst the other contributors were Messrs. Dar shire, Gregory, Clay, Newton & Co., &c., &c.—Mr. W. Boo the president, delivered his inaugural address, in which deprecated the system of cheap architecture adopted by some the members of the profession. The system, he said, was cheap after all; but if there was any sacrifice to be made, should be at the expense of ornamentation. He congratula the association on its prosperous condition.—Mr. J. Boult, p sident of the Liverpool Architectural Society, thought that alliance meetings should be peripatetic, and not confined to particular place (as London), so that there might be more mut intercourse between them.—Mr. Bowman, Dr. Clay, and oth gentlemen also spoke; and votes of thanks were accorded to contributors and the president.

Exhibition of French Art in New York.—An arrangement h been made for an exhibition of the works of French artists New York, and the *Moniteur des Arts* of Paris says that M. C dart, one of the editors of the *Société des Aquafortistes*, will lea in a few days for America, to organise the exhibition, which to open in March. He takes with him about two hundr pictures, by the best living artists of France, and represen the school in all its phases. The idea is certainly a good o and if well carried out is likely to furnish French artists with new and important market for their works.



J.R.Jobbins.

CHURCH OF THE RESURRECTION (ANGLICAN)

CHURCH OF THE RESURRECTION (ANGLICAN) BRUSSELS.

(With an engraving.)

We complete the illustrations of this church, by an interior view, in this month's Journal. The church stands north and south, which will explain the apparent discrepancy in the titles; the ritual east or chancel gable faces nearly south. It was originally intended to erect houses on the eastern side, leaving only a passage to the church, but to this the burgomaster objects, and requires it to be left open, wishing if possible, as he states, that so fine a church should not be hid. This will be acceded to if it can be arranged.

ON IRON: ITS LEGITIMATE USES AND PROPER TREATMENT.

The following are extracted from a paper, "On Ironwork: its legitimate uses and proper treatment," by Mr. William White, F.S.A., F.R.I.B.A., read at the Royal Institute of British Architects.

Having now vindicated the cause of iron, as well in its legitimate use as from its growing abuse, I must endeavour to sum up the chief of the different modes of treatment, and the several processes which can or cannot be justified by a strict observance of the distinctive qualities of the material. It is difficult to lay down dogmatic and unerring rules as to what is right or wrong in principle; or always to say whether such rules are infringed or not in a given instance. It may, however, be stated generally, that proper treatment for wrought-iron is exemplified in that which best exhibits the power of the workman's hand in the forging of it; and it is in design and fashion such as to preclude the probability, if not the possibility, of its having been cast or impressed,—whether by its delicacy of form, or its vigour of finish. Even in works of massiveness or strength some evidence will appear of the yet more overpowering force which has bent the strong metal to its will, whether it be by hand-drawing or tapering, or by some little playful conceit which the workman indulges in, thus stamping it as his own.

Cast work, on the contrary, must be more soft and superficial in its treatment; it must be such as to bear strict evidence of its impressment; it must appear in forms such as to be capable of, and well fitted for, repetition; such, in fact, as could scarcely be wrought even by great skill or by indefatigable labour; such as to exhibit chiefly surface work; such as to avoid all appearance of scroll or curl or tortuous bend, or other little refinements and dexterities which can be displayed to perfection only by the hand of the individual workman. The distinctive difference, indeed, between the true art-treatment of wrought and cast metal is, that the former must display its ductility and vigour; the latter its impressibility and passiveness. It is from the denial or neglect of these qualities that failure commonly commences in either case. But there is a third description of work which ought not to be passed over. It is the treatment of that which is called malleable iron, so called not because it is hammered out, but because after it has been cast or pressed into a die it is capable of receiving without fracture a certain amount of hammer labour. Not that it does receive this, excepting perhaps in minute proportions, and in rare instances; but it is a name which appears in published price lists as a sort of sign-post to misguide an uninitiated and unsuspecting public to the idea that it is not only malleable, but actually worked by the hammer. And if only casting or pressing be used in its production, wherein is it better than common cast or pressed metal? Its superiority consists, say its advocates, in its texture and strength, which are allowed to be nearly equal to those of wrought-iron. And I am bound to acknowledge that here, even in iron, is a material capable to some extent of high art treatment, if only it is used for such. But let it not be degraded to the common level of other moulded metal. Let it be designed suitably to impressed work; let it be worked up dexterously and vigorously into something that shall be worthy of its use. Let not the forms be followed of a quasi-forged and drawn-out construction in its manipulation, but let it be cast and worked to the highest pitch of smithy skill; let its treatment tell the true tale of its high artistic development. Then call it malleable iron if you will,—but till then let it not be ashamed of its proper name. The term "annealed cast-iron" would much more fitly express its known nature and qualities. But let its treatment justify its superiority, without having recourse to an unworthy subterfuge, almost as base as that of marbling a plaster cast to give it the dignity and the character of a genuine and valuable work of art.

Having briefly outlined the several kinds of iron, and their respective treatment, the all-important question presents itself as to the means available, both in regard of the use of machinery and of the position and province of the workmen employed upon it. In considering this branch of the subject we must bear in mind the truth that in forged work there is genuine art to be displayed. There is room for delicacy of expression, and for the exhibition of the forger's power, which is not possible in a mechanical process, and which, indeed, is the very element distinguishing art from mere mechanism. It is equally true, however, that great skill, together with great knowledge and experience, is required in the fitting of castings, or of machine-cut details; and, when well done, skill is evidenced in the absence of imperfection and irregularity, rather than in the presence of any element of pleasure to be derived from display of the workman's individuality. Whereas, in such forged work as comes properly under this denomination, it is the reverse. It is not the absence of imperfection, or of irregularity, which pleases the eye, but the presence of a living power which has made itself felt upon the otherwise inanimate metal, bending it to its will, and giving evidence of its reality, in spite, perhaps, of great imperfections, or of still greater irregularities.

Again, in a proper treatment of forged work, and in order to obtain the desired effect, great regard must be paid not only to the implements used, but to the mode of using them. One prevalent failing in such modern work is that it is so intensely tame and shoppy in its finish. The cold chisel, the scissors, the file, are made to supersede the hammer and the tongs. The indiscriminate use of the file, indeed, has given rise to a false taste in metal work very much akin to that of scraping of the stonework of the noble minster fonts of Lincoln and Winchester. Let me, however, be not misunderstood. It is not that I object to the use of the file; but as I have upon another occasion observed, so I would now again take the opportunity of repeating—"the file must be used only as a means to an end, instead of being, as is too commonly the case, the end to which all metal surfaces must be brought before they will pass muster with a misguided public. The file may be, nay, must be used for fitting and jointing, and the perforation of plates, and other fine work such as the hammer could not touch; but the use of the file for finished surfaces is one of the first things that has to be abandoned before the forger can assert his rightful claim to our regard. Such treatment of surface is of the highest consideration in all art works, whether in wood, stone, or metal. In soft fabrics it is imparted by texture. In hard wares it is to a great extent given by implement and manipulation. A high polish presents one kind of beauty, and a rippled or broken surface another. A merely crude and neglected surface does not satisfy the eye. Labour of some sort must be bestowed; but only in a proportion to the pretensions of the work in other respects. But carving in stone or wood ought commonly to show the marks of the chisel or tool, and if these are scraped or filed or sand-papered away, the play of light upon the surface is dissipated, its character is impaired, and its surface measure, so to speak, over which the eye has a pleasure in travelling, is actually diminished in effect. So, too, forged work ought to show the hammer marks, and wherefore should the roughness of the fire marks be filed down, when, by cold hammering, its surface can be greatly hardened and its tone deepened, its play of light increased, and a polish of a totally different but far superior sort imparted,—a polish not of mechanical labour, but of handiwork? And wherefore destroy the evidences of hard and well-earned labour for what might be effected by the merest apprentice or a human machine?"

But, say the great wholesale iron-workers, in order to carry out this view of art in iron-work, you would have all the workmen to be artists, whereas under our present system we find one artist sufficient to afford employment for a large number of ordinary workmen. I would have no such thing. I only say, do not bestow the term "high art" upon work produced by machinery, and fitted by a machinist. In order to have high art as distinct from mechanism, the hand of the individual must so far predominate as to throw into insignificance the mechanical process by which any of the subsidiary forms may have been produced. This evidence of the hand of the forger in the execution of his work being needful, as the hand of the sculptor is in his, opens up a large field of inquiry with which we are at the present moment scarcely concerned, further than to call attention once more to the importance, which our present President has so often and so ably urged in other places, of promoting, by all the means which we can command, the education and the recognition of a class which has till within these few years almost entirely disappeared from the community—the class of artist-workmen.

The mechanic, as commonly he is in nature, no less than in name, has, in taking the place, altogether usurped the province, of the artist-workman. There is room for both; there is need of both: but at present we are reduced almost to the one. The question to be considered is the relative pesition and the distinctive employment of the two distinct classes.

I have found, in the great iron districts of the North, a mistaken idea prevails that there is no real difference, and ought to be none, between hand-work and machinery as regards effect when finished. It is a mere mercantile calculation as to whether machinery or hand labour shall be employed in the execution of a given work, and has to how far it will pay to produce fresh machinery, dies, or gauges to reduce the work to its requisite state for finishing and fitting, leaving as little as possible for hand labour in the completion of it. And the amount of art displayed is measured, so to say, by the ingenuity of the machinery, and by the success which the article has in pleasing the public and effecting a sale. It is considered unworthy of the age to put to hand-labour that which machinery is capable of executing,—and this as a matter not merely of economy, but of art. Articles so produced are classed with the fine arts, as nearly on a par with stained glass and sculpture, and certainly with forged iron. And no doubt there is great art in the invention of the requisite machinery for the facture of such iron-work,—machinery which performs all sorts of operations,—cutting, piercing, rolling, stamping, and pressing,—machinery of such power, and adjusted withal with such accuracy, as to crack a nut, and yet not crush the kernel, with a force of twenty tons. And it is not without some show of reason that the impression arises of the day of hand-labour being past beyond recall. Am I therefore finding fault with this state of things? By no means. On the one hand, I know the day of hand-labour is not past; and on the other I am too thoroughly convinced of the truth of the dicta of the political economist, not to see that a vast population must have vast supplies at a reasonable cost; that machinery is an untold blessing to poor as well as to rich; although the change must bear heavily at first upon those whom, for the time, it deprives of labour.

We must now pass on to a few details of the processes which may or may not be truthfully and properly employed in the execution of ironwork. It would be undignified and uncourteous, as it would be superfluous, to say anything here as to the general merits or rather demerits of shams, or of their degrading influence upon high art, before a body of men who more than any other in the world have already and for ever repudiated them. But it is needful for me to call attention to the insidious way in which shams do creep into the manipulation of modern metal work; and in order to make my position clear let me give an instance, not as instructing you, but only as illustrating my meaning. All are acquainted with the universal mode of twisting a square bar of iron. This process is said to increase its stiffness or rigidity, but at the same time it enriches its surface. It is essentially a process of the forge. Not only is a certain degree of heat for the operation requisite, but a firm hand and a ready eye in the operator—else the twist will be anything but ornamental. And what do we find? This twist, so telling in its proper place, and in a sparing degree, is actually reproduced in cast-iron by the foot, one may almost say by the mile; and this even by some who aim at leading in the van of high metallic art. I say the sooner they go to the rear the better: the better for themselves and the better for us, and the better for art. One mode of forming a twist by machinery there certainly is, which may be legitimate for work merely decorative, not constructive or quasi-constructive. This mode is properly applicable to brass only, and not to iron. It is the forcing of a tube through a spiral die, which produces the twist clean, sharp, and regular. But when these tubes are used as apparent supports to arches or to entablatures, it may fairly be questioned how far they represent legitimate treatment, even though they form but the casing to cast-iron columns which do the real work for them. Again, I do not see how a constructive arch of iron, whether wrought or cast, can be called defensible as an architectural feature. An arch, as such, implies a constructive process, such as of brick or stone, in its erection. Or once again; what can be more absurd than the reproduction in cast-iron of the distinctive features of caps and bases, cornices and plinths, moulded and cut after the fashion universally suggested by the necessities of a stone construction. Yet I have been gravely told that such narrow views as mine would set aside one great principle of mediæval metallurgy, namely, its comprehensiveness, which found employment for every description of manipulative detail, such detail often following in its ornamental features the constructive forms suggested by other materials. In no way does my objection militate against this principle. For suppose the artist to invent or to select from some such other extraneous source the form best suited to his purpose. the smith will not reproduce it as stone, or as brick, or as other material, but will produce only some general idea of the form, rather than a leading and constructive characteristic of that which he followed; much less will he aim at a direct imitation or reproduction of it, and no matter from whence a form comes, so that that form is good and suited to its purpose. The cast column, even, might be used, and then covered with plates of finer material, so that these be not made as independent cases or cloaks to give an air of construction to that which is only decorative, and yet withal very legitimately is decorative. Nothing, however, can approach to the deliberate perpetration of a cast-iron cresting, such as that of which I give an illustration. In this we have not only pretentious cusps and braces of a wrought construction, but even the apparent rivets with which it is pretended they are fastened together. I would not add a word on the unpardonable parodies uttered in the shape of would-be hinge bands; but that every time a protest or a warning is uttered it may chance to fall on some ear which it has not yet reached and which may yet profit by it. And unhappily, this is a delusion still practised upon those who know no better, through the catalogues of manufacturers of such wares,—the delusion that a cast-iron hinge band adds one whit to the architectural effect of a door, and does not rather destroy all that might be otherwise good about it. The "small cost" is used to justify an expenditure which would be much better saved altogether. The small cost would be much better expended on sending them again to the furnace; for such work becomes a species of trickery, which is quite alien to the true spirit of art.

The great aim of art is not directly to imitate, but to image. Not to deceive the eye of an intelligent being, but to present or re-present to his imagination an idea which is worth reproducing or perpetuating. If the means used are opposed to or inadequate to the end, the imagination takes offence at the deserved failure. And if such poor artifices are used, the taste becomes depraved; and I believe it to be quite possible for the artist to get into a way of living upon fallacies, as the opium-eater upon his drug, till his art-life becomes a morbid state of existence, rather than an existence of energetic enjoyment of its realities. These amongst many prevailing instances of a state of sham pervade our modern iron work, and hinder its rising so rapidly as it might to the position in art which it ought to occupy. And although, as I said, I do not find fault with the state of things as regards machinery and its necessary application to all useful purposes of daily life, yet I do object most seriously, most strongly, to the system so largely adopted of imitating forged work on a large scale by the bending, gauging, cutting, screwing together, by hands which move as mechanically as machinery does, work which is disappointing and insulting, from its tame and lifeless character, whilst it promises and professes at first sight to lay claim to our respect as a genuine work of art.

And such, alas, is the practice of all or nearly all of the monopolists of so-called Mediæval metal-work. The intelligent working artist takes in hand a corona or a grille, which shall impress people with the idea that it is forged by the hand of the expert smith. The work is completed. The popular voice, expressed with all sincerity, "how pretty, how neat, how exquisitely finished," prepares us for the evidence of its having been mechanically cut, bit by bit, from plate or bar, as the case may be, pressed into form by stamp or die, folded, bent, crumpled, filed up and fitted, and finally put together with nuts and screws, by a process of mental machine work, such as might do credit to the professed manufacturer of cast and machine-made wares. But the living working artist, where is he? He is degraded from his post of honour. He is become again a mere mechanist, just when he began to flatter himself that he was rising to the rank of artist in his profession. Let us leave him there,—for he can scarcely come forth again to higher aspirations. Let us draw the curtain over this sad, this humiliating picture.

The mode of manipulation in old work, even till the early part of the present century, was very different. Look at the wrought gates of our country mansions, or even at the ironwork which still graces many a house, not yet a century old, in London. Look again at the fine mediæval hinge bands as an illustration of proper treatment adapted to the several parts. The ornamental bands were forged and finely wrought, and bent to proper shape, but the terminations sometimes were stamped and cut with tool and die made for the purpose. Both of these processes required equally the hand of the skilled workman to use them. The terminals sometimes were apparently first cast in a mould, and then worked up and fastened on in their respective position; and they consisted only of such surface treatment as could be stamped. In none of their stamped work did they ever aim at tortuous bends, or other forms, such as properly could be carried out by forging alone. But there are some who, at the present day, would not scruple to reverse the process, to forge the terminations and to cast the scrolls, if we may judge of them by what they do and say in other ways.

One mode of manipulating an ornament in early work was by the cutting of the cold iron with a hardened tool and hammer, in such a manner as to cause the portion cut to curl up and form a scroll. We all know not only the old picture illustrating this process, but also specimens of hinges ornamented evidently by it. It gives a sharpness and crispness of finish to the metal which could not be got by other means, and which is well worthy of our following. But regard must be paid to the quality of iron required for this process, as in fact for all good work. Much of the iron is very inferior for such purposes at the present day. Modern improvements in smelting have increased the hardness of the metal, and expedited its manufacture at the expense of toughness and ductibility; and such iron is all but useless for the forging of fine work. It breaks away under the process of hammering or of bending, in the forging of it.

One of the most common forms in which cast-iron comes before the multitude is in that of the straight bar enclosing the area of every ordinary dwelling-house in this Metropolis and other large towns; and the question naturally arises, how far that form is justifiable. In answering this we must bear in mind that expense cannot be entirely set aside, however much we may desire it; and that the difference between wrought and cast for the purpose referred to would be, perhaps, some three hundred per cent. in favour of cast. Are we then reduced to the dire alternative either of doing a great wrong to art, by abandoning our principles, or of incurring an unjustifiable expense. I think not. Only, if this cast-iron pretends to be wrought, it is an egregious sham; for instance, if it presents the spicous point or the leafy scroll which ought to be turned out, and properly can be turned out, from the forge, and the forge alone. What would be said by a brave warrior of old, could he now see, bristling on all sides of him, the common but contemptible device of a cast-iron spear, with a cast-iron tassel drooping from its head, set side by side by the neck to line the footway; with mimic urns, it may be, for the standard ends? We may well hope, however, that the day for this is past. One mode of obviating this objection to the upright bar is to have, instead of the bar at all, some impressed pattern of genuine cast-iron design, which in itself will be more artistic and more ornamental. We must, however, remember that the main, I may almost say the sole reason, why a long straight bar instead of an ornamental pattern to a London area is, in many cases, indispensable, is as a mere matter of security. Anything which would afford easy foothold, as all or nearly all cast perforated patterns must do, would afford facilities for the ingress and egress of those whom area railings are chiefly designed to keep effectually. out. But this seems no reason why the upright bar should be of the common round or square section of wrought form, rather than of a flattened, patterned, design; nor why the top of the bar should not be cast in some such form as to show evidence of its impressment, instead of imitating that of a kindred branch of trade. We must, in such cases, meet the case fairly and upon its merits, and we shall find that so far from our art suffering degradation by making use of available means, it will be in reality exalted and ennobled; for then we shall have to contend with those only who are afraid, or ashamed of the truth.

THE MIDLAND RAILWAY COMPANY'S METROPOLITAN TERMINUS AND HOTEL.

The directors having decided to erect an extensive terminal station and hotel in the Euston-road, which should combine all the advantage of experience in arrangement, and present an imposing façade to the public, invited thirteen architects of acknowledged note and standing to submit designs in limited competition. After careful consideration of the merits of the several schemes, and of Messrs. Hart and Stephenson's report on the amount of accommodation provided, and the probable outlay, the directors proceeded to select four designs from the total number submitted for final determination: Mr. Scott and Mr. Sorby receiving each an equal number of votes. After further consideration the design submitted by Mr. G. Gilbert Scott, R.A., which is of Gothic character (in fact the only one of that style in the collection) was selected for execution, and the three premiums severally awarded to Messrs. G. Somers Clarke, E. M. Barry, and Thos. C. Sorby, all of London. The probable outlay will be about £300,000. Designs were also received from Messrs. Owen Jones, H. Darbishire, F. P. Cockerell, of London: and from Messrs. Hine and Evans, of Nottingham, Walters of Birmingham Lockwood and Mawson of Bradford, and Lloyd of Bristol.

In the selected design the hotel portico is in a line with the road footway, and leads into a vestibule with a lofty groined roof. The combined façade of the hotel and station will comprise the hotel, a curved side on the approach leading up to the station, and the front of the station itself, which recedes considerably from the roadway. The total length of the frontage will be about 500 feet, and the curved frontage of the hotel will give nearly 100 feet more,—that is, about 600 feet in all. The front will be of brick, with stone dressings. The frontage will be 90 feet in height to the parapet, and about 120 feet to the ridge of the roof. The chief features in the design are the clock-tower, at the King's-cross end; the hotel principal front; and the two oriel bays on the station front, carried the whole height of the wall. The clock-tower, 30 feet on the side, is finished with octagonal turrets, and surmounted by a spire, the total height of which is about 250 feet. The hotel front has also a tower on the outer corner, about 90 feet high, and has a high truncated roof with an ornamental cresting. The approach to the station is by an incline from the side of the hotel entrance, along the concave side and the straight frontage of the building. There will be two carriage-ways for entrance and exit, which pierce the front by wide and lofty pointed arches, the height of two stories of the building, the carriage-entrances flanked by narrower and lower arches on each side for foot-passengers. The hotel will contain a coffee-room, about 110 feet long by 33 feet wide, on the ground-floor, with its front to the station entrances. The ends of the room will be semicircular, and the one side convex; the other, parallel to it, concave in surface. The roof of the station is designed by Mr. W. H. Barlow, and will have the large span of 240 feet clear.

ON TIMBER AND DEALS.*

By T. A. Britton, M.B.I.B.A.

As it is of the highest importance that those interested in building should be familiar with the nature and properties of the materials used therein, and with none more essentially than those upon which the carpenter and joiner have to operate, I will endeavour in the following paper to bring a few data together, which may be of use to the architectural student, concerning timber and deals.

The soil in which timber trees grow, has much to do with their quality, different soils producing different effects upon the timber; the climate likewise in some degree determines their strength and fitness, inasmuch as the moisture or sappiness will be retained or pushed out, according as the tree is situated in a warm or cold climate. The position of a tree with regard to the compass will slightly alter the character of the wood; for instance, that part of a tree fronting the north is always found to be red, and to produce the hardest and most durable timbers, as all the moisture is pressed out, and the wood made more compact, the concentric rings are closer together; whilst that facing the south is found to be white, soft, and sappy, and the concentric rings further

* Paper read at the Architectural Association.

apart. It will thus be seen that the heart of a tree is rarely in the centre. Where trees grow in forests, and are closely studded, and where they grow alone, and are exposed to the weather, the wood is different in the different positions. There are forests wherein the trees stand so closely together, that the rays of the sun cannot penetrate, and are situated in a good soil; the wood obtained from thence is always of a very tender nature, by reason of the continual shade, which makes it so, and is only proper for joinery. But where the trees grow alone, or in hedges, and are fully exposed to the sun, the wood will be hard, and fit for carpentry. The tree that grows in low situations, and grows rapidly, is never found to be so strong or so durable, as those growing in exposed situations and drier soils. All the oak in the north is much stronger than that of the midland counties, and is closer in grain than the oak in the south. The tree is hardest and most durable when the growth is gradual, and it is taken from the coldest places. The wood is generally bad when taken from a clay soil, as it has too much moisture; it is also bad when taken from the rich black loamy soil, for although the tree grows fast, straight, and large, the wood is too sappy, the soil being too rich for it. Generally speaking, the wood which is the longest growing is the hardest, strongest, and most durable. The driest woods do not last long, they easily rot. Those woods which are moderately dried are the best, there is more stiffness. Moderately dried wood is better than green for carpentry. It is a curious fact, that there is not much sap in those trees whose wood is naturally soft, as the lime, birch, and elder. As the moisture in timber causes it to sag when used as a beam, merely by its own weight, it is necessary, when using long beams in construction, to slightly camber them. The cambering must, of course, be obtained during the operation of trussing, and not by cutting.

The age of a tree is calculated by the number of concentric rings or layers, which appear by its cross section. If there be twenty rings, then the tree is twenty years old, if fifty, fifty, and so on, one ring being added every year; therefore, what is albumen or sap one year, is proper wood the next, the new layers as they come being converted into wood. There are some trees in the north of Europe of eighteen or twenty inches in diameter (which produce timber twelve or thirteen inches square), where one can count nearly three hundred rings; and there are likewise some trees of twelve inches diameter, which are used for cutting into deals, where nearly one hundred rings can be counted. It is worthy of observation, that the character of the rings vary in different kinds of trees. In some, as in the oak and elm, they are very distinct, in others, the distinction between the rings is so small, as scarcely to be recognised, the texture of the wood being nearly uniform, as in the mahogany and beech; whilst in another class the rings are very distinct, and their pores are filled with resinous matter, as in the fir and pine. In the vegetation of a tree, next the leaves, the bark is the most important part; the branches may be cut off, the leaves may be destroyed, and the tree may even be cut horizontally, and yet it will exist, but if the bark be taken off it cannot survive.

As forest trees, when growing, are termed "timber trees," in distinction to fruit trees, so, when they are cut down, they are called "timber." Timber includes all kinds of felled and seasoned woods, or those kinds of trees which, being cut down and seasoned, are required in the several parts of a building by the carpenter and joiner. With respect to the qualities of timber, they may be termed hardness, density, weight, and strength. While the tree is growing, the exterior parts are probably weaker than the interior, but when it has attained full maturity, and approaches towards decay, the circumstances may be reversed, the exterior parts becoming harder and stronger, while the interior are beginning to experience dissolution. The density of timber is in proportion to the time growing. The weight of wood depends upon what part of the tree it has been taken from. When a strong piece of wood is required, the lower part of the tree should be chosen. The heaviest woods are generally the strongest, but this is more particularly the case with regard to those parts that grow nearest the centre of the trunk, and nearest the root, provided they are so far removed from the latter as not to be very cross-grained. The strength of different parts of the same timber, and of different woods of the same kind, is very different. The wood immediately surrounding the heart is weak, the heart is weaker than the exterior parts, and the wood next the bark is weaker than the rest: the greatest strength is generally to be found between the centre and the sap, and timber that is straight in the grain is the strongest; knots tend to weaken it.

Timber may, I think, be called the raw material, and deals, the manufactured article. There are different sorts of timber, which are known by different technical names; for instance, "large" timber means timber about eighteen inches square; fir timber is called "free stuff," as it may be worked freely with the plane without tearing; "baulk," "bulk," "log," or "whole" timber, consists of the largest square pieces that can be cut from the trunks of trees, being from nine to sixteen inches square, but generally thirteen inches square, and sometimes extending sixty feet or more in length. "Baulks," or "logs," are by the workmen denominated timber, in contradistinction to the wood that is used in the shape of deals. "Half timber" is six-and-a-half inches square; "brack timber," is the cheaper sort, which has the defect of being very full of large knots, rendering it unfit to be cut into small scantlings. A "stick" of timber, is any piece of timber of moderate size and scantling; and the waste in cutting timber is commonly called the offal, a great deal of which is exported from France and Holland.

The Baltic timber is generally cut "die square," (or, what the Americans called, "maud edge,") end to end; but the Canadian timber generally is not cut die square, because they could only bring very short timber. The inferiority arises in the nature of the tree, which grows tapering. Die square means, that the sap-wood is squared off, leaving timber to the heart of the tree.

It is very difficult, in fact, almost impossible, to discover whether a piece of timber is sound or not, unless it be sawn into scantlings; you cannot perceive from the exterior, its interior faults; you may, perhaps, see certain splits or shakes, which might be thought to indicate unsoundness; but if the timber is used as a beam, and the splits are of slight extent, they are not of great importance, owing to the large scantling of the timber. Where these fissures exist, the timber is used for beams, rafters, or quartering, but not for thin boards.

Timber in the log, owing to its becoming rent by the weather, deteriorates in value by keeping, more and more every year. The sap, or external wood, acts as a sort of hoop to the heart of the log, which, for some space of time, binds and keeps it tight, and hinders it from splitting until the time at which it can be sawn; and from the moment the saw has divided it into thinner pieces, the tendency to split is over. It frequently happens that a piece of timber that looks perfectly solid on the outside is found deficient at the heart when sawn. Timber columns and posts, to prevent their splitting, should be bored down the middle; and girders should be trussed directly after they are sawn, as the shrinkage and drying tightens the trusses. If square timber lies in the water two or three years, it rends at the heart. It would not, perhaps, the first year, but the exterior part would soon rend by exposure to the weather. Timber does not benefit by keeping, on the contrary, it sells for 15 per cent. less the second year than the first; and so for less and less the longer it is kept, unless thoroughly seasoned.

All those who convert timber into deals, &c., will know that a great quantity of the converted article is useless, or greatly faulty, on account of the inward decay of the wood from rotten knots, or the cross running of the shake. The more free timber is from knots, the more liable it is to be shaken at the core. Knotty timber is less liable to these defects at the heart, because it is said, that the knots serve for bolts throughout the timber, to keep all the parts together. The wood which is just under the sap is more free of knots than that which is nearest the centre. It is impossible to find out the quantity of knots in the centre of the wood till it is opened, but we know very well that on the surface there is the freedom from knot, in consequence of the tree not having shot out the knot or branch to the surface. The knot is the remnant of a branch. When the dead branches fall off, or are broken off, thewood grows over the extremity of the broken branch, and remains clear of knot. When you recede to a certain distance from the centre of the tree, you find the wood most clear from knot, either in size, or altogether. American fir is of a soft nature, and very free from knots. That which is free from large, loose, or dead knots, is the best.

Timber, in order to be of use to the joiner, is cut into different thicknesses, and is known by the name of fir or deal; the American fir is known by the name of pine timber, and, as deals are the form in which it is most conveniently imported (both from America and the Baltic), the word fir or deal has become the common name for all sorts of pine timber. The conversion of timber into deals takes place abroad, it would not come in a fit state for sawing. It is there cut into the proper thicknesses by machinery, and is afterwards cut down in this country into boards of various thicknesses, to suit the purposes required. If the timber was imported, say from the Baltic, in logs, and manufactured into deals here, it would deteriorate the quality of the deals. A deal sawn on the spot is certainly better than one sawn here, because there is a considerable outside shakiness, which takes place from the log being exposed to the air. They are in the habit of picking out the best timber, to be converted into deals. That which is to be sawn, is purchased abroad in the round state; if square timber is used for that purpose, it will be split and injured in being floated down the rivers, and consequently unfit for cutting into deals. If the deal is not cut from the round log, and also as quickly as it can be from the time of felling, the grain will open, and the wood will be shaky, and when cut into thinner boards it will be fit for nothing. If the round logs were brought soon after felling, and sawn quickly after arrival, this evil might not occur; but the freight would be nearly doubled, if not quite, and we should be paying this large freight upon sap, wastage, and defective parts; that is, upon the parts which prove to be defective after the log is divided, and which, when the wood is converted abroad, are not shipped, but kept back.

As the lengths of apartments are different, so great variety of lengths are required to work in advantageously, European deals, which are imported from ten to twenty-two feet in length, and from eight to ten inches in breadth, and American deals are from ten to thirteen feet in length, and from nine to eleven inches in breadth. Deals coming from St. John's, New Brunswick, are from twenty-two to twenty-four feet in length. Besides the deals exported to England and France, there is a third kind, too bad to be used for building purposes; these deals are cut up into firewood, which is exported in considerable quantities to the London market; the firewood is cut from the bad deals, which arise from the timber being rendered useless from rotton knots, or splitting at the heart. These deals are likewise exported in another form, viz., deal ends, which average six feet in length, though sometimes much shorter, and are about five-and-a-half inches wide, by two-and-a-half inches badly squared. They manage to get these deal ends out of the bad deals, by cutting off the defective knots, and other excrescences. Lathwood and deal ends, form the principal part of the broken stowage now with the Baltic.

As there are different sorts of timber, so there are different sorts of deals, which are known by various names. "Rack" deals are often of the same quality as the main timber, but by being cut sappy and slabby, they are not greatly imported. "Slab" deals, are deals cut from the outside of any piece of timber, and are frequently of very unequal thickness. "Hand-sawn" deals, are those deals which are sawn in England by builders, as they are required for use, and are termed hand-sawn in contradistinction to those sawn by machinery. "Spruce" deals, are thin deals, cut from the white fir tree of Norway; they are devoid of turpentine, and are sometimes used by builders. "Deck" deals, are used by ship builders for the decks of ships, and are of very great length. Deals are divided into two classes, which are known by their respective colours, viz., yellow and white deals. Yellow deals are generally of a bright yellow colour, and have not lost ther resin. In selecting them, the brightest should be chosen, and where the strong red grain apparently rises to the surface. The yellow deals are the strongest, and therefore the most suitable for external work; they are likewise the dearest. Fir that is deprived of its resin is termed white deal: it is very clean, and is much used for internal work, but it will not stand the weather. Deals, and likewise timber, are generally named from the ports at which they are shipped, as Riga, Memel, or Dantzic timber, Christiana and Dram white deals, Stockholm and Gefle yellow deals, &c.

Although I have generalised all kinds of timber, cut into different thicknesses, by considering them under the head "deal"; still, deal, more strictly speaking, applies only to timber of a certain width. Deals are usually cut of three different widths, each of which has its appropriate name. Those from eleven to twelve inches wide, are called plank; those from eight-and-a-half to ten are called deal; they consist, as has been said, of various lengths, and are most commonly three inches thick, and seldom exceeding nine inches wide. All below these dimensions, and from two to seven inches wide, and generally from $\frac{5}{8}$ inch to 2 inches thick, are termed battens. They are very often cut from deals, and are $4\frac{1}{2}$ inches wide, one deal making two battens. Battens are frequently used in choice floors, because they contain less sapwood than half deals. Those employed in laying floors may be classed as follows:—first, or the best, which are selected with the greatest care, and are wholly free from knots, shakes, sapwood, or cross-grained stuff, and well seasoned; the second is free from shakes and sapwood, and large knots, but small sound ones are allowed; and the third comprises all that remains after the former have been picked out among the whole lot. The word "plank" is sometimes used in a wider sense than that given above; it is made a kind of general name for all timber excepting fir, which is from $1\frac{1}{2}$ inch to 4 inches in thickness. The word "board" is the name given to flat pieces of timber generally, but applying more particularly to pieces of stuff exceeding $4\frac{1}{2}$ inches in breadth, and under $2\frac{1}{2}$ inches in thickness. "Feather edge" boards, are those boards which are much thicker on one edge than the other. "Stuff" is a general name applied to all woods in joinery. Deals are cut into various thicknesses, called boards, or leaves: so that a deal will always have one cut less than there are boards. If a three-inch deal is cut into a $2\frac{1}{2}$ inch and $\frac{1}{2}$ inch board, two boards will be obtained by one cut of the saw. There are different modes of cutting down deal; they are named according to the number of their subdivisions, as, "three-cut stuff," "five-cut stuff," &c. A whole deal is not three inches thick, as one would suppose, but only $1\frac{1}{4}$ inch. It seems rather absurd that such should be the case, but perhaps it may be accounted for as follows:—deals, especially American, are exported in great numbers of the thickness of $2\frac{1}{2}$ inches; when they arrive they are sawn into two $1\frac{1}{4}$ inch deals, which is the thickness generally required for floor boards, and as an enormous number of $1\frac{1}{4}$ inch boards are thus used in buildings, it is probable that by lapse of time $1\frac{1}{4}$ inch deals have been by workmen taken to mean whole deals. "Slit" deals are generally $\frac{5}{8}$ inch thick, being obtained by sawing down a $1\frac{1}{4}$ inch deal. All thinner boards are termed "veneers." "Tongue" stuff is thin stuff used by joiners for tonguing. What is termed by carpenters, an "offcut," is obtained by converting a 3-inch deal into $1\frac{1}{4}$ inch flooring boards; by that means you obtain a board half an inch thick, which is rather difficult to make use of.

Having, I believe, named all the varieties of deals, I shall now briefly consider their defects.

As a general observation, it may be stated that woods do not alter in any material degree in respect to length. They, however, contract in width, warp, and twist, and when fitted as panels into loose grooves, they shrink away from the edge which is most slightly held, but when held by nails, or other attachments which do not allow them the power of contraction, they will split with extraordinary force. It is said by some authors that the softest woods shrink most in width, but it is very difficult to obtain any correct information on this subject. In woods that have been partially dried, some of these defects are lessened where they are defended by paint and varnish, but they do not then cease; and with dry wood, every time a new surface is exposed to the air, even should the work have been made for many years, these perplexing alterations will, in a degree, recommence, even independently of the changes of the atmosphere, the fluctuation of which, the woods are at all times too freely disposed to obey. The atmosphere has an effect on most woods; and some deals, particularly the stringy deals, are very liable to he affected by the moisture of the atmosphere, and never lose the property, however long they have been seasoned, of expanding and contracting with change of weather. When a log of green wood is exposed to a dry atmosphere, the outer fibres contract both at the sides and ends, whereas those within are, in a measure, shielded from its immediate effects, and retain nearly their original dimensions. Those deals cut near the centre of the tree are very liable to split, yet they are not so bad as those cut near the outside. All deals are slightly split up at the ends, and in twelve feet deals, you can rarely calculate upon more than eleven feet eight inches in actual wood, for they will split up at each end. Splitting is an important thing to be considered in all woods which are cut down into boards: although small splits are not of so much importance in beams and sticks of timber, yet when cut down into thin boards, perhaps half an inch thick, splits and other defects would be total destruction. Sap should be carefully excluded in all deals: we often meet with deals which are very good at one end and defective at the other. The French are not so particular about sap as the English; if the deal has the required quality of good wood on one side, they do not care much about the other side. Their deals are not so good as ours in that respect. The common calculation is, with regard to sap, that in a plank twelve inches wide there shall be nine inches free of sap on both sides. The deals cut next to the sap are the best, between the centre and the sap. The centre deals are clearer of sap than the outside deals. White deals are similar to yellow, except that the sap in white deals is not discernible from the heart. In yellow deals, the sap, or albumen of the tree, ought to show itself only at the edge of that part of the deal which was furthest from the centre of the tree. After the sapwood has been removed from the edges of the board, (or after the edges have been what is technically termed "shot," that is, planed, though they may be shot without removing the sap,) they are called "listed" boards. When the sides are planed, they are described as "wrought." Deals are apt to rend from unequal or too rapid drying, which produces certain fissures or cracks, called "shakes," and deals thus affected, are termed "shaky." Outside deals are very subject to shakes. A knot is frequently very injurious to deals. The bark of a tree sometimes adheres to knots, which consequently have a black ring round them: when the deal comes to be cut into boards, a knot of this kind is apt to fall out. "Cast," or "warped," is an effect produced upon a piece of timber by heat, moisture, or otherwise, the fibres becoming bent, or twisted from their original direction. To prevent warping as much as possible, they are listed.

Such being the defects of deals, it behoves us to consider what are their merits, or what they ought to be. The first thing to be considered is the quality of the wood. Many deals are of good quality, and are therefore fit for rough out-of-door purposes, and coarse floors or carpentry, but are wholly unfitted for joiner's work, for when the saw has passed through them they warp, and will twist like a piece of whalebone. Such deals are termed "strong" deals, and possess the bad property of rending themselves to pieces as they dry, and become shaky. Deals that when sawn do not form sawdust, but are torn into long strings or fibres, and on that account are called "stringy" deals, are in general of this strong nature. Such deals are less uniform in their texture, and vary more in the hardness of their fibres than those deals which are fit for the joiner. The deal, to be good, should be mellow, that is, soft and light, should yield easily to the knife or chisel, should be straight in the grain, without coarse knots (which weaken the deal), and the more nearly it is perfectly clean the better. Such deals are characterised by their light weight, in comparison with the strong fibrous deals; and when planed they exhibit a silky texture. If the deal is cross-grained, it generally becomes shaken diagonally under drying, and falls to pieces under the saw: or if cross-grained in a less degree, it does not yield a smooth surface to the plane, but remains rough and fuzzy. Although from description it may seem extremely easy to tell the difference between a good and bad deal, yet it requires some time before one can do so correctly, as they are sometimes very deceiving.

The next consideration is the mode of rendering the timber fit for use, and the time which can be afforded for that purpose. There are natural and artificial means of seasoning, both of which have their recommendations; it is thought, however, by some, that the former has the right of preference, as it gives greater toughness, elasticity, and durability, and therefore should always be employed in preparing timber for practical purposes. The major part of our best timber is imported from the north of Europe, and is immersed in docks, where it lies floating till sold for immediate use; the consequence of this is, that the timber (though it may previously be properly seasoned) becomes swelled too much, beyond its former and ultimate bulk, is hastily framed together while the very water is running from it, and very soon after it is so converted it shrinks to such a degree, that every tenon becomes loose, every joint strains falsely from the skrinkage, and every ceiling and quartered partition cracks by the opening, diminishing, and distortion of the woods. The effect of this pernicious system may be seen in almost every house in the Metropolis, showing itself in rents, which are caused to the timbers by the irregular strain in shrinkage. Some persons state that the immersion of timber in water is the best method of seasoning it, and I was a few days since in conversation with a London timber merchant, who told me, that the way he seasoned his timber was to immerse it in water for a couple of months, and then stand it end-ways, out of the rays of the sun, but open to the wind and rain. He considered that a windy, showery day, such as we have had lately, was the best possible weather for seasoning timber. Timber for ordinary purposes, should be shrunken to its smallest limits before it is worked up: the least possible change should occur in the timber after the work is framed and adapted; for all the oblique joints, by shrinkage, become imperfect, each bearing timber then hangs straining upon a single point, instead of upon a flat direct abutment; thence many of the struts and other bearing timbers rend, by the weight hanging merely upon their angles. Our specifications are very strict in the requirement of the perfection and proper seasoning of timber; but these precautions are almost useless, as the builder can hardly procure at any price timber which is not in a dropsical condition; and twelve months, in general, suffices to diminish in bulk or split our carpentry, whether it is framed for the palace or the cottage, the public or the individual. This may appear rather a sweeping statement, but I think many will bear me out in the truth of it. Two instances have occurred to me of this fact, within the last few weeks—one in the shrinkage of a large tie-beam, and the other in the shrinkage of some oak wainscoting. The tie-beam belonged to one of the principals of a large building recently erected, the upper floor of which was not ceiled: within one week, and almost before the premises were finished, the upper floor was occupied by a small army of those "who work at the sewing machine." The heat of the rooms began to have an effect upon the beams, and this one in particular, and large shakes and splits opened, and the timber had to be restored, or rather replaced with new. This was, no doubt, owing to the unseasoned wood, which had probably been, within a week or two of being used, lying in a wet dock at some of our timber yards. The other instance is with respect to some oak framing to a large public room, erected within the last five years in London. The architect was very particular in having, what he considered to be, a good piece of workmanship, and good materials, forming the front of two galleries; the work was squared framed, and when finished, appeared certainly a creditable production; but soon after it became subject to the latent heat of a meeting room, the joints opened, and the work has since been patched up with slips of oak inserted in the openings, some of which had opened nearly $\frac{3}{16}$ inch; all this undoubtedly arose from the unseasoned state of the wood.

After timber is felled and sawn, it should be laid along, one piece upon another, only kept apart by short blocks, interposed to prevent a certain mouldiness, which they are apt to contract by sweating one upon another, which frequently produces a fungus, especially if there be any sappy parts remaining. By this means, the rain and the excessive heat of the sun acting upon the timber, it will dry without shakes or fissures. The best way to dry deals is to place them in sheds, due east and west, in Bristol piles. The timber should continue in this situation for two years if intended for carpentry, and three years if for joinery; the loss of weight which should render it fit for the purposes of the former being about one-fifth, and for the latter about one-third. Messrs. Broadwood, and other large pianoforte makers, have their deals and mahogany piled for years before they are used. If timber is to be used round, the core should be bored out, as by this means splitting is prevented. If it is to be squared into logs, it should be done soon after some slow drying, and whole squared, if large enough, as that removes much of the sapwood, facilitates the drying, and prevents the splitting which is apt to take place when it is in the round form, in consequence of the sap-wood drying before the heart, from being less dense; also, if it may be quartered, it is well to treat it so after some time, as the seasoning is by that means rendered more equal. It is well, also, to turn it now and then, as the evaporation is greatest from the upper side. To prevent timber warping, it should be well seasoned before it is cut into scantlings; and the scantlings should be cut some time before they are to be used, and if they can be set upright, so much the better (in order that the seasoning may be as perfect as possible), as they then will dry more rapidly, and, as I have stated, the upper side dries sooner than the lower, they ought therefore to be reversed at intervals. Scientifically considered, the drying is only said to be complete when the wood ceases to lose weight from evaporation; this only occurs after twice or thrice the period usually allowed for the process of seasoning. Some, however, prefer to keep the timber as moist as they can, by immersing it in water, to prevent its warping or cleaving. Evelyn, in his 'Sylva,' particularly recommends this way of seasoning for fir. In this case, when the boards have lain a fortnight under water, they have them set upright in an airy place during the heat of summer, and turned every day; by this practice, new sawn boards (it is said, by those who are advocates of the soaking system) will floor much better than those which have had many years' dry seasoning. To prevent all possible accidents, when floors are laid, let the edges be shot, and brought to a joint, or nearly so, lay them down the first year, and finally fasten them the next; they will then remain without shrinking, provided they be kept dry. The deals imported from abroad, have a year's more seasoning than if they were imported in the log, and cut up in this country; still, it would be a great advantage to have some of them thinner, and so would be sooner seasoned, and fit for use. The deals are cut three inches thick; in that state, they are kept some time to season, and after they are cut the inside of the board is not so well seasoned as the outside, consequently it must undergo a second seasoning, and it would therefore be a great convenience to have deals of various thicknesses. At the end of eighteen months from the time of importation they are scarcely dry enough for the consumer's use.

For the purposes of joinery, steaming and boiling are very good methods of seasoning, as the loss of elasticity and strength which they produce, and which are so essential in carpentry, is compensated by the tendency to shrinkage being reduced; the durability also is rather improved than otherwise, at least from steaming. It has been ascertained that, of woods seasoned by these methods, those dry soonest which have been steamed; but the drying in either case should be somewhat gradual, and four hours are sufficient for the boiling or steaming process. Stove drying, for joiner's work, is also practised by many builders.

The mere seasoning of wood, though it will not altogether prevent its decaying, nevertheless, considerably diminishes its tendency to do so, and is of the very utmost importance in many cases. The value of any process for seasoning wood depends, of course, to some extent, on the time required for its completion. Davison and Symington's method for speedily and effectually seasoning wood, by exposing it to the influence of a rapid and continuous current of heated air, so that it soon becomes thoroughly dry, appears to be satisfactorily proved. Langton's method of seasoning, by extraction of the sap, is another way that is considered well worthy of notice. It consists in letting timber into vertical iron cylinders at top, and the water being heated, and steam used to produce a partial vacuum, the sap, relieved from the atmospheric pressure, oozes from the wood, and being converted into vapour, passes through a pipe provided for that purpose.

Smoke drying in an open chimney, or the burning of furze, shavings, or straw, under the wood, gives it hardness and durability, and by rendering better, destroys and prevents worms: it also destroys the germ of any fungus which may have been commenced. Virgil seems to have been aware of its utility, when he wrote the passage which is thus translated by Dryden:

> "Of beech, the plough-tail, and the bending yoke,"
> "Or softer linden, hardened by the smoke."

Beckman, in his 'History of Inventions,' quotes a passage in Hesiod to the same effect, and adds, "as the houses of the ancients were so smoky, it may be easily comprehended how, by means of smoke, they could dry and harden pieces of timber." In this manner were prepared the pieces of wood destined for ploughs, waggons, and the rudders of vessels. Virgil also says in another place:

> "These long suspend where smoke their strength explores,"
> "And seasons into use, and binds their pores."

When timber or boards have been well seasoned, or dried in the sun, or air, and prepared for fixing, care should be taken to defend or preserve them, which may be done with smearing them over with linseed oil or tar, or the like matters, which contributes much to their preservation and duration. The practice of the Hollanders deserves our notice in this respect; who, to preserve their gates, drawbridges, sluices, &c., coat them with a mixture of pitch and tar, whereon they strew small pieces of cockle and other shells, beaten almost to powder, and mixed with sea sand, which incrust, and arm the timbers wonderfully against assaults of wind and weather. Some, again, advise to bury the pieces of timber in the earth, whilst others are for scorching and seasoning them in fire, especially piles, posts, &c., that are to stand either in the water or in the earth. Sir Hugh Plat informs us, that the Venetians burnt and scorched their timber in the flaming fire, continually turning it round with an engine, till it had got a hard black crusty coat upon it; the wood being brought by that means to such a hardness and dryness, that neither earth nor water could penetrate it. Scorching and drying are undoubtedly good for preventing and destroying infection, but have to be done slowly, and only to timber that is already seasoned; otherwise, by encrusting the surface, the evaporation of any internal moisture is intercepted, and decay in the heart soon ensues; if done hastily, cracks are also caused on the surface, and which, receiving from the wood a moisture, for which there is not a sufficient means of evaporation, renders it soon liable to decay,

When timber is cut before the sap is perfectly at rest, it is bad, by reason of the worm which will certainly breed in the timber. Besides the common worm, to which timber in its dry condition is liable, there are a variety of a more formidable character, which commit their ravages on the timbering of sea works; of these, the most common are the pipe worm or teredo, a species of pholas, the cossi, and another mentioned by Smeaton, which is almost invisible. For the preservation of timber from the teredo, and other sea worms, various methods have been devised. Stockholm tar has been used, but it is of little service, owing to its being manufactured from vegetable substances, and if exposed to the sea the salt acid of the water will eat it away in a very few weeks. Common gas or coal tar has likewise been tried with similar effect; and Kyan's patent corrosive sublimate, or the bichloride of mercury, has been used, but has proved equally useless. Some persons advise that the oil of tar, and pyrolignite of iron, be used; the pyrolignite of iron must be of very pure quality, and the timber must be dry; afterwards the oil of tar should be applied, and not on any account should it contain a particle of ammonia. Mr. Pritchard, of Shoreham, has tried this process in hydraulic works, with great success, and states that in timber piling it destroys sea worms, and supersedes the necessity of coating the piles with iron nails. It is exceedingly difficult to prescribe for the preservation of timber from the teredo; but one thing may be stated as certain, that at present pyrolignite of iron has superseded all the patents.

Besides worms, timber is exposed, chiefly in the Indies, to most dreadful havoc from some species of the ant tribe; from the destructive jaws of the termite or white ant there is nothing secure, unless it be stone or metal; roofs, floors, and other parts of buildings that are constructed of wood are infested by them, and will present when painted a solid appearance, while they are completely hollowed; furniture and wooden utensils alike undergo their devouring ravages. The red ant of Batavia is another little devastator. To destroy ants in wood, kyanize the wood, corrosive sublimate being an effectual poison to them. Arsenic is a good destructive, and charcoal is said to prevent their depredations, though I do not know how it is applied.

But what else have we to battle against, which is worse than the teredo, or the entire ant tribe? Dry rot, which is to timber what consumption is to the human frame: once let it seize hold of a log, and you may send it to Madeira without any effect.

The dry rot may be divided into three classes; the first is generated in the earth, the second in the walls of buildings, and the third is produced by the timber itself. Of the fungus causing the dry rot as generated in the earth, little is necessary to be said. It is a white and fibrous substance very commonly attached to the roots of trees, the banks of hedges being sometimes covered with it; this fungus when attached to timber produces dry rot. Hence it appears that we frequently build on spots of ground which contain the fundamental principle of the disease, and thus we are sometimes foiled in our endeavours to destroy the fungus by the admission of air. In this case, the disease may be encouraged by the application of air as a remedy. Where workmen are employed in buildings which contain dry rot, and where they are working on ground which contains the symptoms of this disease, they have been known to suffer in their health, and one of our first builders informed me some time since, that whilst erecting some houses at Hampstead his men were never well. He afterwards ascertained that the ground was affected with dry rot, and that at present nearly all the timbers were in a state of premature decay.

The fungus which issues from the brickwork of buildings has likewise the property of decomposing timber; it is found in the spaces between the bricks, &c. The causes of it may often be traced to the use of loamy earth and dung with sand for the composition of mortar for walls. This refuse being mixed with a small proportion of lime, and deposited in a humid and warm situation, creates a fungus, which will vegetate, and assume a flat, corrugated or spongy substance which issues from the space between the bricks and penetrates into the ends of the bressummers, joists, &c. No mortar should have sand as a compound unless the sand be previously washed, to separate the loamy particles, which serve as a hotbed for the vegetation of fungi.

Of the fungus causing the dry rot as produced in timber, various opinions have been held. Papworth, in his treatise on Dry Rot, says as to its probable origin, "that the germs may be conveyed into the earth by the rains, and thence absorbed with the sap into the bodies of trees and other vegetables; and when the putrescence attendant on their decay has prepared a suitable fluid for the germination of the seeds, that they produce fungi." That these seeds are germinated by the sap is conformable to the opinion of Pliny, who says that fungi are produced by sap.

Fungi are not in some cases the primary cause of the decay of timber: they are not the disease, but the effects of it; and thus a small portion of unseasoned timber, when placed in a building, may generate the dry rot, and disseminate its baneful effects throughout the edifice into which it may have been unwarily introduced. Sometimes the dry rot is caused by a collection of putrescent matter adhering to the timber, caused by an adjacent vegetable corruption and to a natural disposition in the timber to decay, assisted by the situation in which it has been placed. When the parts of an edifice are so formed that the successive admission of pure air cannot take place, the exhalations from corrupted matter in the earth will collect upon the surface of the timber, affording a proper recipient for the seeds of fungi, which speedily become attached to and find nourishment within it. Many instances of the propagation of fungi might be given, but as all are derived from the same cause, viz., vegetable corruption, it will be unnecessary to dwell longer upon them. In a review, therefore, of the foregoing observations, it will appear that vegetable corruption is suitable to receive and germinate the seeds of fungi, and that such fungi are capable of absorbing the medullary particles of the wood, thereby wholly decomposing it; and that the timber itself, when confined or deposited in warm and moist situations before the motion of the particles is suspended, necessarily undergoes the fermentation which is attendant upon vegetables, by which nature effects the purposes of reproduction, and is consequently decomposed, with similar appearances to that effected by the fungus. To descend from the theoretical to the practical part of the subject, there is one cause of the decay of wood which is very seldom noticed, but which is at the same time a very important thing; and that is, the use of paint in buildings. When wood is painted on every side, the moisture within it is completely sealed, and must become stagnant: decomposition and decay of the timber immediately commences. It is clear that, except when thoroughly free from moisture, or as it is called seasoned, painting must be as effectual a method as any for accelerating its decay. If wood is painted on one side only, it will last as long again as if painted on both sides: experiment has proved this to be the fact.

In regard to the dry rot in connection with the different qualities and species of foreign timber, a few words may not be out of place. In considering the liability of any particular species to take the dry rot, consideration must be paid to the circumstances under which it is imported. Sometimes it is a long time coming here, while at others it is imported in a very short period. The length of time has a great deal to do with its likelihood of taking the dry rot; it may have a very favourable passage, or a very wet one, and the ship is very often in some degree affected with the rot. The rot perhaps begins in the ship, and it may often be seen between the timber or deals, when it will impregnate the wood to a great extent. It is a difficult thing to say whether it is inherent in the timber or not, but of this we may be certain, that where there is a fœtid atmosphere it is sure to grow. American timber is more subject to it than the Baltic, though some think otherwise, for Baltic timber sometimes decays in four or five years. Turpentine is a preventive against dry rot, and American timber is largely impregnated, especially the redwood timber, but not the yellow wood—the yellow wood is exposed very much to the dry rot. Very few cargoes of timber in the log come from America in which in some part of every log you will not see a beginning of the vegetation of the dry rot. Sometimes it will show itself only in a few reddish, discoloured spots on the surface of the log, which, if you scratch with your nail, you will find that to the extent of each spot the texture of the timber to a slight depth is destroyed; and will be reduced to powder—you will generally see also in these spots a white fibre growing. If the timber has been shipped in a dry condition and the voyage has been a short one, there may be some logs without a spot, still, I should think there was scarcely a cargo that came from America in which you will find many logs of timber that are not affected. But if the cargo has been shipped in a wet condition, and the voyage has been a long one, then a white fibre will be seen growing over nearly every part of the surface of each log, and in cargoes that have been so shipped all the logs of yellow pine, red pine, and oak are generally more or less affected on the surface.

Every deal of yellow pine that has been shipped in America in a wet state, when it arrives here, is also partially covered over with a network of little white fibres, which are the dry rot in its incipient state. There is no cargo even that is shipped in tolerably dry condition in which, upon its arriving here, you will not find some deals with the fungus beginning to vegegate on their surface. If they are deals that have been floated down the rivers in America, and shipped in a wet state, they arrive quite covered with this network of the fungus, so that force is often necessary to separate one deal from another, so strongly does the fungus occasion them to adhere. They grow together again, as it were, after quitting the ship, while lying in the barges before being landed. Accordingly, if a cargo has arrived in a wet condition, or late in the year, or if the rain falls on the deals before they are landed, and you pile the way in which Norway and Swedish deals are piled, that is, flatways, in six months' time, or even less, the whole pile of deals becomes deeply affected with the dry rot; so that, when the flat surface of one deal is upon the flat surface of another, the rot penetrates to the depth perhaps of one-eighth of an inch. You arrest its progress by repiling the deals during very dry weather, and by sweeping the surface of each deal before it is repiled; but the best way is to pile the deals in the first instance upon their edges, by which means the air circulates round them, the growth of the fungus is arrested and the necessity of repiling them is prevented. If the ship is built of good, sound, well-seasoned heart of oak, I question if the dry rot would affect it; but in order to prevent its doing so the precaution is usually taken, I believe, to scrape the surface as soon as the hold is clear of the cargo of timber. Were the cargo not cleared and the hold not ventilated, a ship that was permanently exposed to this fungus would no doubt be affected. It is very easy, however, to prevent its extending, by washing the hold with any disinfecting solution. There are two descriptions of European deals very liable to take the dry rot, viz. yellow Petersburgh deals, and yellow and white battens from Dram, in Norway. When Dram battens, which have been lying a long time in bond in this country, have not been repiled in time, they have been found as much affected by the dry rot as many American deals, though this has not happened in so short a time as has been sufficient to rot American deals. The fungus growing on the Petersburgh deals and Dram battens has all the characteristics and effects of dry rot as exhibited in the American deals, the detection of dry rot being in most cases the same. I have not time to go into the different patents for the cure and prevention of dry rot, some are excellent, others good; many ineffectual, and many absurd; some other evening, in some other session, if you will hear me, I will go into the whole subject.

Correction of Ships' Compasses at Sea.—M. Faye suggests to the Academy of Sciences at Paris, a method of determining at any time the error of the compass aboard a ship. This is done by attaching to the ship's log, which is suitably modified as to inclends and form, a compass so arranged, that at any moment it may be stopped, and its direction thus registered. The log is towed in the wake of the ship, and at a sufficient distance to be out of reach of its magnetic influence, and when it has taken the true direction of the ship, which, if of proper shape, it will soon do, the compass is registered, hauled aboard, and read. The proposition assumes importance, from the perpetual variation of the magnetic constants of iron vessels and sea, and the resulting impossibility of perfect correction of compasses. In the course of his communication, M. Faye records a curious experiment, which is worthy of repetition and study:—"Dissolve in an acid, soft iron devoid of any magnetic coercitive force, and then deposit it, by a galvano-plastic process, in a thin film upon the surface of a plate of copper, as is done in coating copper plates with iron, to give them greater endurance. This thin coating of iron, chemically pure, but hard and brittle, will possess so strong a coercitive power, that I have heated a plate thus prepared to the melting point of copper without destroying the magnetism which I had before given it."

INSTITUTION OF CIVIL ENGINEERS.

*President's Address.**

On assuming the chair of this Institution as its President, and undertaking for the first time its duties and responsibilities, allow me to assure you that I feel deeply the honour you have conferred upon me by electing me to this, the highest position to which the civil engineer can aspire; and that I feel still more deeply the weight of the duties which are inseparable from this honour. I will also venture earnestly to request you to extend to me your indulgence during my period of office, and afford me your kind co-operation in any efforts I may make for the advancement of our profession, or for increasing the usefulness of this institution. I ask this assistance from you with peculiar anxiety, because I cannot but feel that the present is a period of unusual importance to this society, and that the rapidly increasing prominence of the profession demands at our hands a corresponding care for its efficiency and dignity. The high degree of material prosperity which this country and its dependencies have now happily enjoyed for a considerable time, has naturally led to great activity in our profession; and probably at no former period have the skill and enterprise of engineers been so severely taxed as during the last few years; and as civilisation continues to advance, and labour to require increased assistance from mechanical contrivances, the connection of civil engineering with social progress will become more and more intimate.

I hope I may be allowed to say, with a deep feeling of professional pride, that hitherto the inventive genius, the patient perseverance, and indomitable energy of the members of our profession have not been found unequal to the tasks they have been called upon to perform; and although I have full confidence in the future, I venture to suggest that the present is a fitting moment for considering the means by which our younger brethren may be best prepared for the arduous duties, and growing difficulties, which they will undoubtedly have to encounter in their professional career. It is not merely that works of magnitude and novelty are increasing, and will continue to increase, but it is becoming apparent that we shall have to meet the competition of foreign engineers in many parts of the world; and that great efforts are now being made, not only by careful scholastic education, but by more attention to practice on works, to render the civil engineers of France, Germany, and America, formidable rivals to the engineers of this country. Here it has always been found that friendly and honourable rivalry among members of the profession has been on the whole beneficial to science and to engineering progress, and we cannot doubt that the same result will follow the more extended rivalry which we shall have now to meet from the engineers of every nation. At the same time this consideration renders it our especial duty to take care, that the distinguished and leading position which has been so well maintained by our great predecessors, shall not be lowered by those who come after them.

The whole field of discussion and description of the past has been so completely and so ably occupied by my predecessors in this chair, that I shall not attempt to travel over the same ground; but I propose to deal almost exclusively with the future, and endeavour, although I possess no peculiar personal fitness for the task, to suggest some of the means by which the younger members and the rising generation may best prepare themselves for the duties which that future will bring with it.

I may first briefly notice, and for the purpose of illustration and introduction, a few of the great engineering problems of remarkable boldness and novelty which are now presenting themselves for the supply of the future wants and convenience of mankind; amongst them may be enumerated the Suez Canal; the tunnel through, and the railway over, Mont Cenis; railway bridges over and under great rivers and estuaries; new ferry works of unusual magnitude; vast warehouses and river approaches for commercial cities like Liverpool; railways under, over, and through great cities; long lines of land and ocean telegraphs; and comprehensive schemes of water supply, drainage, and sewerage. All these works present problems of great interest, and it will require cultivated intelligence, patient investigation, and enlarged experience, to accomplish the task of their satisfactory solution.

For the Suez Canal we must be content to wait a few years before the work be so far advanced as to enable us to judge of the effects of the physical and moral obstacles which to some experienced minds have appeared all but insuperable. The Mont Cenis Tunnel, and the temporary railway being constructed over its summit, will continue to be watched with interest by all engineers, and it may yet be a question how far the mode of traction which has been adopted for the temporary railway will prove to be the best. The modified locomotive has no doubt, with the aid of a central rail, succeeded in surmounting gradients which have hitherto been considered to be more severe than is compatible with the economical use of the locomotive engine; but further experience is still required, and the results of the trial will be watched with great interest, because it cannot be doubted that conditions will continue to present themselves to which the ordinary locomotive engine cannot conveniently be applied. In many of the proposed and future designs of bridges over or under great rivers and estuaries, no novelty in the principles of construction may probably be required; but in other cases the mere magnitude alone will demand new arrangements and combinations, and may possibly also suggest the use of steel for parts or the whole of the structure.

The docks and warehouses of our great commercial cities are rapidly advancing in importance, and are constantly demanding increased facilities to enable them to meet the exigencies of trade; and for this purpose every possible resource of steam machinery, and hydraulic and pneumatic mechanism, will have to be taxed to obtain convenient and adequate power and expedition. The new scheme of river approaches at Liverpool is one of the most remarkable proposals of modern times, for its boldness in grappling with the difficulties and necessities of a pressing want, and the complete solution of a difficult problem. It is understood that the engineer of the Mersey board, who has designed this great work, is preparing a model on a large scale, which I have no doubt will be brought before the Institution. The railways under, over, and through great cities are amongst the most striking results engendered by the necessities of rapidly increasing and closely crowded population, and may be regarded as one of the most useful economical developments which engineering has supplied to satisfy the requirements of modern civilisation. The engineering problems they present are infinite in their number, and interestingly intricate in their character.

Ocean telegraphy is yet in its infancy, but enough has been done by the numerous lines already laid, and by demonstration before this Institution, to prove that further experience alone is wanting to enable deep or shallow sea cables to be successfully laid and maintained wherever they may be required; and probably in no branch of our profession is the future of greater interest than in the coming telegraphic connection of every part of the world by sea and land, and in the political, commercial, and social results which must follow such a remarkable increase in the facility of general intercommunication. The rapid growth of communities to which I have already alluded has also developed the necessity of provision being made for a more abundant supply of pure water, and for a more complete system of sewerage than is now generally possessed by our towns and cities; some of these works are already being carried out, or seriously contemplated, on a scale of almost startling, but not unnecessary, magnitude.

It is plain, therefore, that in every department of civil engineering the wants of commerce and society are pressing more and more urgently upon the resources of our profession. We have ship canals; but the Suez Canal throws them all into the shade. We have long tunnels through our English mountains; but we have now to penetrate the Alps. We have large bridges; but larger are required. We have noble ports; but they are choked with trade, and new accommodation of an improved kind is called for. We have steam ferries across rivers, estuaries, and straits, and rapid ocean steamers; but higher speed and better accommodation are demanded. We have large warehouses, with convenient mechanical appliances; but larger warehouses and better mechanical appliances have become a necessity. We have many thousands of miles of telegraphic communication; but nothing short of its universal extension will suffice. In the solution of these problems, thus rapidly indicated, and in others which could be easily adduced, we may rest perfectly satisfied that the difficulties they present are not to be overcome by a stroke of genius or by a sudden happy thought, but they must be worked out patiently by the combination of true engineering principles, ripe experience, and sound judgment.

Having thus called your attention to the peculiar position of

* Abstract of Inaugural address delivered by Mr. Fowler, President, Jan 9, 1866.

our profession in consequence of its rapid growth, and pointed out some of the problems which await an early solution, I shall now attempt to describe the nature of the functions of the modern civil engineer, and consider how the coming generation can be best prepared for its inevitable work, and to what extent this Institution can be made ancillary to that purpose. Although we know from history that men have existed from the earliest times who have been distinguished by great mechanical capacity, remarkable skill in working materials, profound science, and constructive knowledge, yet it is only during the present century that civil engineering can be considered to have become a distinct and recognised profession. Now, however, it has assumed the position of an art of the highest order. Perhaps we may without arrogance be entitled to claim for it the title of a true *science*. Many attempts have been made to define and describe a civil engineer in a few general words, but all such attempts have been more or less unsatisfactory. Still, though it is difficult, if not impossible, to describe an engineer by a short definition, it is not so difficult to enumerate and describe the nature of the works he is required to design and execute, and the professional duties he is called upon to perform. He has to design and prepare drawings, specifications, and estimates, and to superintend the carrying out of works which may be thus enumerated:—1. Railways, roads, canals, rivers, and all modes of inland communication; 2. Water supply, gasworks, sewerage, and all other works relating to the health and convenience of towns and cities; 3. The reclamation, drainage, and irrigation of large tracts of country; 4. Harbours of refuge and of commerce, docks, piers, and other branches o hydraulic engineering; 5. Works connected with large mines, quarries, ironworks, and other branches of mineral engineering; 6. Works on a large scale connected with steam engines, with machinery, shipbuilding, and mechanical engineering. This list, which might be almost indefinitely extended, involves a vast variety of work, and must appear almost appalling to a young engineer, and yet it greatly concerns his future success that he should, as far as possible, be prepared to undertake any or all of the works embraced in the list. I believe the personal history of most of us would show that circumstances have led us in a widely different direction in the exercise of our profession from that which we originally contemplated, and that the success of many men may be distinctly traced to their ability to avail themselves of unforseen opportunities to advance in some new direction. The civil engineer must therefore be prepared for the various classes of constructive works thus enumerated: but in addition to this professional preparation it is of the first importance as affecting his true position, and the confidence which ought to be reposed in him, that he should also have a correct appreciation of the objects of each work contemplated, as well as their true value, so that sound advice may be given as to the best means of attaining them; and he must be prepared, if necessary, to advise his employers that the objects which are sought are not commercially worth the cost of the means which would secure them. It is not the business of an engineer to build a fine bridge or to construct a magnificent engineering work for the purpose of displaying his professional attainments, but whatever the temptation may be, his duty is to accomplish the end and aim of his employers by such works and such means as are on the whole the best and most economically adapted for the purpose, at the smallest possible cost, having reference to future maintenance, and ultimate permanence.

I will now proceed to the question of the kind and degree of knowledge which is required to enable a young engineer to proceed to the actual design of a public work of importance, such as a railway with its stone, brick, and iron structures, its earthworks, and its all-important permanent way, a railway station, a station roof, docks and their appliances, waterworks, breakwaters, or a Great Eastern steam ship. Although it has become the practice in modern times for many civil engineers to be employed chiefly, or almost entirely, in some one branch of the profession, I desire to repeat my conviction, that it is most important that the early preparation and subsequent study should be as extensive as possible, and should embrace every branch of professional practice, not only for the purpose of securing to a young engineer more numerous opportunities for his advancement, but also because sound knowledge and experience in all branches of engineering will greatly add to his efficiency and value in any especial branch; in the same manner that a medical man will be more reliable in his practice on the eye and the ear if he possesses a sound practical and theoretical knowledge of every part of the human frame. All classes of the profession, but especially the railway, the dock and harbour, and the waterworks engineer, must possess a knowledge of parliamentary proceedings, so as to be able to avoid all non-compliances with the standing orders of parliament. This, it is true, is no easy matter, as the clauses are often drawn up with so little care and practical knowledge that neither engineers nor solicitors, nor the most experienced parliamentary agents, can understand what is intended. On the subject of parliamentary proceedings generally, it may be taken for granted that all committees desire to do justice to the cases which are brought before them, and that if they sometimes fail in their decisions, either as regards the interests of the public, or in arranging a fair settlement between antagonistic interests, it is not unfrequently due to the imperfect and crude manner in which cases are presented to them; and I would impress on all young engineers the importance, both to themselves and to their clients, of laying their cases before committees in the most perfect manner possible, accompanied by full and correct information, carefully prepared and clearly worked out.

The professional knowledge required by the railway engineer commences with surveying of all kinds, the use of the theodolite, the aneroid barometer, the level, the sextant, &c., and includes surveys for preliminary and parliamentary purposes; and also working surveys of minute accuracy, on a large scale, from which engineering works may be set out with precision upon the ground. The railway engineer must understand thoroughly the nature of earthwork of every kind, and the proper angles or slopes to be adopted for cuttings and embankments. He must have the requisite qualifications to enable him to design bridges, viaducts, tunnels, and all other incidental works and buildings, in the best and most economical manner. He must have a knowledge of the training of rivers, and the effect of floods and drainage, to enable him to make accurate provision for the discharge of water, without waste of money by unnecessarily large works, or the risk of damage from works which are insufficient. He must be familiar with the various characters of permanent way, the best description of rail, sleeper, fastenings, and ballast, and with the different descriptions of switches, crossings, turntables, signals, and telegraphs. In the matter of permanent way, it is somewhat remarkable that, with all our experience, there should still remain a doubt amongst engineers as to the best kind to be adopted even under similar circumstances. For, although continental engineers have almost without exception adopted the flat-bottomed or "Vignoles" form of rail, the I form of rail with equal top and bottom webs, and cast-iron chairs and wooden keys, is still largely used in this country. A collection of facts with respect to the different descriptions of permanent way in use in this and other countries, with a view to arriving at a comparison of the advantages and disadvantages of each, would form a most interesting and important paper for the Institution, especially if it embraced all the recent experiments with reference to the use of steel rails.

The railway engineer should not be destitute of some knowledge of architecture, and such a taste for those graceful outlines and simple appropriate details which should always characterise the works of an engineer, avoiding, on the one hand, the unnatural ornamentation which seems to have no connection with the structure, and, on the other hand, a disregard of either form, outline, or proportion. But all such knowledge may fail if there be not constant supervision and control over the quality of all the materials and the workmanship employed upon the railway; and it is not too much to say that, without the practical knowledge which is only obtainable by having first performed the duties of resident engineer, it is hopeless to expect that any engineer can be competent to undertake the responsibility of important works, or be fit to have large sums of money entrusted to him for expenditure. It is in the capacity of resident engineer that all previous preparations, both scholastic and professional, and all theoretical acquirements, become utilised and rendered of practical value; and it is only after much experience on different works of varied character, dimensions, and materials, that a young student of engineering can claim to take rank as a "civil engineer."

The dock and harbour engineer requires the general and much of the special knowledge of the railway engineer, such as that which belongs to railways and tramways, and warehouses for goods; and to this he must add a vast amount of other special knowledge not required by the railway engineer. For example, he must understand the laws which govern the ebb and flow of the tides, the rise and fall and time of high and low water, and he must have a knowledge of marine surveying, or the best means of ascertaining the set and speed of currents, and their tendency to increase depth of water by scour, or to diminish it by silting; he must also know, in the case of docks, what kind and extent of entrance accommodation to provide, whether the general plan should comprise only a simple lock, or be combined with a half-tide basin; whether single or double gates should be used; and whether it would be necessary to have a tidal basin, or a recessed space, or both. The nature of the trade to be accommodated in the proposed docks must also be carefully ascertained, in order to provide a proper proportion of quay space and water space, and proper width of quays, warehouses for bonding or for goods to be deposited, sheds for temporary protection, entrance for barges into warehouses from the docks, graving docks and workshops, with mechanical appliances for gates, sluices and pumping, and for shipping or discharging minerals or goods. He may have to deal with solid foundations, and enjoy a facility of procuring suitable materials for construction, as at Liverpool; or he may have the bad foundations of Hull and other places where alluvial silt of great depth has accumulated. It may be that good sound stone is too costly for the mass of his work, and that he must resort to brickwork, or rubble stonework, or concrete, or to a combination of all three; but in determining such questions it is impossible that anything but previous experience and habits of careful investigation will enable an engineer to arrive at the best decision. For it is not enough that his work should be solid, permanent, and safe, but it should be rendered so at the smallest possible cost. The dock and harbour engineer is also required to report upon, and to construct, harbours of refuge, piers, landing-stages, lighthouses, forts, canals and their appliances, river improvements, and many other hydraulic works; and, in short, of this branch of engineering it may be truly said that questions are continually arising which require special study and mechanical invention to a greater extent than in almost any other branch of the profession. Harbours of refuge, being large and costly works, are necessarily few in number, and they are so slow in progress, and have generally been so often changed from their original object and design, that few engineering works have given less satisfaction either to the profession or to the public; but we may hope, that if governments will accurately appreciate the objects they desire to obtain, and boldly grapple with the difficulties and cost of well-matured designs, better and more useful works of this nature may be accomplished than have yet been undertaken.

The waterworks and drainage engineer must possess many of the qualifications of the railway and dock engineer, and especially those which concern earthwork and masonry; he must also be familiar with the means of obtaining information on the subject of rainfall in different localities, the methods of correctly gauging streams of every kind; the proportions of the rainfall available for his purposes after estimating for evaporation and waste, and the extent of the provision to be made for periods of dry weather, or for compensation to mill-owners and other interested parties. He must be conversant with the proper mode of executing the works of reservoirs, conduits, weirs, tunnels, and aqueducts. He must understand, by the aid of the chemist and his own experience, the nature of the impurities in water, and the best mode of diminishing them, whether mechanically, by subsidence and filtration, or otherwise. To the waterworks engineer we must look for the solution of one of the great problems which the rapid increase of population is now forcing upon us; viz., a comprehensive system of conservancy of the flood waters of mountainous localities for the use of large cities and towns, and densely populated districts. We are completely outgrowing our present arrangements for water supply in the great majority of instances; and the convenience, comfort, and health of the public demand that such works when required shall be no longer postponed. The initiative has been taken as to the question of a new source of water supply for London, in a pamphlet by a well-known authority in this branch of engineering, and sooner or later the subject must command public attention. The waterworks engineer must also be competent to design and superintend works of sewerage, as well as of water supply, for large and small towns and localities; and his familiarity with waterworks will naturally aid him in this, as the problems for the discharge and pressure of fluids are identical in both cases. The great sewerage works of London are now far advanced and have already produced beneficial results; the attention of other still neglected cities and towns has recently been called to this important subject by the loud and startling voice of a threatened return of cholera, and it is to be hoped that the proper authorities will perform their duty promptly and efficiently in this matter; but I cannot here refrain from calling attention to a gigantic evil which has been created by certain drainage and sewerage works already executed, and where the convenience and comfort of one set of people have been secured only by the infliction of a nuisance upon others: I allude to the discharge of collected sewage, without any attempt at purification or deodorisation, into streams of pure water. It is remarkable that an injustice so great, and an evil so intolerable, should in any case have been permitted by parliament or by the general law of the land; but now that public attention has been fairly directed to the subject, let us hope that as soon as possible a remedy will be applied to the cases where mischief has already been done, and that care will be taken to prevent its recurrence. It is no longer a matter of doubt that deodorisation or purification is quite practicable in every locality, and therefore no sewage should ever be permitted to be discharged into existing streams without this purification, or it should be carried out to the sea, and there discharged, as is now proposed for the north side of London.

The mechanical engineer deals with the most varied and numerous subjects of all the branches of engineering. They require that he should thoroughly understand the means of producing mechanical power, and of applying it to all the infinite variety of purposes for which it is now demanded. To this end he should be master of the laws of motion and rest, of power and speed, of heat and cold, of liquids and gases. He must be familiar with the strength of materials under every variety of strain, the proper proportions of parts, and the friction of surfaces. He must apply existing tools and contrive new ones for his work, and know how to direct power in the raising of weights, or for driving all fixed machinery, or in producing locomotion on land or water. On railways he is responsible for the vast number of objects required in the machinery for erecting and repairing shops for the engines and carriages, for the pumping and other fixed engines, and especially for the locomotive engine itself, and for rolling and fixed plant generally. In connection with docks, he is required to design the machinery for opening and closing the dock gates, working sluices, emptying graving docks, or for working the cranes on the quays, or in the sheds and warehouses. The mechanical engineer generally also executes the designs of the gas engineer, even when he does not originate the work which is intrusted to him; and in this branch considerable chemical knowledge must be added to his mechanical qualifications. For waterworks he designs and executes pumping engines, sluices, valves, stopcocks, &c. In the case of mines he supplies the designs of the engines for pumping, drawing, winding, or ventilating; for locomotives above and below ground, as well as for the various mechanical appliances required in collieries, mines, and ironworks.

The adoption of the telegraph has been so astonishingly rapid and extensive, both by sea and land, and the purposes to which it has been applied so important, that a considerable body of able and accomplished engineers have devoted themselves almost exclusively to the subject for the last few years, and have already created a new branch of the profession, called telegraphic engineering; but to be an accomplished telegraphic engineer, it is necessary first to be a good mechanical engineer, and then to add the special knowledge of the electrician, and therefore I include them under the head of mechanical engineers. I think it may fairly be traced to the distinguished ability of that class of mechanical engineers who have devoted themselves to telegraphic engineering, that already so much has been done in telegraphy. Certainly no discussions have been more ably sustained in this Institution than those upon this subject.

Allied with the mechanical engineer is the naval architect, and only a mechanical engineer could have constructed the vast steam-ships of modern days. The ordinary timber-ship builder of old would have been literally "at sea" in the construction of modern vessels, wherein the material is iron, and when the size of the vessel requires scientific knowledge of form and resistance, of strains and of strength, and when steam is the motive power. The demand for large and swift vessels for ferries, for long voyages, for floating batteries, and for iron-clad sea-going vessels, has of late been so great that the construction of steam vessels has become a distinct branch of engineering, under the name of naval architecture.

The mining engineer must possess much of the knowledge of the railway and mechanical engineer, and he must add to that general knowledge much special knowledge of his own. He must know how to sink shafts to the minerals if they require to be extracted from beneath the surface (which is usually the case) and how to divert or pump out the water he meets with either in the shafts or the workings. He must know how to excavate and bring to the surface minerals, whether they be coal, copper, tin, lead, or iron, and to do this he must construct subterranean railways, provide means of ventilation by fans or furnaces, supply power to lift the extracted mineral to the surface; and when brought there he must understand the further requisite work, as the coal will probably require screening, or washing, or manufacturing into coke; and the ore will require crushing, washing, or smelting, or possibly all three operations. In all these cases, and many others, such as the collection of surface ironstone and other minerals by railways and locomotive engines, and the working of lifts and inclined planes, the mining engineer has most important functions to perform, and special machinery to adapt or invent; and relying on his judgment and skill alone, the investment of large sums of money for the development of the mineral wealth of this country is annually made.

I must not altogether omit a passing reference to the scientific talent which of late years has been devoted to artillery—its weapons of attack and works of defence; and I think we may fairly claim that it is mainly due to some of the able members of this Institution that this art has been placed on a new and vastly improved basis, and that as a consequence a new branch of the profession has been actually created—artillery engineering.

ON THE TENACITY OF SOME FIBROUS SUBSTANCES.

By W. J. Macquorn Rankine, C.E., L.L.D.

In order to compare the tenacity of a substance with its heaviness, the load required to tear a given bar, strip, or cord asunder is to be multiplied by the length of so much of the same bar, strip, or cord as weighs an unit of load: the product being the tenacity of the material expressed in units of its own length. The following examples are taken from ordinary tables of the heaviness and tenacity of materials:—

Material.	Dimensions.	Tearing Load, lbs.	Length of 1 lb. weight in feet.	Tenacity in feet of the Material.
Cast steel bar	1 in. × 1 in.	130,000	0·297	38,610
Charcoal iron wire ...	area 1 sq. in.	100,000	0·3	30,000
Iron wire rope ...	girth 1·27 in.	4,480	0·6	26,880
Iron bar, strong ...	1 in. × 1 in.	60,000	0·3	18,000
Boiler plate, strong ..	area 1 sq. in.	50,000	0·3	15,000
Teak wood	1 in. × 1 in.	15,000	3·0	45,000
Deal	1 in. × 1 in.	12,000	4·0	48,000
Hempen rope, hawser laid	girth 1 in.	1,050	26·0	27,300
Ditto, cable-laid ...	girth 10 in.	67,200	0·279	18,750

It would be easy to multiply examples such as the preceding.

If the same method be applied to the weights and tearing loads of canvas, as given in Mr. Carmichael's paper on that subject, the following are the results:—

	Royal Navy Canvas. Mean of Nos. 1, 2, 3, 4, 5, 6,	Mean of Nos. 7, and 8.
Tenacity of warp in lineal feet of canvas ...	21,552	27,200
Tenacity of weft in lineal feet of canvas ...	30,788	32,000
Mean tenacity of the flaxen yarn in lineal feet of itself, being the sum of the tenacities of the warp and weft ...	52,340	59,200

These results show the least strength that is allowed to pass the test.

Since reading Mr. Carmichael's paper, and making the foregoing calculations, I have made some experiments on the tenacity of flaxen thread and silken thread, of which the following are the results:—

The flaxen thread was unbleached, and measured 15,833 feet to the pound weight. Its tenacity was not uniform in different parts; and as, in the practical use of any material, the least strength alone is to be relied on, I ascertained carefully the breaking load of the weakest parts of the thread, which was 6 lb. Hence the tenacity of that thread, in feet of itself, was

$$15{,}833 \times 6 = 95{,}000 \text{ feet.}$$

The silken thread was of two sizes, measuring respectively 9417 feet, and 19,950 feet, to the pound. The tenacity of each specimen was sensibly quite uniform at different points. The breaking load of the thicker specimen was 12 lb.; that of the thinner specimen, 6 lb. Hence their respective tenacities, in feet of themselves, are as follow:—Thicker specimen, $9417 \times 12 =$ 113,000 feet; thinner specimen, $19{,}950 \times 6 = 119{,}700$ feet;—the latter specimen thus proving to be three times stronger for its weight than cast steel.

In these experiments the length of one pound of the thread has been ascertained to the precision of about 1 per cent., and the breaking load to that of 3 or 4 per cent.

It is probable that silk is the most tenacious for its weight of all known substances; and when, together with that fact, we take into account that its specific gravity is almost exactly that of water, it would seem, from a purely mechanical point of view, as if silk were the most suitable of all substances to give strength to submarine telegraph cables. But, unfortunately, when we consider the question from a financial point of view, it turns out that the price of silk is so high as to make its use in telegraph cables quite impracticable.

Knowing that silk fibre is of the same heaviness with water, so that a prism a foot long and an inch square weighs 0·433 lb., it is easily computed that the tenacities of the two specimens in lbs. on the square inch are as follows:—Thicker, 49,000, very nearly; thinner, 51,900, or equal to the strongest boiler plate.

I have also made a few experiments in order to determine the extensibility of silken thread; but the complexity of the phenomena which take place when that material is stretched, have hitherto prevented my obtaining precise results. Even a small load produces a stretching which gradually increases with time, and which also gradually disappears after the load has been taken off.

A load of 5½ lb. put upon a thread of the thicker kind, whose original length was 52·78 inches, produced a total extension of 3·56 inches, of which, between 1·5 and 1·6 inch, was set, continuing when the load was taken off, but gradually diminishing afterwards; while the remaining inch, or thereabouts, was elastic strain. About half of the set, viz., ·75 or ·8, had disappeared two hours after the load was taken off; the remainder continued to exist after the load had been off 8 hours. The extension, with a given load, was on an average about 0·10 inch less when the load was increasing than when it was diminishing, showing the effect of what Prof. William Thomson has called "molecular friction." The results of the experiments correspond on the whole approximately with the following value:—Modulus of elasticity of silk fibre, 3,000,000 feet=1,300,000 lb. on the square inch. If we take the proof load, or greatest safe load, at one-third of the breaking load, the modulus of resilience or power of bearing shocks, which is a third proportional to the modulus of elasticity and the proof strength, is found to be as follows, for the thicker specimen of silken thread:—473 feet (that is, 473 foot-pounds for a prism weighing 2 lb.), corresponding to 205 foot-pounds for a prism of 2 feet × 1 inch × 1 inch.

The resilience of a tie bar 2 feet long, and 1 inch square, has the following values for some other substances.

Very strong tough steel	60 foot-lb.
Strong hard steel	46 „
Soft steel	31 „
Good iron wire	36 „
Good bar iron	14 „
Strong plate iron	12 „
Strong tough cast iron	4 „

Occasions may arrive when it is necessary to have cordage of the least possible weight for a given strength or for a given resilience, without regard to expense; and then without doubt the best material is silk.

Steam Fire Engine.—A trial of a very powerful Steam Fire Engine, stated to be the most powerful one of the kind ever constructed, took place on the 29th ult. The engine tried was the sister engine to the "Sutherland," built by Merryweather and Sons, and proved herself to be even more powerful than her celebrated predecessor—throwing a jet of 1¼ inch diameter, in the direction of a moderate wind, to a distance of 300 feet—the spray going much farther. Under similar circumstances, a 2 inch jet was projected over 200 feet.

EXPANSION AND PROPULSION.

All persons are familiar with the transcendant achievements of steam power, and almost all consider them prelusive to others still greater; but while everyone sees what it does, comparatively few perceive how it is done. Ideas of it that reach no further than external features and movements of an engine are indefinite, and more or less cloudy and chaotic. Even with engineers themselves, there are points on the evolution, treatment, action, and applications of the fluid far from being lucid and sharply defined. Opinions greatly vary. Two examples may here be quoted—one of marked interest to the engineering community, the other of greater importance to the national and commercial marine: 1. The economy of expansion by cut-offs. 2. The virtue of *form* in propelling blades. The competing engines of the Algonquin and Winooski will go far to settle the first, but not the second, without removing the undershot water-wheels, suspended as paddles over the sides of both vessels.

Of the economy of stopping the flow of steam into a cylinder before the piston reaches its ends, there is and has been no diversity of opinions; the fact is palpable, and such has been the uniform practice since the beginning. The points in dispute are the extent to which the principle is urged, and the amounts of gain claimed. Prevailing opinions, right or wrong, have always governed, and much that is due only to reflection and demonstration is still yielded to popular dogmas, to interest and feeling. Inventors oftener build without data than with them, and what is worse, their propositions are too commonly made bases of speculation. All this is natural, at any rate unavoidable; nor is it on the whole, to be regretted that truth in mechanical as in other departments of research, has to be reached through conflicts with interests and error. Without efforts to attain it we could neither be prepared to receive it, nor capable of appreciating it. That which costs little or nothing is held of small account.

While admirers of "independent" cut-offs dwell complacently on that part of the operation to which "the great saving" is attributed, others glance at what they hold as a full counterbalance. Thus, when a charge cut off at one-third drives the piston through the remaining two-thirds, a clean profit is claimed. To this other observers say nay; that against it should be placed the expenditure of two-thirds more power—steam—on the first part of the stroke than was necessary, and hence that what is gained at one point is lost in another; at all events, that the difference is rather slight than serious. But may not the surplus force on the first part be recovered and applied to the latter? No, not a particle. Misspent force can no more be recalled than misspent time. It vanishes with its action, and no longer exists. Yet the steam is still in the cylinder. Granted, but it no longer possesses the power gone out of it. The power is in expansion, and while the piston was stationary it was intact, but diminished as that gave way before it. At a first glance the loss may not be apparent, but the difficulty will vanish when it is remembered that communication with the boiler is not closed till the piston has passed through the cylinder to the point fixed on for the cut-off to act. Till then, the loss is made good from the boiler, and consequently does not appear in the cylinder. Could unproductive or misapplied force, of any kind, be recovered and turned to profit, the economy of creation would be very different from what it is.

It would moreover be a marvel if additional power could be got out of a definite quantity of steam by increasing its tension—if one-third of a charge at 90 lb. on the inch were more effective than a full one at 30 lb. As well expect to spin more thread out of closely than loosely packed cotton. Compression can add nothing to the fibre or fluid. The gain, however, is ascribed to economy in expending the fluid, rather than to an increase of its quantity, and engineers on both sides of the Atlantic have indorsed the system. The government experiments will, it is presumed, definitely settle the question. When they are completed and published we shall learn whether the principle of high or extreme expansion is to be preferred to the doctrine of those who hold that the available force of the charge can vary but little, whether compressed into one-tenth, one-fourth, or one-half of its initial volume—that disbursing steam and money is much the same, a gold dollar going no further than a silver one, nor it varying in value, whether laid down in one piece, or in halves, quarters, or dimes. There are probably no expenditures of force unattended with loss or waste, but by no system of saving can the principle be reversed and the outlay of one portion command a return due to a greater.

It is to the second proposition this paper is intended more especially to invite attention—one of high import to the government, since it involves the question of speed, and that in vessels of war is vital—is everything. It has elsewhere been remarked that an increase of a few knots in our cruisers would have virtually ended the late horrible war two or three years ago, saved thousands of lives, and multiplied millions of money—that it may as well be obtained as current rates, and will be, though perhaps not without further struggling against a plain law of physics—plain and perfect to those who look into it, a stumbling-block and foolishness to those who do not; that is, those who prefer rectangular planks to the form of blade which science proclaims, and nature everywhere confirms—whose ideas of driving ships over seas and rivers are those of the builders of Roman gallies, and engineers of the Middle Ages. They propelled vessels by two, four, and sometimes six oxen. Two were yoked to and travelled round a vertical shaft, and each shaft carried a pair of paddle wheels identical with those by which they ground corn on the edge of running streams, and in boats anchored on rapid rivers.

If there are other examples of non-advancement over the dark ages as gross as this, we know not where to look for them. Our planet is a school for engineers, as for other professions It is alive with illustrations of mechanical laws, as fixed and immutable as the universe itself; and nothing is more certain, that only so far as our devices accord with them can they succeed. Thus it will be, as heretofore, with the propelling blades of a steamer as with the force that propels them. Abortive must be all attempts to make her speed what it ought to be, as long as the principle of form so distinctly and variedly manifested in organisms that move rapidly through air and water is ignored. It is fundamental. No finite intelligences can improve or supersede it. There is marvellously more in it than common observation perceives. It governs other attributes. Endless are the projects on minor points, and all of them fruitless for lack of that which only can give value to any.

Every horizontal section of a blade has a different velocity and, to make the resistance and effect uniform, its width must diminish with the dip. The centre of resistance, instead of being near the extremity. will then be drawn in towards the centre of the blade, and economy of force will result. There is, in fact, a reciprocal influence pervading every part, every feature and movement of a perfect blade; and wherever this harmonious action does not exist, loss of speed and waste of power are and will for ever be inevitable, for physical laws are eternal. There are some things which the present state of science and the arts cannot accomplish, but there is no obstruction, mental or physical, to our giving to sea-boats a maximum of speed with a minimum of force—to our rivalling in this respect the ablest engineers of the future!

If not disgraceful, it certainly is not creditable to American and European engineers that the problem has not been solved before now. It would seem impossible for it to be much longer neglected. The present opportunity of again bringing it to the notice of the Navy Department is singularly favorable. Numerous public vessels have been sold, and more are yet to be disposed of. Out of so many, one or two might surely, and without injury to the public interest, be detained for the purposes of experiment. The British government has experimental steamers, and much more should ours; but passing that, all that is now asked is that the Algonquin or Winooski—the one which proves the fleetest in the approaching trial—be fitted with blades on the principle recommended in the Patent Office Report of 1849. It is therein demonstrated that speed is essentially affected by the figure, thickness, and number of the blades—that their propelling power expands and contracts with the volumes of water they displace. Ocean steamers had them of 2½, 3½, and even 4 inches thick, amounting to from four to five hundred cubic feet of solid timber to be kept whirling through air and water, and losing on the average 7 feet of effective stroke (the aggregate thickness of one wheel's blades) at each revolution: some wheels actually lost 12 feet of stroke at every turn. But there were engineers then who maintained the hypothesis, "the thicker and heavier the blades the better, for the heavier the wheels the easier they work!"

The length of paddle planks then varied from 12 and 14 to 22 feet! The incessant jar arising from their striking the water was shown to be a ceaseless source of destruction to both engine and vessel, as well as waste of power. Some boats had wheel-houses wider than their decks, so as to make it doubtful to strangers to such craft whether the hulls were accessories to them or they to the hulls. In this respect the number of blades has been greatly reduced. There were then steamers with 36. The United States, among others, had one bolted to each side of her radial arms or levers. The number settled down to 28, next to 14, and now there are examples of only 7 being employed, as urged in the report. But the most important suggestion is yet ignored by those who have taken advantage of the rest, and, with scarcely an exception, without the slightest acknowledgment. It will, however, yet be conceded that the naked arms of old steamer's wheels would, if sufficiently lengthened, have propelled them more effectually than the usual plank paddles attached, because of their approximating to the only principle applicable to the case—that which nature illustrates in the long, narrow, and tapered organs of her swiftest swimmers and flyers; and (as there is no originating a law or principle of our own) which, in order to succeed, we must adopt or fruitlessly oppose and fail as heretofore. Instead of churning the water's surface with wide dashers, we must take deep hold of it with blades that enter without jarring and lift no loads of it on leaving.

The usual prenomen to steamers' wheels is a wrong one, there being no analogy in their action and that of the Indian's paddle. To resemble it the longer axis of the floats or buckets, instead of being parallel with the shaft, should be perpendicular to it, and instead of seeking resistance away from the hull, find it in depth close to it. The oar reaches out, but that is to adapt it to human power. Sweeping horizontally through the water at a much greater distance, more power is lost in being imparted to its blade than to that of the paddle. In large wheels the loss is considerable, as the power has to pass to and from the furthest ends of the buckets, whose action is really that of rotating oars—widely different from that of vertical paddles, which would dispense with three-fourths of the massive overhanging shafts.

To use the narrow blades of paddles for undershot wheels would be quite as rational as employing the wide planks of the latter for propellers.

A series of experiments was proposed to the administration of President Taylor, and a vessel—the Water Witch—was designated for the purpose, but his sudden and lamented death put an end to the design. Conducted under the supervision of the heads of the Coast Survey and Smithsonian Institution, scientific officers of the navy, and representatives of the Franklin Institute, the result, whether in favour of or against the current wheel, would have been of lasting value, and so will the solution of the problem be, whenever and by whomsoever it is accomplished. The government has now another reliable source of information and advice in the National Academy of Science.

In 1855, Profs. Bache and Henry, in a letter to the Secretary of the Navy, stated that the proposed experiments "would be of great practical value to the world at large, and of particular advantage to the Navy of the United States." But the time for them had not come. The reply was, "The Department appreciates very highly the importance of a series of experiments on the best form of propelling blades or paddles for producing, with a given expense of power, the greatest useful effect. It has, however, to regret the want of authority to undertake them, * * and could not, without inconvenience to the public service, furnish a vessel for the purpose."

It may be that the Navy Department inclines to the opinion of some of its subordinates, that the paddle wheel is all that is wanted, and, so far from ever being superseded, is destined to move the earth's fleets of steamers as long as its prototypes transmit power from running streams to mills and factories. Well, why not then have a practical demonstration of its superiority, which would repay the cost a thousand-fold, and reflect enduring honour on the department. The expense can hardly exceed the tithe of a tithe of the pending experiments on steamers and steam. Were it as great, it would be true economy to incur it.

There is, of course, an end of the question of propulsion with those who think there is no natural law or principle of velocity in steam vessels, or, if there is, that it has no relation to the form of propelling instruments. If they are right, the highest speed has been attained, and we must sit down and rest satisfied with the common wheel, for there is no risk in repeating the assertion that nothing more is to be got out of it. After undergoing endless variations in details, its dimensions have been swelled to extreme practical limits, and to meet the resistance an unprecedented amount of metal has been put into the shafts—and to what purpose? The largest have been strained to breaking, yet no increase of speed. But it is preaching in the desert to reason with those whose ideas of progress are bounded by the present, who imagine that steam-ships of the future are not to surpass those of to-day.

The sole motive in calling the attention of the government once more to the subject, is an abiding conviction of its importance to the navy. The writer has no selfish object to accomplish—no wish to divert a dollar from the treasury into his pocket. He has nothing to gain by the adoption of his views, and nothing to lose by their rejection. E.

SOCIETY OF ENGINEERS.

The following are portions of the inaugural address, delivered by Mr. Zerah Colburn, on his election as president of the Society of Engineers, on the 22nd ult.

It is not necessary that I enlarge here upon the past progress nor upon the probable future of the engineering profession, nor shall I detain you with a review of the engineering works achieved last year, nor with a list of what is to be attempted this year. All these you are in the habit of reading in the newspapers, and I need only say, if it be considered necessary in my position to say it, that I believe the profession of engineering is now established upon a footing which will ensure the success of every qualified person who adopts it and practises it rightly and well. What, I think, should be particularly addressed to the members of this society on an occasion like this, are some remarks upon the possible development and probable future of the society itself. It is now in its eleventh year, and it already counts a large number of members, and is in receipt of a considerable annual income. So far the society has been exceptionally fortunate in having enjoyed the benefit of the unceasing labours of our honorary secretary, Mr. Williams, and but for his services, exerted in every manner that could secure the best interests of this society, it might, I am inclined to believe, have fallen to the ground long ago. I say this quite apart from any complimentary considerations, and merely because it must enter into our estimate of the future position of the society. We occupy, as a society, a somewhat exceptional position. Only a small proportion of our number are engaged in the design and conduct of engineering works upon their own account. I am glad, however, to see that our numbers are now being steadily recruited by gentlemen engaged in actual practice. The value of a society like this is in its power of concentrating professional talent, in influencing it in new directions, and in securing public respect and confidence. Now this can be done only by deserving both. Unless it can be seen that successfully executed works are described here and discussed by those who are competent to do so, we cannot expect to take the rank which, as a society, we all wish to have before the world. We have had here many papers, exhibiting much industry in their preparation, papers containing unexceptionable truths, yet these papers have been, in many cases, compilations, instead of being prepared from the special knowledge of their authors. Not but the society is under obligations to whoever prepares and reads a paper here which is not in itself unsound. Members should dismiss from their minds any idea that they are doing a favour to the society in preparing papers for reading and discussion. Not but what the society may and probably does derive some actual benefit from the papers, but they should be prepared from a sense of duty, and as but a fair contribution towards the interest and usefulness of the proceedings. Those who will take the trouble to put upon paper any subject which they really understand, cannot fail, too, to derive some advantage from doing so. The preparation of papers disciplines the mind, and compels the writer to choose his forms of expression. A facility for this kind of composition, whether natural, or acquired as it may be by practice, is of great value in every sphere of professional life. The ability to give correct expression to sound truths and to good ideas often enables the speaker or writer to influence those who would be otherwise far out of his reach, and thus not only to derive direct advantages for himself, but to advance whatever proper cause he may make the subject of his communication. In this light the preparation of papers by members of this society is to be regarded as a valuable exercise, and for the sakes of the writers themselves it should be followed whenever time and a good subject can be found. This preparation compels the writer to study and to reflect, and is in many ways an excellent means of self-improvement.

The course which I have endeavoured to point out is the one which, along with some other circumstances, has brought the parent society, the Institution of Civil Engineers, to its present high position. It might, indeed, be asked why a further society like ours should be needed at all, but I believe that our meetings furnish additional and valuable opportunities, more especially for the younger members, which the Institution, useful as it is, can nevertheless hardly afford so well as this society. However we may secure the co-operation of gentlemen in actual practice as engineers, we shall always be represented, upon the whole, by a much younger class of men than those forming the Institution. And our subjects for discussion will also embrace more works of mechanical engineering, and it may, indeed, be said that ours is the only professional body in London which habitually does deal with mechanical engineering. Our meetings give opportunities for the expression of opinions, and for practice in discussion, which could not be expected, at least by the younger members, at the Institution. Our past success is, indeed, sufficient to show that, properly conducted in the future, the Society of Engineers has no need to fear that its position will not be duly recognised and the value of its proceedings acknowledged by the profession. Any idea of rivalry with the parent society, as we may call the Institution, can never, I feel sure, have been entertained for a moment by anyone amongst us.

The demands for all kinds of professional knowledge is now greater than ever, and this society enjoys many facilities for collecting and disseminating such knowledge, and thus for commanding the general respect and confidence of the profession The society will do much for those, and they are perhaps the majority of the younger engineers, most of whose instruction in their future profession is self-instruction. It will not only bring before them subjects which are new to them, but the discussions will lead them to reflect and compare one thing with another, and to push further inquiries, and besides to cultivate a habit of reading. I believe that in this way the society has already accomplished a great amount of positive good, although we may have no precise means of estimating it. I believe that nearly every one of our members who has habitually attended our meetings, and preserved our volumes of Transactions, will own that he has derived direct personal benefit from what he has heard here, and it is by improving, as the council now believe they see the way to improving, the preparation of papers and the tone of the discussions, that these benefits will become more and more distinctly recognised and appreciated. It should be the wish of every member to co-operate in the plans of the council, so as to bring this society into a position where its membership will be publicly regarded as a beneficial distinction, by giving an assurance of professional fitness for such works as the members may undertake.

In looking about us upon the works which are already in progress, and in looking forward to those upon which the younger members are likely yet to be engaged, we cannot fail to be struck with the increasing scope which our profession offers. Never before were so many, so extensive, and such varied engineering works in hand; never before have so many new works been contemplated. Improved machinery and improved processes are so cheapening almost every kind of production, in the getting of coal, in the working of metals, in the manufacture of bricks, glass, paper, &c., in agricultural operations, and in the means of communication, that we are adding to our national capital faster than ever before. It is impossible, indeed, to define the limits within which invention, as applied by civil and mechanical engineers—for, whether they are inventors themselves or no, engineers are the best fitted to carry most inventions into practice —it is impossible to say within what limits invention thus applied is now adding to the permanent wealth of the nation. What the steam engine, the spinning frame, the power loom, and the iron rolling mill have done for Great Britain is really beyond our powers of estimation. Then came a later series of inventions of not less importance—gas-lighting, the locomotive engine, the steam printing press, the hotblast, ocean steam navigation, and the electric telegraph. Still later we have had the reaping machine, the steam plough, and the Bessemer process. Each and all of these has done, is doing, and will in future time continue to do, more for the good of mankind than was accomplished by all the art and skill of the two thousand years of the world's history previous to the time of Watt, excepting only the invention of printing and the discovery of the mariner's compass. It is engineers who are turning all these grand inventions to practical account for the useful purposes of men, and in many cases engineers are themselves the inventors of new processes and machinery. A great secret of professional success consists in knowing how to improve upon previous practice, whether by invention off-hand, or, more commonly, by that course of elaborate thought and comparison which results in what the engineer prefers to call design. Not that the inventive power is indispensible to success, but when controlled and regulated by good knowledge and sound judgment it is a great aid.

Many of the members of this society are now at an age—and I am speaking of the younger members—when new inventions, once studied and understood, make the most permanent impression upon the mind. There is enough now that, if not absolutely new, is but now beginning to attract general attention, or which, at most, has not been for any great length of time before the world. The young engineer should make himself conversant with the contemporary inventions of his own time. The new coal-cutting machines, new puddling machinery, the Bessemer process, the steam-plough, the steam fire-engine, the pneumatic railway, the universal telegraph, the gas-engine, the Enfield rifle-making machinery, the various patent moulding machines employed in the large foundries in the North, the recent applications of frictional gearing, the injector and the later improvements made upon it, the newer apparatus for testing iron, the Mont Cenis railway, Mr. Sturrock's steam tender, &c., should all be well mastered, and the young engineer should have definite opinions upon them all. So of inventions relating to warfare—the construction of the principal kinds of ordnance and their rifled projectiles, the construction of armour sides for ships, of gun-carriages, and of turrets. There are, also, those large engineering questions which the younger members of the profession should keep themselves informed upon—the large bridges now contemplated in many parts of the kingdom, and the drainage and water supply of towns, and especially of the Metropolis, the improvement of rivers and harbours, and the great question of ocean telegraphy. In touching thus briefly, and almost without regard to their relative importance, such a number of subjects to which the minds of so many of the members of this society may be profitably directed, I do so more to suggest the opportunities for, as well as the value of, constant thought. It is the power of thinking closely, and for practical purpose, that gives to the engineer his ability to deal with fresh difficulties as they arise, and if the younger members of this society have made up their minds that the opportunities for engineers are to be greater than ever in the future, they must also bear in mind that the preparation for the duties of our profession must also be more complete than ever. To this end we may all hope that the Society of Engineers, as an establishment or an institution, may in future be enabled to render greater services in the advancement of engineering knowledge than ever before.

THE NATIONAL BOILER INSURANCE COMPANY.

Mr. Hiller, chief engineer, has laid his annual report before the National Boiler Insurance Company (Limited) 22, St. Ann's-square, Manchester. The following is an abstract:—

Mr. Hiller commenced by stating that the company had already acquired an extensive and rapidly increasing connection amongst boiler owners in the districts to which its operations have been extended, and the prospects for the future are of the most promising and encouraging character. No explosion has occurred to any boiler insured with this company. Some of the boilers have been injured through mistake or negligence of the attendants, and other cases have been reported where serious injury would have been sustained had the boilers been unprovided with good fusible plugs on the furnace crowns, which, by their timely action, prevented damage. One case of partial collapse of the furnace tube of an insured boiler is worthy of special note. The boiler was fed with water strongly impregnated with salt and chalky matter, which, owing to omission of frequent cleaning, was so thickly deposited on the furnace crown as to cause overheating of the plates, and consequent injury. The use of good surface blow-out apparatus would have prevented the accumulation of the deposit, and subsequent damage to the boiler. Many serious defects, some of them of a most dangerous character, have been met with in the boilers inspected. Internal corrosion is frequently met with, in some cases seriously weakening the boiler in a very short period. In most cases its progress may be arrested by the daily admixture of a small quantity of common soda with the feed-water. In any case where the use of soda does not prove effectual he would suggest that the water should be analysed by a first-class chemist, who would doubtless be able to recommend an antidote. Many of the leading boiler makers now rivet on the boilers suitable joint-beds for the fittings, and good mouthpieces, with planed joint faces, at the manholes, which much facilitate the proper making of the joints and materially strengthen the boiler. Where these beds are properly attached, and the joints thereto carefully made, leakage is avoided, and much trouble and expense saved to the owners. Many glass gauges were met with, where the handles of the taps were broken and in other cases the taps were so leaky that the guage could not be properly tested; others were so dirty that the height of the water was scarcely distinguishable. Many instances of the consequence of neglect of the water gauges have been recorded. In one case a two-flued boiler was fitted with a glass gauge and a float gauge, but the former was not kept in order, and the float only was used, the result was that both the furnace crowns were seriously injured through deficiency of water. He did not consider ordinary float gauges sufficiently sensitive for use on internally-fired boilers, and would strongly advise that where attached to those externally-fired there should be two gauges to each boiler, as a check on each other. Several cases have been reported where the glass gauges were fixed so low, that the furnace crown would be actually bare of water when several inches were visible in the glass. These were certainly proofs of gross carelessness or ignorance on the part of those who fitted up the boilers. As an instance of the gross negligence which is occasionally displayed by boiler attendants, he mentioned the following:—An externally-fired boiler, fitted with a "float-whistle" gauge, was found with the water so low, that it was out of the range of the float, which the inspector found was scotched fast, to prevent its indicating the deficiency.

Many safety valves have been found defective from various causes, and he was sorry to remark that, despite all that has been written at various times on the subject, and the numerous disasters which have occurred through their abuse, many instances of overloading with irregular weights of various kinds and other defects have been reported. In one instance where the safety valve was loaded to 40 lb. per square inch, the pressure gauge indicated but 26 lb. when the valve was blowing off. The safety valve had in consequence been overloaded with pieces of iron to blow off with the gauge, thus seriously increasing the pressure; and the mistake was not discovered until the gauge was checked with a correct indicator, which showed it 14 lb. per square inch below the actual pressure. Fortunately, the boiler was amply strong for the pressure at which it was usually worked.

The safety valves of some of the boilers proposed for insurance were found on inspection to be loaded to above double the proposed pressure, of which the owners were quite unaware, until the boilers were inspected by the officers of this company. Compound safety valves, which discharge the steam when the water sinks below the proper level, and also act as ordinary safety valves, are a useful fitting, especially when attached to single boilers. The defects to which gauges are liable is exemplified in the remarks on safety valves. Some of the gauges noted were found seriously inaccurate; in one instance, the gauge indicated 20 lb. below the actual load.

Mr. Hiller states that the great superiority of Smith's fusible plug has been fully sustained by the experience of the past year, and confirms the confidence placed in it by this company, in making the reduction of 10 per cent. from the premium of insurance of those boilers to which it is attached.

Many boilers are quite unprovided with blow-out apparatus. A number of internally-fired boilers are reported as having nothing but an iron plug at the bottom for the purpose of emptying them. This plan is most objectionable, as the water soaks into the brickwork at the bottom of the boiler, and leads to corrosion of the plates, and also frequently backs into the flues, interfering with their proper cleaning, and preventing satisfactory inspection. Suitable rivetted beds should always be provided for the attachment of the elbow pipe to the bottom, and the pipe should be of such a length that the tap may be easy of access for use, cleaning, &c. Where the water contains much sediment the use of good surface blow-out apparatus is in most cases of great benefit.

No boiler insured with this company has exploded during the past year. Fifty-three serious explosions have occurred in the United Kingdom alone, by which 47 persons lost their lives; and 82 persons were seriously injured; total, 129. The following is a list of the explosions above referred to:—

The exploded boilers were of the following descriptions:—One or two flued internally-fired, 14; locomotives, 11; cylindrical externally-fired, 12; iron furnace boilers, 5; portable (locomotive type), 2; vertical internally-fired, 2; marine ditto, 2; balloon or haystack, 2; other descriptions, 3: total, 53.

The causes of those explosions of which particulars have been obtained, are as follows:—Deficiency of water, 10; external corrosion, 1; internal ditto, 2; internal grooving at seams, 4; insufficient staying, or mal-construction, 4; weakness of flue-tubes, 4; fracture through flaws in iron, 3; over-pressure, 2; failure of seams over surface (externally-fired boilers), 2; defective fire-box stays (locomotive), 1; weakness of manhole cover, 1; no particulars obtained, 12: total, 53.

The serious increase in the number of explosions of locomotive boilers calls for special remark, and must impress those persons entrusted with their charge with the necessity of providing, in new boilers, for more reliable and frequent internal inspection than is now practicable. The number of explosions recorded in 1865 is 11, against 6 in 1864, 2 in 1863, and 3 in 1862. The number of explosions of these boilers in 1865 being equal to the whole of those recorded for the three preceding years.

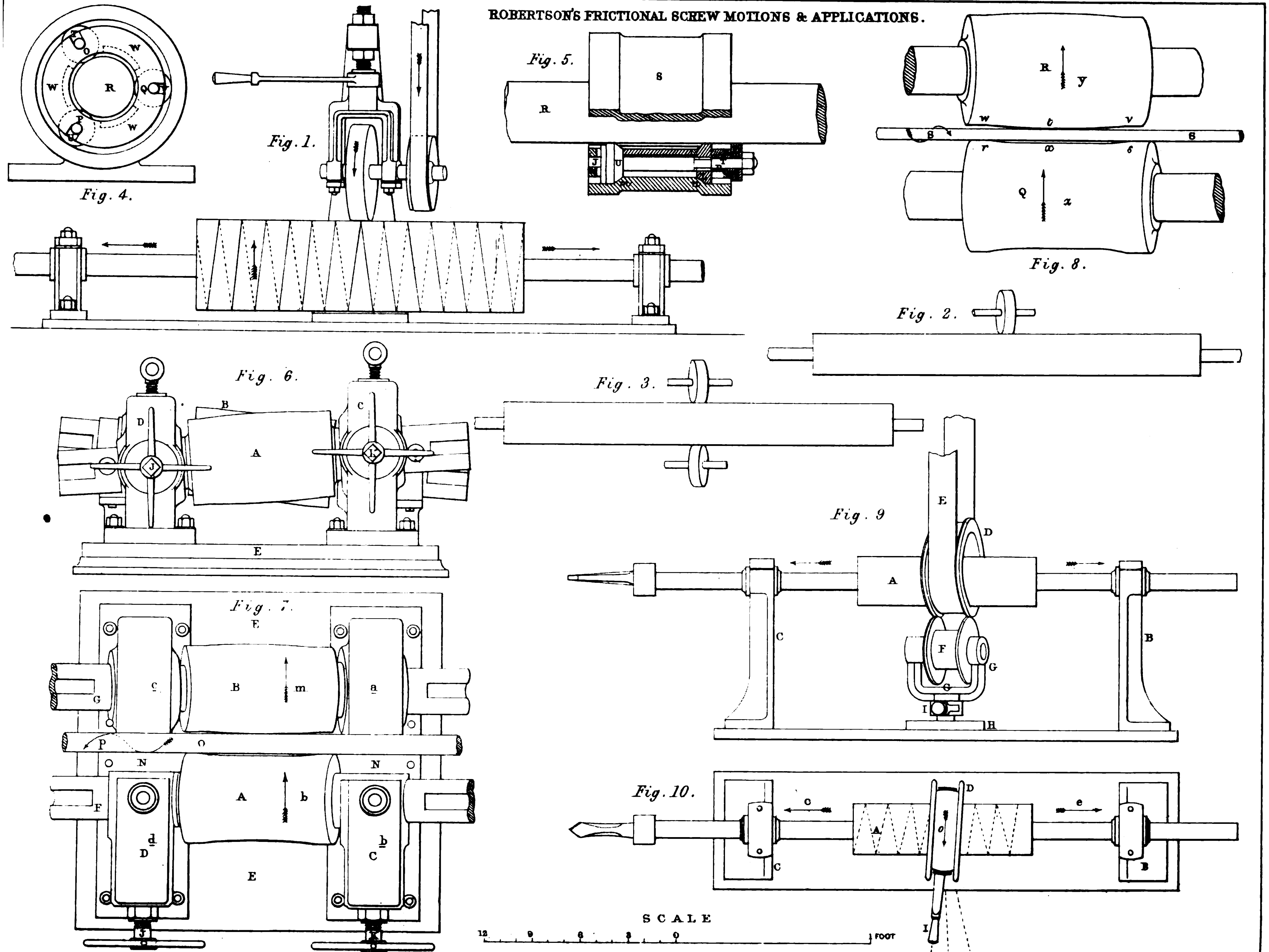
The judicious application of the hydraulic test would probably have led to the detection of weakness in some of the boilers which have failed. When applying this test, every part of the boiler should be exposed to view, and it should be carefully gauged and examined before, during, and after the test, so that any alterations of shape or other defect may be detected; and it is of the utmost importance that the pressure should be kept up for a considerable time, so that any defects which may exist, may have time to develope and become manifest, otherwise the test may prove worse than useless.

As an instance of the value of the hydraulic test, the following is worthy of record. A large one-flued boiler was proposed for insurance with this company, which was in course of being generally overhauled and repaired, and also enlarged by the addition of several feet to its length. The old flue-tube was 3 feet diameter throughout, $\frac{3}{8}$ plates, the new part of the tube was gradually enlarged to about 3 ft. 4 in., the total length being about 38 feet. The proposed load on safety valve was 60 lb. per square inch. It was suggested to the owners to strengthen the tube by angle iron hoops or cross tubes, and their attention was directed to the fact that the calculated load (per Mr. Fairbairn's formula), under which such a flue might be expected to collapse, was little over 80 lb. per square inch. It was also recommended to apply the hydraulic test after the alterations, &c. were completed. Unfortunately the tube was not strengthened as advised, and on the test being applied, the flue collapsed almost the entire length, when the pressure had reached about 83 lb. per square inch, thus illustrating most forcibly the correctness of the formula referred to, and the value of the hydraulic test, as, had the boiler been set to work, the flue would, in all probability, have failed with fearful result.

The explosions caused by external corrosion, were chiefly due to moisture in the brickwork seating of the boilers. In several cases the boilers were placed in low situations, so that the water from the higher ground drained into the flues, keeping the plates continually damp, thereby inducing serious corrosion and consequent explosion.

When boilers are stopped for internal cleaning, the external flue brickwork should always be cooled down as much as possible, by opening wide the damper, and allowing a current of cool air to pass through the flues, for a considerable time before the water is run out of the boiler. Many good boilers are seriously injured by the neglect of this most necessary precaution.

ROBERTSON'S FRICTIONAL SCREW MOTIONS & APPLICATIONS.



J R Jobbins

ON FRICTIONAL SCREW MOTIONS AND APPLICATIONS.*

By James Robertson.

(*With an Engraving.*)

The object of this paper is to describe a system of frictional screw motions, with which the writer has been more or less engaged for the last ten years, and which appears to be a principle of mechanical action not previously recognised by mechanicians, and one of very considerable importance. The application of the principle seems also infinite, and can produce useful effects where the common groove-threaded screw is unserviceable; but is one requiring mechanical nicety and tact to apply it rightly, and, moreover, brings with it so much change in the form of the machines to which it can be applied, that it is at considerable expense and risk, in most cases, that it can be usefully developed.

The writer, though familiar with many useful applications of this principle, having been otherwise closely engaged, has therefore, not sought to apply it to any purpose involving much risk in the form of expense, nor allowed it to occupy his time in any considerable degree, except for such purposes as have happened to come in the wants of his own engineering practice. It is hoped, however, that by some information given on the subject, and a more general recognition of the principle by engineers, useful applications will increase more rapidly, as there are many of these motions suited to particular branches of machine manufacture; and many men, with many mechanical ends to reach, would find use for this principle were it well understood. Any contrivance of a generic or organic nature that forms a useful and obedient organism to the designer of machines for producing the motions and effects he desires in the shortest way, and with the least expenditure of force—contrivances such as the cog-wheel, the thread-screw, the crank, eccentric pulley, &c.—is of greater importance than the combination of these, and adaptation of them in a machine for any particular purpose, as new motions tend to suggest new adaptations in machines, and these motions, after a little study, will not merely be found useful for some purposes already accomplished, but also suggest new operations not hitherto attempted. They will not supersede the ordinary thread or groove screw to any considerable extent; but are suitable for many purposes, and for producing effects of a nature which it would be impossible to accomplish with the common screw.

Frictional screwing action is produced by any body that causes continuous oblique tangential impingement on a revolving cylinder or round bar, where the cylinder or bar is free to move on *end* as well as to revolve. The force at which it will revolve and screw forward on end is proportional to the frictional contact of the impinging body, and the pitch of thread described or produced proportional to the angle formed by the direction of motion of the impinging body to the axis of the screw-bar or cylinder. In some of the larger applications made, the force of the screwing action, though not accurately measured in any case, would range from 10 to 20 tons, and the thread or pitch of screw described perfectly accurate or uniform throughout, there being no limit to the force that may be exerted, or difficulty of producing perfect uniformity of pitch by these screw motions, although the purposes to which they are likely to be applied with most advantage are not those that require either great power or minute accuracy of action.

The mechanical properties possessed by these screw motions, as distinguished from the ordinary screw, are chiefly the properties of indefinite variation, or change of thread, or pitch of screw, produceable in one screw, any pitch being readily obtained from an infinitesimally small pitch, to direct rectilineal motion on end; and of reversing the thread from right to left without changing the direction of the motion of the nut or screw; the mechanism which constitutes the nut being in most cases easily adapted to do this.

The mechanism which constitutes the nut is very varied—screwing action being effectively generated, or produced by straight or curved bars, by parallel or by bevelled pulleys, or a combination of these acting tangentially on the surface of a round bar or cylinder, and these, instead of surrounding the screw like an ordinary nut, acting external to, and revolving on different axes to the screw bar, giving thereby a great variety of new facilities of application; as both nut and screw, while they are acting in this relation to each other, may be serving other purposes in the machine, and their functions as a screw motion of a secondary character.

The primary principle of these motions will be understood by Fig. 1, Plate 8, consisting of a cylinder mounted on an axis, and placed on bearings so as to be free to move on end, and to revolve freely, representing thereby the screw, and having placed in effective driving contact with it a parallel frictional pulley of sufficient breadth to withstand wear, keyed on an axis, and held in bearings in a forked holder having a lever fixed in the fork so as the axis of the frictional driving pulley is kept horizontal to the plane of the screw barrel, but may have its axis set by the lever, shown at right angles, or at any intermediate angle with the axis of the screw barrel, thereby representing the nut. Motion being communicated to this pulley by the belt pulley and strap shown, and communicating motion by its contact with the frictional screw, causes it to revolve; and, on the lever and axis nut pulley being held at an angle to the axis of the screw barrel, a screwing action at a corresponding angle, as indicated by the dotted helix line on drawing, is produced; and when the screw pulley is turned round to a corresponding angle in the opposite direction, a reverse or left-hand screw motion will be described as indicated by the left-hand screw dotted helix line in barrel; and any intermediate screwing motion, in either direction, can be described without changing the direction of the motion of the nut or screw, from a screw of an infinitesimally small pitch of thread up to direct rectilineal motion on ends.

Figs. 2 and 3 are elevations of similar screw motions; Fig. 3 showing a nut composed of two frictional pulleys, placed at opposite sides of the screw barrel, in which position the contact pressure on the axis of the barrel is neutralised, and double the effective contact thereby obtained.

By increasing the number of nut pulleys, the adhesion between the nut and screw may be increased to any required degree, without causing too great a pressure on the axis of the nut pulleys, although, for most purposes, two pulleys are sufficient and most convenient. Motions of this nature, chiefly of an experimental character, as adaptations for feed traversing motions, for tools, &c., have been tried, but it would be tedious to enter into the details and modifications of these, the figures having been given chiefly to illustrate the principle of these motions.

Fig. 4 is an elevation, and Fig. 5 a sectional plan of a frictional nut and screw, in which the contact pressure is maintained on three sets of nut pulleys or rolls, and which resembles the common screw nut. Instead of working in bearings, a tubular piece or hoop turned out truly, encircles the spindles and rolls, and are so adjusted to roll on the screw barrel at one point of their periphery, and directly opposite this point to roll on the internal turned surface of the hoop. An arrangement is also made to tighten on the hoop to any required pressure, and thereby a rolling action. with pressure on the outside points of the peripheries of the nut rolls, is substituted instead of a rubbing one on their axis, as seen applied to the necks of the nuts in Figs. 1 and 2.

The frictional screw barrel R R, Figs. 4 and 5, is shown broken off short, and portion of the hoop S is also broken off, to show the arrangement for keeping the nut rolls in their oblique positions.

The nut rolls, T, U, and V, have their diameters enlarged at each end, and portions of the enlarged parts turned slightly conical on the inside edge, seen in section in Fig. 4, by the enlarged part of the roller U. The lower enlarged piece *l*, of the roller U, is moveable on end, and is drawn on upon the internal inclined edges *m* and *n*, of the barrel S, so as to tighten itself in between the screw barrel R, and the internal surface of the barrel S. By thus tightening up the one roller U, it also tightens up the other two rollers T and V, giving any required amount of bite without causing other than a rolling friction, which is very slight.

To keep the rolls in the required angular position, a guide piece, W, W, W, with the notches O, P, and Q, in the upper flanged part for guiding the necks of the rolls, seen in Fig. 5, and in section in Fig. 4, at *j*, *r*, and *s*. Corresponding notches are cut out for the necks at each end of the roll, and placed obliquely to each other, to give them severally a corresponding angular position. The neck *t*, has upon it a tubular gland-piece, which communicates the pressure of the screw nut to the enlarged moveable part of the roller L.

* Read before the Society of Engineers in Scotland.

On the hoop S being made fast, and the screw barrel R made to revolve, the guide pieces W, as described, move round with the rolls at a reduced motion, and as it is out of contact with both the screw barrel R, and the pressure hoop S, it moves round freely, as all the pressure exerted on the bearings formed in it for the roll necks is only such as is caused by its own weight, its action being simply to preserve the rolls in their due position.

Nuts of this description can be constructed to give great force and with sufficient breadth of acting surface to have little tendency to wear, and ready means of tightening should it occur. There being no slack in the nut, such as must necessarily be the case in the common screw, and the barrel being capable of being made quite rigid, this form of nut is likely, in the opinion of the writer, to become serviceable for certain forms of planing machines and tools, the screw barrel being made to serve the double purpose of traverse motion and slide table for supporting the tools or body to be planed.

Fig. 6 is a side elevation, and Fig. 7 a plan of a set of rolls for straightening round bars, tubes, and similar articles, in which a frictional screwing motion is employed, and is an example of the use of this principle in positions to which common screws do not apply: the rolls here and machine generally, representing the nut, and the bar the screw, the nut being the straightening rolls, and its function as a screw nut a secondary matter, the bars or tubes to be straightened—something not belonging to the machine at all; and this double purpose or nature, after a slight study, will be found quite characteristic of this principle of mechanical action.

The first set of these rolls of a large size was constructed for the Barrowfield Works, of Messrs. R. Laidlaw & Son; and afterwards a large set for the Glasgow Iron Co's Works at Motherwell, which is adapted to straighten round bars in a cold state up to 6½ inches diameter, and which have now been several years in operation. There are other two sets in the neighbourhood of Glasgow used for straightening lap welded tubes of from 1½ inch up to 8 inches diameter. Those at the Works of Messrs. A. & J. Stewart, of St. Enoch-lane and Coatbridge, being the first used for this purpose, and subsequently a larger set by Messrs. Eadie and Spencer, of London-street. Other sets for England and abroad, made for similar purposes, and of late somewhat more in demand.

Referring to Figs. 6 and 7, the rolls A and B are provided with necks and coupling bosses, and are supported in the cheeks C and D, which are firmly bolted to the sole plate E. The cheek C has the neck bearings *a* and *b*, in which the necks of the one end of the rolls are placed; and the cheek D has the corresponding bearings *c* and *d*, in which the necks of the other ends of the rolls are similarly placed.

On this end of the rolls, the coupling bosses G and F, extending beyond the cheek, have angular working loose couplings placed on them, and the driving shafts coupled with them for communicating motion to the rolls.

The bearings of the roll necks are placed in the cheeks to give the axis of each roll an inclined position, and in opposite directions to each other. The bearings or steps *b* and *d* of the roll A are placed in longitudinal slots in the cheeks, seen in Fig. 7, at *e*, and the bearing steps, *b* and *d*, are formed with sliding guide flanges to fit the slots, and are adjusted to any required position laterally by the strong set screws, J and K. The wedge-shaped transverse adjustable bar or anvil piece N, passes between the cheeks in a horizontal direction; its upper edge is steeled, and supports the bar or tube upon which the rolls are operating, keeping the centre of the bar or tube in line with the cross centre line of the two rolls at their mid length, the rolls being, as described, inclined in opposite directions; but the bar they are made to operate upon kept level, as seen in Fig. 6.

The position of the supporting bar N, and the bar placed in the rolls, will be seen in Fig. 7, the end of the supporting piece being shown at the centre of the bar O. This adjustable anvil piece or bar is secured in any position required for the various sizes of bars; the smaller sizes requiring the steeled edge of the bar near to the roll B, and the larger sizes proportionately farther from it. On the screws, J and K, being adjusted to take sufficient hold of the bar to be straightened, motion is given to the rolls in the direction indicated by the arrows *b* and *m*, and the bar is made to revolve in the opposite direction; while it is thus made to revolve, the angular position of the rolls causes it to move or screw on end in the direction of the arrow *p*. By this motion the bar or tube is straightened by short rolls, every part succesively, as it passes through. The most suitable inclination for the rolls for iron bars and tubes is one in fourteen: for softer materials, where greater speed might be desirable, a greater angle could be used. The surfaces of the rolls have to be formed slightly hollow in the direction of their length, to form a parallel space between them for the bar; and for some purposes can be bevelled out at the entering end with advantage.

Fig. 8 is an enlarged plan of a pair of rolls formed for straightening bars of an elastic nature in a cold state, in connection with Figs. 6 and 7. The roll Q, Fig. 8, is formed with its surface hollow, in the direction of its length, and the roll R, opposite it made correspondingly rounded, so as to make the channel formed between them of equal width, and curved when apart, and to fit each other when in contact. By passing a bar through rolls thus formed, it is subjected to continuous bending, and at every point throughout its length, so that elastic bars of iron, steel, or any other substance possessing elasticity, can be bent to the limits of the curve from which it recoils, and thereby, when a crooked or bent rod is passed through them, the parts that are high before entering the rolls are bent beyond the distance from which they recoil, and consequently they will pass from the rolls straight. Any bar possessing a moderate degree of elasticity can be straightened cold in this way, and without requiring much power, as the surface of the rolls can have a greater curve given to them than is necessary, so that the bar does not require to be pressed hard between the opposite points of the rolls. Referring to Fig. 8, in which this action is illustrated, the bar S, is shown in contact with the roll Q, at the points *r* and *s*, and in contact with the roll R, at the point *t*, whilst it is correspondingly out of contact at the points *u* and *v*, in the roll R, and out of contact in the centre of the roll Q, at the point or position *x*. The position of the rolls being as shown, and their motions as indicated by the arrows *y* and *z*, the bar moves forward in the curved position in the direction of the arrow *q*.

In bar-rolling mills the bars are usually put through the rolls from the forge rolls while slightly hot, but no heating is required; and in millwright's shops they are straightened in a cold state, and are delivered from the rolls entirely straight. In tube works these rolls impart a fine finish to the tubes, the tubes being passed through the machine somewhat quickly, and hot from the finishing rolls; sandstone being made to act on the tube as it revolves, the rounding, straightening, and finishing being all done at the same time. The tubes or bars are passed through continuously, one tube following closely after the other, no adjustment of the machine being necessary for a fresh tube, once it is adjusted to a particular size.

These rolls can be variously shaped and applied to the purposes of forging and shaping iron. Pieces of soft metal may be drawn out with them in part, and their action either reversed or discontinued by being suddenly removed from each other. In this way they can be used for raising bosses on shafts, bolts, and similar articles, although this as yet has not been tried.

Fig. 9 is a side elevation, and Fig. 10 a plan of a frictional screw, in which a "speed ring" acts as the frictional nut. It affords a very direct means of transmitting the screw motion to the barrel, and bears a close resemblance to the common grooved nut. It has however, besides the properties of reversing and varying the thread, the property of transmitting rotary motion, which is not possessed by the common screw nut, nor by the frictional nut described in connection with Figs. 4 and 5. From its simplicity and quick action, this motion is peculiarly well suited for light boring, and boring substances like wood, as by it the drill can be made to advance to, and recede from, the object to be bored rapidly, and at the same time affords a yielding pressure to the drill, which can be intensified or reduced at pleasure, by the same handle that regulates and reverses the screwing action. The screw barrel A, Figs. 9 and 10, is similar to that described in connection with Figs. 1, 2, and 3, and placed in the bearing pedestals, B and C. The internal diameter of the hoop D is larger than that of the screw barrel A, to give it the facility of twisting round in an angular position to the barrel to produce screwing action. It is lined internally with leather, and formed with flanges to keep its driving-belt in position. The driving-belt E is placed upon the ring D, and disposed vertically; the belt being applied over an overhead driving-pulley: the *taut* of the driving belt E, keeping the internal surface of the driving ring D, in effective driving contract with the surface of the screw barrel A. The belt flanges of the speed ring D, are bevelled on their outer edges, and a pulley F, having corresponding flanges bevelled from the inside, acts on the bevelled edges of the ring in the manner of a wedge and groove pair of frictional wheels. The pulley F, is supported in bearings formed in the swivelling fork G, which is placed upon a stud pin H, similar to that described in connection with Figs. 1, 2, and 3. A handle I, is fixed on the fork, by means of which the fork G, and with it the pulley F, and speed ring D, are moved round to any screwing angle that may be required.

Motion being given by the belt to the speed ring D, in the direction of the arrow *a*, and the ring set at an angle as shown in the direction of the handle I, the barrel A, will screw on end in the direction of the arrow *c*. On the handle I, being turned to the position shown at *o*, the speed ring will be placed in a parallel position to the barrel, and the barrel will rotate without motion on end. On the handle I, being placed as shown at the dotted lines P, and the speed ring placed in a reverse angular position, the screw will move on end in the direction of the arrow *e*. By placing two guide pulleys on the speed ring in the screw pitchfork, steadiness is given to the ring when the barrel works in a vertical position; and the guide pulleys can be placed at the two sides, instead of under the ring as shown.

There are several frictional screw motions analogous to the common worm wheel and worm screw, and which, in general appearance and arrangement, have little resemblance to each other.

In answer to questions relating to the action of the arrangement shown by Figs. 9 and 10, Mr. Robertson said that the speed ring D, was loose, and held by its driving belt in position. The driving frictional contact of the ring on the barrel was produced by the *taut* of the belt, and the driving action thus obtained was as great as if the pulley were passed over the barrel itself. Its motion on end was reversed by the handle being turned to an opposite angle, as indicated on the drawing. The power or driving action obtainable was more a question of power to hold the surfaces together than one of *extent* of surface. The screwing speed was regulated by the angle at which the speed ring was held. Any pitch of screw was readily obtained from an infinitesimally small pitch up to about one of one inch pitch.

Mr. D. More had seen this motion of the speed ring working. The only thing in this application of it he would regard as objectionable was the angle at which it required to be held to produce the screwing action.

Mr. Robertson said, that in order to illustrate the action, the drawing showed far more angle on the ring than was required in practice. If the ring was twisted one-sixteenth of an inch, it produced a screwing speed of about three-sixteenths of an inch every revolution. The motion on end could be nicely regulated.

Mr. James R. Napier asked an explanation of how the end pressure on the axes of the friction rollers, due to the forward motion of the cutters, was disposed of, as shown in Figs. 4 and 5?

Mr. Robertson replied—that the contact pressure in this form of screw motion as explained, was obtained between the periphery of the screw barrel on the inside, and by the internal surface of the surrounding hoop on the outside, at the opposite points of their peripheries, so that there was no pressure on their bearings, and no friction except what was necessary to keep them in their angular positions. There was end pressure on the nut, but the friction was small, as it was borne by the conical ends of the rolls at both ends of the nut.

Mr. Jas. R. Napier asked whether the principle, as illustrated by Figs. 4 and 5, had been applied to cut screws. The machine for boring, especially its application to timber, was very ingenious and simple; but he thought that it would be difficult to make use of it in cutting screws of the same thread over and over again.

Mr. Robertson said that, in the form of screw illustrated by Figs. 4 and 5, the thread would be obtained over and over again, at least pretty nearly alike in pitch, and would be uniform. He would expect, however, that none of these motions could be depended upon to give the same pitch of thread over and over again with the exactitude of the common screw, which could only give one thread.

Mr. Gale said that it was alleged that, by giving to the screw motions a very high speed, or over great pitch, the rolls would slide, and still present the same pressure on end. For purposes such as boring iron, he thought this action, should it occur, would not be objectionable.

Mr. Robertson said that the intensity of the force exerted on end would be great or small in proportion to the pressure given to hold the surfaces of the rolls in contact, and which was easily regulated. In boring, suppose the pressure given was just enough for the tool to withstand, the action would be as described by Mr. Gale. In one instance, at the Glasgow Iron Works, he had seen the passage of the bar being straightened accidentally obstructed by another bar being left lying in its way, and indications were given of enormous power. He should say that in straightening round bars of 6½ inches diameter, the force on end would range from 10 to 20 tons.

Mr. W. Smith said that it was well known that some of the English makers of bars made them straight and ready for use. If the Scotch makers could make them straight it would save £1 per ton.

Mr. Faulds said that they were now obtained from the Glasgow Iron Company straightened.

Mr. M'Donald said that he had used the bars from the Glasgow Iron Co., and found them quite straight.

MATERIALS MOST APPROPRIATE FOR LONDON EXTERIORS.

By J. Douglass Mathews, A.R.I.B.A.

(Continued from page 5.)

A great disadvantage in the use of iron externally, is that it must be frequently painted, as without this means of preservation it will soon corrode, by the action of the atmosphere.

One other substance requires notice before dismissing the subject of constructive materials. Wood was at one time used wholly in London buildings, now it is almost wholly abandoned in external construction. The Building Act contains no clause forbidding its use in bressummers, story posts, and shop fronts nor indeed, in any way, provided it is set back 4½ inches from the external face of the wall. It is now an acknowledged fact that, in case of fire, wood is a safer and stronger material than iron, and its resistance to the weather, so long as it is preserved by paint or otherwise, requires no argument. It readily admits of carving and other ornament, and bears a treatment peculiar to itself, which gives at once a domesticity which cannot probably be equalled by any other material. Frequently the judicious design of a shop-front and the windows of the upper stories, will give great character to an otherwise plain building. It can be employed with the greatest ease and readiness, but the chief disadvantage is the cost of triennial painting.

Having now considered some of the principal materials adapted for the construction of buildings, it is proposed in the second place to bring under notice those applicable for external decoration. And although, as a rule, the use of superficial ornament cannot be advocated, there are cases (and those not of unfrequent occurrence) when it becomes an absolute necessity; whether it shall assume the appearance of some other material, and thereby prove a sham, or whether it shall have a treatment peculiarly its own, is a question for the architect to determine; but there seems no reason that, by its judicious use, it may not bear the stamp of truthfulness.

In no material is the want of a distinctive treatment more felt than in Cement. No other has been more abused, and no other has been applied to such base purposes. When it is used as a coating to cover a multitude of imperfections in bad building, or so applied ornamentally as to lead people into the belief of being another material, no words can be strong enough to condemn its use. In London there are many kinds and qualities of cements manufactured, but that known as Portland has the character for standing the best, and certainly has the best colour. The chief requirements in its manufacture are, that the ingredients are well and properly mixed, thoroughly burned, and ground to powder. Care is required in working that it sets properly, and that one coat is sufficiently hard to receive the next, and that no frost attacks it while in progress, or before it is thoroughly set. It requires painting occasionally, or otherwise preserving, as without this the weather penetrates the outer coating, and destroys its affinity for the one below, and consequently soon peels off. Some of the legitimate uses for cement appear to be, margins for ceramic panels, mosaics, &c., and panels and flat surfaces generally. Incised ornament seems most applicable, and the introduction of a coloured cement ornament, in a Portland cement ground, would be effective, if some preservative process could ensure discolouration, patents for which have been obtained, but are not in general use. As a rule, applied ornament in cement should be rejected, as much of that now in existence will sooner or later lose its key, and fall by its own weight. A painful instance of this occurred recently in the Strand.

Scagliola has of late been much used in interior decoration, and although the imitation of marbles cannot be recommended, yet the same materials are applicable to ornamentation of another description, and there seems no reason why the material may not be used externally. The manufacture consists of plaster of Paris, or any fine uncoloured cement, free from grit, which, when wetted, is carefully worked by a trowel or smooth stone or slate; the colour, consisting of acid, is then introduced, which eats itself entirely into the material. It is then rubbed down with fine grit stones, and finished by a rubbing with snake-stone, till it receives a beautifully even polish. Keene's cement is said to stand the atmosphere by combining copperas in its preparation. If so, an artistic and cheap material for decoration may be obtained.

High art has not, is not, and it is hoped never will be, sufficiently cheap to employ painting as an external decoration. The process of water-glass painting may stand the London atmosphere, but it is a very great question, especially as so much depends on the chemical compositions of the materials employed. With so much speculation, there are few men who would go to the expense of the trial, and, unless the paintings were really works of art, more harm would be done than good. The general narrowness of the streets would also prevent paintings being seen to the extent they ought to merit.

The advantages and disadvantages in the use of granite, serpentine, and marbles, have been eummerated in the former parts of this essay, and apply equally to superficial as to constructive ornament.

Slate is a material that might be more generally used in a decorative manner. For roofing, it will scarcely need notice, for although a material in London exteriors, the roof is generally so high from the street as not to warrant the bestowment of much expense in any novelty in the covering, and few materials are better than slate for this purpose.

Sawn slate might well be used in panels, cornices, simple mouldings, &c. Its colour is good, and will harmonise well with stone and brick. Enamelled slate opens up a wide field for design, and is a material likely to stand the weather. Care, however, should be taken that the arrises are protected, to prevent chipping.

There are not wanting indications of a revival of pottery, adapted to the purposes of architecture, though whether any of our English potters possess the genius, or have caught the spirit of Lucca della Robbia, and the other great Italian artist potters of the middle ages, is unfortunately more than doubtful. For this revival the country is much indebted to the untiring exertions of the late Josiah Wedgwood. Miss Meteyard, in her Life of Wedgwood, says, "he had one great disappointment in his artistic life. He wished to induce the architects of his day, amongst them the brothers Adams and Sir William Chambers, to introduce terra-cotta ornaments and bas-reliefs into façades, and other parts of houses and buildings." At that time the effect of the London atmosphere was not so apparent in external materials as at present, and therefore the need of terra-cotta and other weather-proof materials, as adjuncts to design, was not so much felt as now.

The decoration of a building with majolica panels, friezes, pilasters, &c., and encaustic tiles, is well worthy the attention of an architect, as by their use he may obtain an imperishable material. The chief objection however is, that having no other fixing than cement, the weather can easily find its way through the joints, and in course of time destroy the key. Mr. Digby Wyatt, at a recent meeting, suggested the formation of a small eye at the back of the tile or plate, to receive a hook of wire or other material, to be built into the brickwork, so that no danger might be apprehended in their use for external decoration. If used in a panel, an iron, slate, or wood bead, or moulding, might be fixed, to form a stop. Machinery has lately been used in the production of encaustic tiles, the benefit of which is apparent from the fact, that tiles of two colours may be produced at a cost of 1½*d*. each. Although at present in its infancy, enough has been accomplished to show that encaustic tiles may be as cheap and plentiful as common bricks, and, on account of the increasing love of colour and ornament, will sooner or later take the place of cement. The process of manufacture is exceedingly simple, and any design that may be desired can be worked out at a very small charge.

Majolica will, however, find the greatest favour as a means of external decoration. Being capable of production to any reasonable size, it will remedy to a great extent the fault in tiles, viz., the frequency of joints. It can be ornamented to any extent, from a simple stencil to the most elaborate painting: by its use, grace and beauty can be given to a design at a comparatively trifling cost. In its manufacture the prepared clay is moulded to the required form, then allowed to dry and harden, and after which it is fired in the same way as terra-cotta. The design is then painted in colours, which when fired in, produce the colours and glaze at one and the same time.

A process has lately been patented, whereby drawings may be made in crayon, by artists or amateurs, on porcelain, and afterwards burnt in various colours, and glazed.

There is still a want of a cheap ceramic material somewhat proportioned to the cost of common plates and dishes. The chief expense is the drawing. In the last-named articles the pattern is printed and transferred to the biscuit. If instead of printing the design to be produced could be drawn or traced in some fatty substance, which would adhere to the biscuit, a great end would be gained. A common stoneware moulding has been used in several stations of the London, Chatham, and Dover Railway, but the colour is so ugly that its use cannot be advocated: at the same time, it has shown that a common glazed material may be produced.

The potter's art seems to have now been brought into such general use, that most of the manufacturers have their hands full of their own particular description of work, and consequently unable to devote much time or labour to the development of original suggestions. This is to be regretted, as a wide field, especially in connection with architecture, is open to any one practically acquainted with the art, and with somewhat of the undaunted spirit of Josiah Wedgwood.

The increasing use of Mosaic, as a superficial ornament, demands a short notice. Whether it be in tile or glass, it is equally durable as a material, and ornamental as a decoration; but with whatever success it is used as a means for internal, it cannot be recommended for external, decoration. It is a question also, whether it is desirable to bestow so much minute ornamentation and expense on an exterior, and which must to a greater or less degree give a smallness to the design, rather than breadth and boldness. But apart from the question of taste, the mode of fixing will prove a great drawback to its extensive use. The difficulty complained of in tile fixing applies in much greater extent to mosaic, owing to the large number of tesseræ used.

Lead might occasionally be advantageously employed ornamentally, being a very accommodating substance, as for instance in cast or stamped enrichments, applied to either wood or stone, the lead cisterns and other works of our forefathers a century ago proving its ability to stand the London atmosphere. No other material can equal it as a covering for flats, gutters, &c.

Zinc, also, may be very serviceable where stamped decoration is required. It can be minutely cut, is very light, and consequently easily fixed, and, if good, will stand the weather. It forms a good roofing material if properly laid, and under certain conditions.

Glass is a material which enters largely into every design for a London building, often to so great an extent as to cause much regret to the architect. Clients frequently make a great mistake in insisting on so much glass in their designs. Less would in many cases meet all the requirements for light, and make the rooms more private and comfortable in summer and winter; but (as before observed with iron) it is a necessity, therefore the architect should use every means to make it accord with the other portions of his design. It frequently happens, especially in shop fronts, that the tradesman is desirous of having as imposing a shop as possible, "goes in" largely for plate glass, but the very thing that he desires the most becomes his greatest trouble. Few men have goods sufficiently large to fill a window with high plates of glass, the greater part of the goods being exhibited as near the eye as possible, while the upper part is left almost bare. A means of getting over this difficulty may be, to engrave, or emboss, the upper portion of the glass, by which means, an opportunity is afforded to obtain a more solid and united appearance to the general design. Incrusted glass might be used with much effect, whereby ornament or letters are drawn upon a piece of glass wth a vitrified black paint, and burnt in; the inscribed glass is introduced at nearly a red heat into a glass pocket, the air is then exhausted, and the opening closed up. A similar process will preserve porcelain or other cameos, which with great care might be introduced in portions of buildings. Being solid they would not easily break, and would have the additional advantage of being thoroughly imperishable.

The advantages and capabilities of paint are too well known to need comment, but it is somewhat strange that so little polychromy and artistic feeling is used externally, while it is now so generally used internally.

Having considered London exteriors, and some of the materials best adapted for them, a few suggestive hints on their design may not be out of place.

It must ever be remembered that beauty will never be wholly obtained by the use of certain materials. The design itself must be pure—and proportionate, while the materials used are of the greatest importance to the appearance of a building. They must never be allowed to take the place of form and proportion in design. A building, to be satisfactory, should always look well in a drawing without the colours of the materials being shown, as architecture should never be dependent on colour, but rather that, as an accessory, it should serve to heighten and enrich it. Colour must enter to a greater or less degree in all designs, and it is fervently to be hoped that it may be more used than it has been hitherto, but great care is needed that it may not become a snare. Harmony must be carefully studied, so that a building may form a whole, and not a number of bits. This is especially applicable when tiles or mosaics are used. Where non-absorbent materials are used, the whole façade should be carried out with them, otherwise the soot and smoke will discolour the porous materials, while the others will retain their colour, and stand out with a glare, thus destroying all harmony of parts.

Every building should be designed with especial reference to its situation; as, for instance, large and heavy projections, producing light and shade, will be entirely out of place and useless in a building with a northern aspect. Cornices are great temptations, but generally, on account of the narrowness of the streets, and the limited space for light, they should be avoided, and the building, as a rule, being high, the upper part is scarcely visible to an ordinary passenger. The want of them is frequently more felt in a drawing than in reality. All materials should be used truthfully; if part of the construction, they should so appear: if decorative, they should be so apparent as not to be mistaken for a part of the structure.

Utility must be the motto of a London architect. This will be pressed upon him by all his clients. Every building should therefore be fitted for its intended uses. Precedent should never so far trammel him as to affect a client's interest, and, besides, a great field is open to all architects of the present day, to give to town buildings a distinctive character, and which can only be done by much careful study, both in design and materials to be employed. Were these points more attended to, we should have little need for a "nineteenth century style," as the variety of requirements would give ample opportunity for variety and development of design.

In these days of cheap travelling, much information may be gained by observation of buildings in other places, as there are few ways in which provincialism is more apparent than in building materials, and their mode of setting.

In conclusion.—In the foregoing essay, it is not pretended that the whole of the materials adapted to London exteriors have been noticed. Indeed, there are many materials and processes scarcely known beyond the Patent Office; and it is much to be regretted that there does not exist in London an exhibition of materials and inventions adapted to building. Those of the Architectural Galleries, and the South Kensington Museum, supply the want to some extent; but until the whole is brought together—in a building where the architect may judge for himself of the quality and expense of the materials, and compare them one with the other, prejudice in favour of the old-fashioned materials will continue. And further, manufacturers would generally find it to their interest to put architects in possession of their prices, as many are deterred from specifying articles not generally in use, for fear of the cost being excessive.

Although not possessing the richer materials abounding in other countries, there are few that offer to the architect so great a variety of building materials as our own highly-favoured land. From such he can make his own selection, and, in so doing, should give the preference to those which will effectually resist the London atmosphere, so that his buildings may retain their character and colour long after they have passed out of his hands, and the builder and architect have passed away.

In the course of the paper, Mr. Mathews alluded to specimens of Mansfield Stone, exhibited by Mr. Lindley; Little Casterton Stone, by Mr. Simpson; Patent Concrete Stone, by Mr. Ransome; Patent Compressed Bricks, by Messrs. Bodmer; Glazed Bricks and Tiles, by the Architectural Pottery Company; Bricks, Tiles, and other Terra-cotta articles, by Mr. Blashfield, of Stamford; and Machine-made Encaustic Tiles, String-courses, and Majolica Ware, by Messrs. Scrivener, of Hanley, Staffordshire.

Mr. Blashill, in moving a vote of thanks to Mr. Mathews for his paper, observed that any material which required painting, could not be considered satisfactory for the purposes contemplated in the essay just read. Highly polished materials were only desirable in special situations; for general purposes, smooth and hard materials, somewhat of the character of rubbed Portland stone, were required, as they could undergo washing, a process it would be, in towns, highly desirable to apply to our statues, as well as our buildings. Such stone was in ornamental work to be preferred to brick. Large sums were often lavished upon polychromatic designs in cut and rubbed work, which in London did not become mellowed, but actually obscured, and could only be considered as temporarily ornamental.

Mr. Lemon seconded the vote of thanks. With regard to terra-cotta, he had found the great defect to be the twisting in the burning, which altogether spoils the straight lines of the design. He observed that price was an important consideration: some manufacturers offered to supply terra-cotta at one-third the price of stone, but the quantity and amount of repetition affect the price materially, as the chief expense in the manufacture is the moulding. He suggested that the new Metropolitan Fire Brigade might be employed in washing the public buildings, and that St. Paul's would be a good one on which to commence operations.

In answer to a question, Mr. Mathews said that Minton made bricks or tiles which would work to a less thickness than three inches, but they were all glazed.

Mr. J. K. Colling (visitor), on being called on from the chair, said he had great pleasure in seeing the tiles and majolica exhibited by Mr. Scrivener, which had been manufactured by machinery. The great drawback to the use of terra-cotta arose from the effects of the burning. In manufacturing tiles for wall decoration, some more effective manner of forming a key ought to be adopted than that now in use.

Mr. E. J. Tarver had seen some good pargetting at an old grange known as Calais Court, near Broadstairs, in which effect was obtained by inserting white cement of various patterns in the rough cast, which was very dark, thus forming a pleasing contrast. This he considered suggestive of a legitimate mode of treating cements externally.

Mr. Riddett thought tiles might be manufactured in larger, or rather, longer pieces, than was now the case, and that they might be secured in grooves in the brickwork, or be used to supersede the cement reveal to our windows. Some of the rougher kinds of mosaic, he thought, might be advantageously employed. At present it appeared, from his observations, that indurating processes, applied to stone, required repetition at intervals, to render them in any way useful.

Mr. Florence defended to some extent the use of cement architecturally treated, as good Portland cement was more durable than many stones. He considered effect might be obtained from a simple manner of painting our buildings, without having recourse to the higher branches of the art, and desired members to study the perfecting of old materials, rather than the introduction of new ones.

The President (Mr. R. W. Edis), in putting the vote of thanks, expressed his opinion that the essay contained many valuable suggestions; but although freedom of opinion must be allowed, he considered it necessary to protest against the manner in which many materials, and eminently cements, were used, so as to amount to a practical lie. That which glosses over any monstrosity, such as bad brickwork, is bad in the extreme.

All cast ornament must, from its nature, be without that feeling which gives the value to true ornament; and terra-cotta, he had found, from painful experience, had the further defect of so warping during the baking, as to render its use very unsatisfactory,

The vote of thanks was unaminously passed, and Mr. Mathews replied.

AUTOMATIC TELEGRAPHY.*

By Alexander Bain.

Introductory Remarks.

Electricity is, unquestionably, the most extraordinary law or force of nature. It exhibits its presence everywhere and in everything by the effects it produces; we see the effects in the air, the sea, and in the more solid materials of the earth; and, although we cannot see the force itself, we weigh it as it were in the balance. We can produce its effects by simple friction or by change of temperature, by chemical action, or by the motion of magnetic bodies. We can produce artificial currents for short or long periods, perhaps for any duration of time; already they have been in constant and uniform action for upwards of twenty years, and have performed well the duty assigned to them.

It would, however, be unwise in us to imagine that all the effects of this most subtle force have been discovered; it is more probable that it silently produces in nature many effects which are not observable by our senses, or at least have not yet been discovered. But, be that as it may, the effects which we have already become acquainted with have led to many important results, and are still leading onward to greater achievements; and of all the purposes to which this force have been applied the telegraph seems to be the most wonderful. It is now capable of conveying our thoughts hundreds of miles far faster than we can think them, and many times faster than we can write them. In doing this it will travel overland through conductors and back again by similar paths, or it will travel out by the earth or sea and return through other conductors, or it will travel out by conductors and return by the earth or sea. It will print our thoughts on paper in common type, or it will merely exhibit them to the eye. It will write autograph letters hundreds of miles away, and it will draw our attention by audible sounds. It will tell mariners at our seaports the exact Greenwich time to less than a second by the falling of a ball, whereby they may regulate their chronometers without leaving their ships. By it we can regulate all the clocks in a town, or even work them throughout the whole kingdom, or find the longitude of places with far greater accuracy than could ever be done before. By it we can sound the deepest sea, and it will tell the mariner the instant the lead touches the bottom. It can work the machinery of our lighthouses and produce the light at the same time, besides many more purposes of utility too numerous to be described here.

Of all the effects produced by this force, magnetism has hitherto been the most extensively used for telegraphy. This seems to have arisen from the fact of its being more easily applied, and for some special purposes it is unquestionably the best; for instance, for the purpose of working the traffic of railways, where but few signals are necessary to be transmitted at one time, or between establishments at moderate distances, where but few messages are sent and but a few words in each, there can be nothing better used than electro-magnetic instruments, which can be in the form of letter-showing apparatus, so that any one can work them without previous teaching.

But when we come to general telegraphs for public use, which are often hundreds of miles in length, and the messages very numerous and often very long, the case is far different, and is presented to us in a very different aspect. Here, for various important reasons, which will be presently explained, we find the chemical effects of electricity are far better for our purpose than the magnetic effects.

Automatic Telegraphy.

Automatic telegraphy consists of methods of transmitting and receiving previously-composed messages between distant places by means of self-acting machinery in connection with electric circuits, and where properly carried out it is distinguished from common telegraphy by the great celerity with which messages can be sent and received, as well as by the great accuracy it ensures in the transmission and reception of intelligence. Indeed, the advantages it offers has appeared to the writer of this paper so vast, that he has devoted to it much thought, time, and labour. He was induced to do so from the following reasons, viz., seeing that the action of the human hand, however expert, could never take a tithe of the advantage of the speed of electricity, and also that the use of numerous wires was very objectionable, in consequence of the increased expense, but far more so from the great difficulty of obtaining good insulation among many wires of great lengths. At the time he first turned his attention to the subject of electric telegraphy, several wires were used for each pair of instruments, and never less than three; in consequence of which he endeavoured to contrive methods for reducing the number of wires, and soon succeeded in producing instruments capable of working on a single circuit, and afterwards succeeded in working with a single wire, having discovered that the earth might be used with great advantage for one-half of the telegraphic circuit. As this property of the earth is unquestionably a most extraordinary phenomenon, and still remains a paradox even to scientific men, and plays now a most important part in telegraphy throughout the world, and as the discovery has been independently made by others as well as the present writer, it will be well to give the ideas of scientific men respecting it. For instance the writer on mathematical and physical science in the 'Encyclopædia Britannica,' eighth edition, vol. 1, p. 986, observes, under the head of "The Earth Circuit,"—"There is one circumstance connected with the electric telegraph deserving of particular notice, I mean the apparently infinite conducting power, of the earth when made to act as the vehicle of the return current. Setting all theory aside, it is an unquestionable fact that if a telegraphic communication be made, suppose from London to Brighton, by means of a wire going thither, passing through a galvanometer, and then returning, the force of the current shown by the galvanometer at Brighton will be almost exactly doubled; if, instead of the return wire, we establish a good communication between the end of the conducting wire and the mass of the earth at Brighton, the whole resistance of the return wire is at once dispensed with. This fact was more than suspected by the ingenious M. Steinheil, in 1838, but, from some cause or other, it obtained little publicity; nor does the author appear to have exerted himself to remove the reasonable prejudice with which so singular a paradox was naturally received. A most ingenious artist, Mr. Bain, established for himself the principle, and proclaimed its application somewhat later; and in 1843, perhaps the first convincing experiments were made by M. Mateucci, at Pisa."

Again, Lardner observes that, "of all the miracles of science surely this is the most marvellous. A stream of electric fluid has its source in the cellars of the Central Electric Telegraph Office, Lothbury, London; it flows under the streets of the great metropolis, and, passing on wires suspended over a zigzag series of railways, reaches Edinburgh; where it dips into the earth, and diffuses itself upon the buried plate. From that it takes flight through the crust of the earth, and finds its own way back to the cellars at Lothbury."

Instead of burying plates of metal, it would be sufficient to connect the wires at each end with the gas or water-pipes, which, being conductors, would equally convey the fluid to the earth, and, in this case, every telegraphic despatch which flies to Edinburgh along the wires which border the railways, would fly back, rushing to the gas pipes which illuminate Edinburgh, from them through the crust of the earth to the gas-pipes which illuminate London, and from them home to the batteries in the cellars at Lothbury.

Although the automatic system has met with much opposition and neglect for a period of nearly twenty years, the writer thinks the time is fast approaching when the increasing requirements of the public will compel its general adoption; indeed, this necessity is partially shown by the number of telegraph inventors who have brought forward machines on the same principle during late years; but it is more clearly shown by the huge double ranges of numerous wires we already see stretched in all directions over the country, causing a vast (first) outlay, and a continual unnecessary expense to keep in order; but, setting the matter of cost aside, let us look at the working effect. It is well known that in damp and foggy weather, however well insulated the wires may be, small portions of the electric fluid will escape, from wire to wire, at all the points of suspension, and often from one to all on the same line of posts, especially between the

* Read before the Society of Arts.

longer and shorter wires, causing confusion among the instruments, and this confusion is greatly increased when many instruments are working at the same time.

Again, when storms arise, numerous wires, especially when near to each other, present so large and compact a surface to the gale, that they are far more liable to be broken down than one or two would have been, especially when snow or ice collects upon them. Should this take place to a considerable thickness, a heavy gale must exert an enormous force against them, so much so, that the post or wires must give way (as has recently happened), very likely both. And when such a disaster takes place, what is the result? Why, it will take as many weeks as it would days were there only one or two wires to repair, causing an immense loss to the public, as well as to the companies themselves, leaving the great cost of repairs out of the question.

Yet notwithstanding these well known facts, these double ranges of many wires are stretched within a few inches of each other for hundreds of miles amidst the humid air of this country. Among numerous wires the fluid has thousands of chances of escaping from one to all, or any of the others. These chances are invariably seized, and hence deranged action of the instruments, causing mistakes, repetitions, general confusion, and consequent delay, and every additional wire put up only adds to the difficulty. In consequence of the foregoing reasons, the chief object of every telegraphic engineer should have been to contrive instruments of the greatest possible celerity, for the purpose of doing as much work as possible with a single wire. With a view to that end the writer turned his attention to the subject of automatic telegraphy at an early date, and in 1843 patented an automatic copying telegraph. Diagrams of these instruments are shown. They consist of two powerful pendulum clocks, and two smaller pieces of clockwork; these last are moved by weights, which consist of metal frames, in each of which is placed a plate, N, composed of conducting and non-conducting materials, in the following manner:—A frame is filled with short well-insulated wires parallel to each other, and then filled in with sealing-wax, so that the whole forms a perfectly compact body; the two flat surfaces are then ground perfectly smooth, and are permanently fixed in the metal frame at the back of the plate, in which may be placed either a composed form of printers' types, or any other surface which may be desired to be copied at a distant station, and chemically prepared paper at the receiving station. Each of the pendulums carries a metallic arm, the points of which act as tracers on the surface. Now let us suppose one frame filled with a previously composed form of printers' types, and the other frame with chemically prepared paper. The electric current will flow from the positive pole of the battery to the type, from thence through the small wire to the tracer, up the pendulum to the long telegraph wire, down the pendulum rod of the receiving instrument, through the tracer to the short wires, and from thence to the chemical paper, forming thereon a series of small dots, corresponding with the forms of the types at the transmitting station. The magnets to the left of the clock movements release the small clock-work, so as to allow the frames to drop through a small space at every vibration of the pendulums; the pendulums regulate each other at each vibration to the left.

The writer believes that this was the first copying telegraph ever contrived, but as the plan required that all the instruments should go sinchronously together, or that several wires had to be used, either of which he soon saw would produce too many difficulties for practical use, it was proceeded with no further, and is only noticed here to show that the invention of that class of scientific toys, called copying telegraphs, is much older than many imagine.

Having by the foregoing efforts gained much experience, although he arrived at little satisfactory results in automatic telegraphy, he had decided to compose the messages in some simple telegraphic characters by mechanical means; and after much labour, and the trial of many methods, he was fortunate enough to hit upon the plan of composing the messages by means of punching groups of perforations on paper, in such manner that each group represented a letter, numeral, or other sign, which has turned out to be a most simple and efficient plan. At first the punches were operated by hand, without the aid of machinery, and the working was consequently rather slow; but the writer having subsequently contrived machinery for the purpose, they can now be worked with great rapidity.

Of all the known effects produced by electricity, the chemical has been found by the writer best suited for automatic telegraphy, principally because it is quicker in its action than any other, having nothing of ponderability to move, and consequently no inertia to overcome.

Electro-magnetism, it is true, would answer to some extent, but in that case ponderable bodies had to be moved with great rapidity by the electro-magnetic force, and on long telegraphic lines, the force being small, all the mechanical actions produced by it must be of necessity very delicate, and require fine and delicate adjustments, which have to be often varied with the varying strength of the currents. Besides, delicate mechanical actions are always liable to get out of order; so that, after much thought, and numerous experiments with the magnetic as well as the chemical effects of electricity, the writer decided to use the latter only for his automatic system, as the currents would have nothing to perform but decomposition at the point of the chemical pen, the machinery being worked by other power.

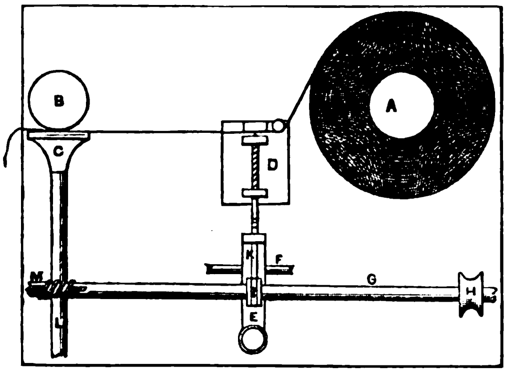
In order to show how the chemical property of the current may be made to produce visible marks or signs, let us suppose a sheet of paper, wetted with an acidulated solution of ferroprussiate of potash, and laid upon a plate of metal, and let the point of a steel or copper style be applied to it so as to press it gently against the metallic plate. Let the style be now put in metallic connection with the wire which leads to the positive pole of a voltaic battery, and let the metallic plate upon which the paper is laid be put in connection with the wire which leads to the negative pole. The current will, therefore, flow from the style through the moistened paper to the metallic plate, and it will make a blue or brown spot thereon according as the style is of iron or copper.

If the paper be moved under the style while the current flows, a continuous line will be traced upon the paper. If while the paper is thus moved the current is permitted to flow only during intervals of long or short duration, the paper will be marked with lines long or short, according to the intervals during which the current flows; there being no mark made during the suspension of the current. The long or short lines thus traced upon the paper will be separated one from another by spaces more or less wide, according to the lengths of the intervals of suspension of the currents. It is evident that the same effects will be produced, whether the style be at rest and the paper moved under it, or the paper be at rest and the style moved over it. The paper may be moved under the style by various mechanical expedients. It may be in the form of a ribbon coiled upon a roller, and drawn under the style, which was one of the writer's first plans; or it may be in the form of a common square sheet and wound upon a cylinder, to which could be given a revolving motion, and at the same time receive a slow motion in the direction of its axis, so that the course of the style upon it would be that of the thread of a screw or helix; this was also one of the plans the writer adopted in his early experiments, but the plan he has found most convenient in practice is to cut the paper into the form of circular discs, about 18 or 20 inches diameter, and after being chemically prepared, any required number are laid upon a metallic disc of equal size. To this disc is given a motion of revolution round its centre, in its own plane, by clockwork, or any other convenient power, while the style receives a slow motion directed from the centre of the disc towards its edge. In this case the style traces a spiral curve upon the paper, winding round it continually, and at the same time retiring constantly but slowly from its centre towards its edge.

Punching Machine.

Fig. 1 represents a plan of so much of the punching machine as will explain the principle of its action. A is a roll of ribbon paper; B and C are two revolving discs for the purpose of drawing forward the paper from off the reel; D represents the punch; E a finger key, with its axis at F; H is a pulley, which receives rapid motion from a wheel driven by the foot, similar to that of a sewing machine; I is an eccentric on the shaft G, which gives rapid to-and-fro motion to the rod K, on the rod G; at L there is a screw which works into and gives motion to a wheel M, which is on the shaft of the disc C. It will be observed that when the pulley H receives motion from the band, the eccentric I gives rapid to-and-fro motion to K, at the same time the screw at L gives a slower motion to the wheel M and the discs C and B, which draw forward the paper in front of punch D. Now, if the finger key is pressed down at E (shown in elevation by Fig. 2), the other end of the key will raise the rod opposite the punch, which will be pressed forward rapidly and punch the paper. If the key is pressed but for an instant a short hole will be punched, but if kept down for a longer interval a longer hole will be punched. In this way groups of short and long holes can be punched at pleasure, representing letters, words, and sentences, and thus messages can be composed of any length and with considerable celerity. These messages can then be carefully compared with the manuscripts from which they were taken, and, if needful, corrected before being placed in the transmitting machine, so that no mistake should ever be sent along the line.

Fig. 1.



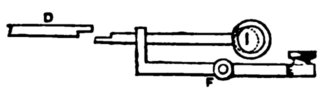


Fig. 2.

Transmitting Apparatus.

Fig. 3 is an enlarged view of so much of the transmitting apparatus as will explain the principle ot its action. N is a portion of paper ribbon with groups of perforations, each group being supposed to represent a letter of the alphabet; O is a metal bar in which are fixed five metal springs in the form of the teeth of a comb; Q is a metal roller insulated from O, except at the points of the springs P. Now let O and Q be in the telegraph circuit, and the paper drawn through, as it may be, with great rapidity, when the perforated portions of the paper pass under the springs they come into contact with the roller Q, and the current flows through the circuit, and when the unperforated portions of the paper are under the springs the current is interrupted thereby. In this way electric currents can be sent through telegraph circuits with extraordinary rapidity and perfect accuracy in their duration and grouping.

Receiving Apparatus.

The receiving portion of the apparatus is a revolving disc carrying chemically-prepared paper, and a metal frame carrying a revolving screwed shaft; on the upper end of this shaft is fixed a roller, which lies gently on the disc. The screwed shaft carries a style-holder. As the disc revolves it gives motion of rotation to the roller, and consequently to the screwed shaft, which causes the style-holder to recede slowly but constantly from the centre to the outer edge of the disc. Now let us suppose the apparatus properly arranged in the telegraph circuit, as is well known, the currents from the comb and roller at Fig. 3 will pass through the style into the chemically-prepared paper at the receiving station, and make marks thereon corresponding exactly in their lengths and their groupings with the perforations in the paper shown at Fig. 3.

Having thus described the principal actions of the composing machines, and also of the transmitting and receiving apparatus, let us now proceed to show how they are combined so as to form a complete system.

The author purposes to have only two wires at most on one line of posts, one to be called the up wire and the other the down wire, so that messages can be transmitted in both directions at the same time. The messages are transmitted by the apparatus through the main wire in the manner shown at Fig. 3, but his experience has shown him that the best way to receive the messages is through branch circuits, so as to keep the main wire contacts always complete, except in the process of transmission.

Figs. 4, 5, 6, represent three different stations on a telegraph line. A represents a galvanic battery, C the transmitting apparatus, and D the receiving portions at each of the stations; the trans-

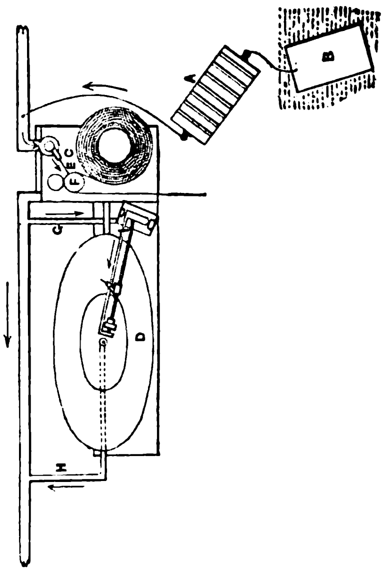


Fig. 6.

Fig. 3.

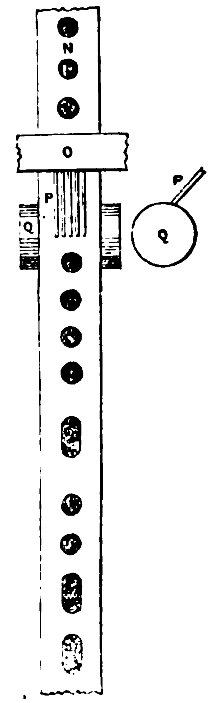


Fig. 5.

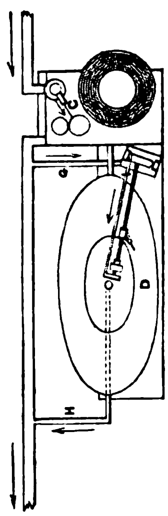


Fig. 7.

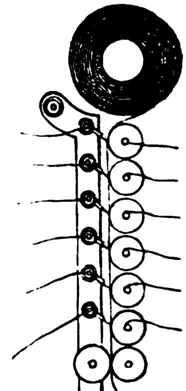
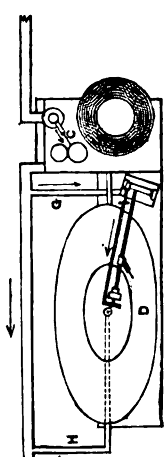


Fig. 4.



mitting and receiving apparatus, it will be observed, are moved by the clock mechanism at C, the instrument (Fig. 6) is shown in the act of transmitting. Figs. 4 and 5 are shown in the position of receiving. Although only three instruments are shown, there may be any desired number on the same line.

The action is as follows:—The current passes from the battery A to the main wire, from thence to the spring E, through the perforations of the paper to the roller F, then to the frame of the clockwork, and from thence to the main wire, but at each of the intermediate stations, when they are necessary, a portion will pass down through the ends of the branch circuits at G, to the frames I, through the styles to the chemical paper, and will return by the end H, to the main wire. In this way the currents are made to write a copy at every station on the line, but at the stations where copies may not be desired, all that the operator has to do is to lift up the pen from the paper, and let it stand in the position shown at Fig. 6, or he may turn back the penholder frame altogether away from the disc.

Fig. 7 shows a method by which a despatch can be transmitted from a central station, say from London, to any number of telegraph lines simultaneously, so that the despatch may be received and written at any number of towns on each line, in the way already described.

This system has been proved electrically, chemically, and mechanically, in England, France, and America. It can transmit intelligence from London to the farthest corner of England or Scotland at the rate of, in round numbers, six words per second, 333 per minute, 20,000 per hour, and with a degree of accuracy never before obtained by any other system, and, further, it can automatically transmit despatches of any length from any place, say from London to all the principal towns of England simultaneously, at the above-named degree of celerity.

THE ARCHITECTURAL ASSOCIATION.

The regular fortnightly meeting of this Association was held on Jan. 19th. Mr. R. W. Edis, President, in the chair. Mr. Vialls, Mr. Northcote, and Mr. R. O. Harris, were elected members of the Association.

The Hon. Sec. (Mr. Mathews), read a communication from the Dean of Westminster, having reference to the restoration of the Chapter-house, and requesting the support of the Association.

The President observed that he was glad to learn from the letter that a deputation was about to wait upon the Chancellor of the Exchequer in order to influence him to provide funds for this restoration. Dr. Stanley had proposed in his letter that he (the President) should join the deputation. He could only say that he would have much pleasure in doing all that lay in his power to promote this object. The President then proposed the following resolution:—"That the Association learns with much pleasure that the Committee which has been formed with a view to the Restoration of the Chapter-house at Westminster, is about to take active steps therein; and begs to express its most cordial sympathy in the work, and promises to use its best efforts in any way that may be in its power for the accomplishment of this great national undertaking."

This resolution was passed unanimously.

The President said that the Association taking, as it did, an interest in the welfare of its members, would be glad to learn the honour which had been conferred upon Mr. James Lemon, in his appointment to the surveyorship of Southampton, he having been selected from a list of sixty or more competitors. The Association would lose a useful member. He (the President) hoped that Mr. Lemon would still continue his connection with the society. It was his duty also to announce, with great regret, the sudden and lamented death of their late Registrar (Mr. Moody). He was sure they would all join with him in passing a sincere vote of sympathy and condolence with Mrs. Moody, in her sad and sudden bereavement. In cases of this kind it was well to say as little as possible; but he was sure that all who had met Mr. Moody had ever found him attentive, courteous, and willing to render every assistance which lay in his power. He (the President) thought that the expression of the feeling of the Association ought to go beyond mere words. He did not, therefore, think he was exceeding his duty in proposing that a subscription be raised as a testimonial of respect for one who had served the Association faithfully while living; and he should be happy to receive subscriptions from any members who might be willing to assist him in this matter. He then proposed the following resolution:—"That this Association has heard with great regret of the death of their late Registrar (Mr. Henry Moody), and begs to express its sincere sympathy with and condolence for the widow and family in their sad and severe bereavement."

Mr. Mathews seconded the motion, which was unanimously agreed to.

The Chairman then called upon Mr. R. P. Pullan, F.R.I.B.A., to read a paper on "Christian Architecture in the East," of which the following is an abstract

CHRISTIAN ARCHITECTURE IN THE EAST.

When we speak of Christian Architecture, we are generally understood to mean either some of the Gothic styles, or at the utmost some of the various forms which the Romanesque assumed during its gradual development subsequently to the ninth century, such as the Lombard, Teutonic, or Norman. But this is at the least a very narrow and limited sense, for it amounts to the ignoring of all that was done by Christians before that period; men shut their eyes to the fact that in the East there were architects and church-builders none the less expert, and perhaps more original, than those in the West; for they invented a style of greater grandeur in its masses, and more magnificent in its decorations (when properly carried out), than any style that prevailed elsewhere. I mean the Byzantine; and I speak deliberately when I say that the interior of St. Sophia's at Constantinople,—the building in which Byzantine architceture sprung into perfection from the brain of its inventor, Anthemius—like Pallas from the head of Jove, garnished at all points,—presents the finest interior in the world. In the first place, it has that great element of architectural grandeur, massiveness, in its enormous piers and vast arches, from which spring the pendentives of the flat dome, which, by the way, is far more imposing than a lofty one like St. Paul's or St. Peter's, for the dignity of these can only be fully appreciated when you are immediately beneath them, and looking upwards. It possesses appropriate decorated construction in its columns of every kind of rich marble, its carved capitals, rich inlaid spandrils, and in its mosaic decorations, which are now unfortunately only visible in the soffits of the arches, as those of the dome and apse have been whitewashed by the Turks. All this is perceptible at a glance, all taken in in one view, hence the sublimity of a *coup d'œil* which surpasses in effect the interior of Milan Cathedral, which is perhaps, independently of detail, the finest interior of the West.

The style of which this fine building is really the prototype we have been content to overlook, as well as all the various ramifications which spring from it, and which really present almost as many varieties as our Gothic. I propose to introduce it to your notice this evening for the purpose of showing its claims to be studied, and of vindicating its position amongst its sister styles, as being equally with them worthy the attention of the architect.

The lecturer said that he should be inclined to divide the epoch of Byzantine art into four periods. Assuming the reign of Justinian, from A.D. 327 to 356, to be the pure period—equivalent to the thirteenth century to Gothic—he should consider the buildings erected between the time of the foundation of Byzantium and the time of Justinian, as belonging to the first period; those erected by Justinian to be of the second; from the end of his reign to the year 1000, to be the third period; and from that time to the fall of Constantinople, the fourth. In addition to these general divisions, there were those of geographical and local character, such as those of the Armenian, Georgian, and Servian styles. Hence the field offered for archæological research in the East was as wide as that in the West, and it also had the advantage of being comparatively untrodden ground.

He then traced the rise and progress of Christian architecture from the earliest period, remarking that until the time of Justinian, churches were built on no fixed plan, some were round, in imitation of the Pantheon, such as the Anastasis at Jerusalem, and the church of St. George at Salonica; some octagonal, such as that at Antioch; others were dromic, such as Constantantine's church at Jerusalem, and some of the fourteen built by him at Byzantium; some had transepts, like that at Bethlehem. But in the time of Justinian, Anthemius determined the future form of the Byzantine church—a Greek cross inscribed in a square—this form being a natural consequence of the vast central dome. Anthemius was a man of genius, and the inventor of pure Byzantine architecture, he altered the proportions of the Classical column used hitherto, to suit the purposes for which it was now required.

After describing the churches erected at Thessalonica and elsewhere during the time of Justinian, the lecturer remarked that, while Byzantine architecture was thus making that slow progress in the West of the Byzantine empire, it was advancing by gigantic strides in the East. There the builders were not fettered by precedent, consequently their architecture had a freshness and novelty unequalled, and we are only beginning to learn what this architecture was. Travellers unlearned in archæology told us that in the country round Aleppo and Antioch there were numerous ruined cities, but they were unable to ascertain their dates or styles, and it has been reserved for that enterprising traveller, the Count de Vogüé, to astonish the architectural world with a complete revelation in the history of Byzantine art. He is at present publishing a magnificent work, full of engravings of the buildings he discovered in the central district of Syria, and in the Hauran beyond the Jordan, and we find in it representations of buildings which perfectly astonish us. There are entire cities full of houses and churches built in what is to us an entirely new style—a development of the Byzantine, which want only roofs to make them perfect: there are churches of every variety of plan, and with characteristics of all periods, from the third to the sixth century, some dromic, others octagonal, some that have had wooden roofs, others that have stone roofs, many of them with semi classical mouldings, others with mouldings closely resembling our Norman, of all dimensions, from the little village church to the immense cathedral. Those in the Hauran have stone ceilings, while those in northern Syria have had wooden roofs; some have apses, others have not.

Amongst the host of remarkable churches, one may be specially mentioned for its size and magnificence. It is in reality four churches in one, as it consists of four naves, with aisles adjoining them, standing at right angles to one another, so as to leave at their intersection an open court, octagonal in plan, in the centre of which is a socket where formerly was the pedestal of the column upon which stood that remarkable pillar-saint, St. Simon Stylites, in honour of whom this group of buildings was erected. Many of these churches want but their roofs to restore them. These edifices are confined to two districts in Syria, one the Hauran, east of Damascus, and the other that around Aleppo; as both these districts are unvisited by the ordinary traveller, these archæological treasures have remained unknown for centuries.

Dismissing for a time the subject of Byzantine art, which necessarily had the chief claim for consideration, Mr. Pullan proceeded to mention the works of the Crusaders existing at Jerusalem and other places in Syria, remarking that the character of their architecture was almost exclusively French, and of good style, especially that of the south façade of the church of the Holy Sepulchre; the church of St. Anne, the Hospital of St. John, and the church in the village of Abou Gosh. He then briefly alluded to the works of the knights of St. John, in the isles of Cyprus, Rhodes, and Cos, and the Castle of Boudroum, and concluded his lecture as follows—

To return to the legitimate part of my subject, I have to say that Byzantine architecture, which did not materially alter during the fourth period, became the parent of the Russian and other styles which prevailed under the dominion of the Greek church, but that in later times the first Byzantine building was never surpassed, or even equalled.

The study of this architecture then I commend to your notice. But some of you may be inclined to say—Of what practical use can a knowledge of it be to us: now-a-days we cannot afford to waste materials in erecting massive piers, nor to construct immense domes over our churches, as the former would obstruct both sight and sound, and the latter would require more science in their construction than groining, and without decoration would have a bare and bald effect. In answer to this, I may urge that, as the architects of the twelfth and thirteenth centuries in Acquitaine adapted the Byzantine dome with great success, altering its proportions and making it pointed instead of flat, in order to suit their more aspiring architecture,—so might we, in like manner, use it in our town churches. Those who know Angoulême Cathedral will remember what breadth and dignity it gives to the aspect of the interior, and, now that we have a rising school of decorators, the bare effect might be removed by frescoes or distemper paintings.

So long as we carry our utilitarian principles into church-building we can never expect to have in England so magnificent a cathedral as St. Mark's at Venice—which, by the way, is the most perfect Byzantine church to be seen in Europe, built by architects from Constantinople—but it is not so certain that we may not see a reproduction of one of the grand dromic churches of Byzantine times, as a church on such a plan would afford wide spaces and comparatively small obstructions, and would at the same time afford opportunities for fine proportions and for refined ornamentation, both of which are often neglected in our Gothic buildings. At all events, the study of Byzantine architecture may be useful, in showing how Classical proportion may be applied to a distinct style, and willpoint out the direction in which our expectation of an improved Gothic should lead us to direct our studies.

Mr. Pullan's paper was illustrated by a series of drawings from Eastern Churches, and with an original design by Mr. Pullan of the Interior of a Church in the Byzantine style.

Mr. DUNPHY said that, though they might not entirely agree with Mr. Pullan with regard to the applicability of Byzantine architecture to modern uses, yet the members of the Association were deeply indebted to Mr. Pullan for the able and luminous paper which he had read. He had the greatest pleasure in moving, that the thanks of the Association be offered to Mr. Pullan for the same.

Mr. BENWELL seconded the motion. He had been at Venice, and his study of the style as there seen led him to question whether it could be adapted to an English climate. If an architect retained the typical forms of Byzantine architecture, he could not sufficiently light a church for this country. Looking at Mr. Pullan's design he (Mr. Benwell) could not see how it could be suitable for Protestant worship. The Byzantine churches are gloomy, morose, and wholly unsuited to the Church of the present day, and unless the style can be made lighter it is useless to suppose that it can form the nucleus of a new order of architecture.

Mr. W. RIDGE remarked, that in the study of any style our object was not to reproduce buildings in that style, but to study the effect produced and the means employed to produce them, for the sake of our own education. We often speak of the space under the dome in St. Paul's Cathedral—and space is perhaps the impression chiefly conveyed to the mind by the use of the dome. If in our large churches we had more of this feeling of space, it would add much to their grandeur as well as their utility. Mr. Ridge, however, questioned the desirability of using domes, on account of their effect on sound. It would not do to build a church with a large dome at the intersection of the transepts, if that dome had the property of swallowing up the voice; and a series of domes would probably interfere more with the sound than ordinary vaulting. The study of Byzantine architecture was therefore to be pursued more for the purpose of educating the mind than for the purpose of building churches in that style. He hoped that before long they would cease to build in any particular style; that they would not put up 13th century, or 15th century, or Byzantine churches, but that the buildings they erected would be built with truth and consistency, and not "cribbed" from any particular style which has gone before.

The President said that the paper contained information of a most interesting and valuable character, and showed the results of much travel and research. The man who had travelled most, and had seen most, will, in most cases, conceive the best designs. The artist did not travel for the sake of making a copy of some building, but in order to have his mind imbued with ideas of beauty, and the man who knows most of the buildings of the past will best give us his experience when he comes to design for this day and generation. It was not necessary to copy, but the man who did not take advantage of all that the ancients had left behind was deficient of common sense. Of Byzantine architecture he would speak with all humility. He had only read about it, and seen some of the churches in France which partook of its style. The impression left upon his mind by these was, that they expressed great solemnity, but he could not admire the style to the extent Mr. Pullan appeared to do. He (the President) did not think that churches ought to be built in the 19th century with a grand nave, long aisles, and long façades. He could not, moreover, agree with Mr. Pullan as to the dome. He considered they were not bound to erect great unnatural walls to support what had a heathen signification. He did not think they should take a heathen temple as a model for a Christian Church.

Mr. DUNPHY said Mr. Pullan's remarks on space were most valuable. But before they got the space they would require to get more reverence in the people. He had lately asked one of the vergers in St. Paul's, if the building was ever used by individuals for acts of devotion. He had replied that foreign visitors occasionally knelt in silent prayer, but that the British public never manifested any such emotion in the building; except, of course, in that portion which was railed in for stated public worship.

Mr. PULLAN, in replying to the comments which had been made upon his paper, stated that his object in bringing the subject before the association was not that they should have a slavish revival of Byzantine architecture, but to induce those who had not hitherto paid attention to the style to study it, so that they might produce something new. Byzantine architecture would be something new, and he believed it could readily be adapted to suit the requirements of modern Protestant worship as regards light and hearing.

Mr. RIDDETT inquired what was the heathen significance of the dome, to which the President had adverted.

The President explained that he meant that the dome was in use among the Romans, and had been handed down from them.

The vote of thanks to Mr. Pullan was unanimously adopted.

Mr. Ridge called the attention of the meeting to an advertisement issued by the Trustees of St. Mary's, Islington, calling for designs for a workhouse, and offering to pay the architect 2½ per cent. upon the outlay. The Trustees also offered premiums of £100, £30, and £20, respectively, to be awarded to three designs, which are to become the property of the Trustees. With regard to the third premium, he hardly thought £20 a proper price for a design for a workhouse for a thousand persons. He thought that the question of the two-and-a-half per cent. put forward, as it had been, in such an unblushing way, ought to be taken notice of by the association in some manner.

The President thought it better not to take any action in the matter. So long as architects were found willing to compete for such prizes, trustees would be found ready to offer them. These gentlemen no doubt did it in ignorance.

Mr. Ridge could not agree with the President upon this point. He thought that, out of compassion to the ignorance of the Trustees, they ought to receive some intimation as to the proper scale of remuneration, and he therefore begged to move, "That the Secretary be instructed to forward to the Trustees of St. Mary's, Islington, the Institute's Schedule of Architects' Charges, with a letter, calling attention to the remuneration clause."

Mr. Riddett seconded the resolution, which was carried.

EXPERIMENTS IN MIXING AIR WITH LOW-PRESSURE STEAM.*

By T. McDonough.

The apparatus used is of a simple form, steam being generated in a small boiler and allowed to escape through a nozzle so as to strike upon the fans of a little air-mill. The quantity of steam escaping in a given time, and the number of revolutions introduced in the air-mill by this means was determined in the first place by direct experiment. Air from a gas-holder under moderate pressure is then allowed to flow into the rear of the same jet and issue with the steam. The amount of air so added, and the number of revolutions in the air-mill during a given time being again determined, it is thus found that the addition of a small amount of air, say $\frac{1}{10}$ that of the steam, would increase the number of revolutions in the mill by a much greater quantity, as in this case by ¼.

The following table exhibits the result of many experiments:

Table of Experiments in Mixing Air and Steam.

Revolutions of wheel ℔ min...	60	60	60	60	60	60	60	60	60	70	60	84	60	86
Cubic inches of steam ℔ min...	432	432	432	432	432	483	432	432	432	504	432	604	432	619
Inches of air added ℔ min..	43	60	83	120	150	200	40	66	55	85	56	100	85	120
Motion of wheel with steam and air	78	90	91	120	165	164	74	107	88	111	80	180	99	150
Gain by adding air over what is due to increased vol...	0·29	·23	·17	·37	·61	·56	·39	·44	·30		·25			·32

Example.—In the first column, by adding 43 inches of air to 432 of steam, the wheel increases its speed from 60 to 73, or about one quarter for an added volume of one-tenth.

This action it is proposed to apply to steam engines by so arranging the valves, &c., that air in place of steam will be admitted during the first part of the stroke, after which the steam will be admitted and mix with this air.

These experiments and results do not stand alone, but are supported by other independent investigations. Thus, similar facts have been observed in connection with a small steam turbine, by Prof. R. E. Rogers, of the University of Pennsylvania, and a plan for using air and steam together mentioned in the London *Mechanics' Magazine*, January 1865, page 7, points to some observations in the same direction.

In explanation of some of these experiments, it may be suggested that the introduction of cold air might condense some portion of the steam, so causing it to be projected in liquid drops against the wheel, by which means its motive power would be more efficiently applied than when it issued as an expanding and diffusable vapour.

The apparatus referred to above was explained by means of a drawing made upon a plate of glass (coated with a collodion film, which had been sensitised, exposed, and developed in the usual manner) placed in a powerful lantern, by which a greatly magnified image was thrown upon a screen conveniently adjusted, and thus made distinctly visible to all in the room.

* From the Journal of the Franklin Institute.

Reviews.

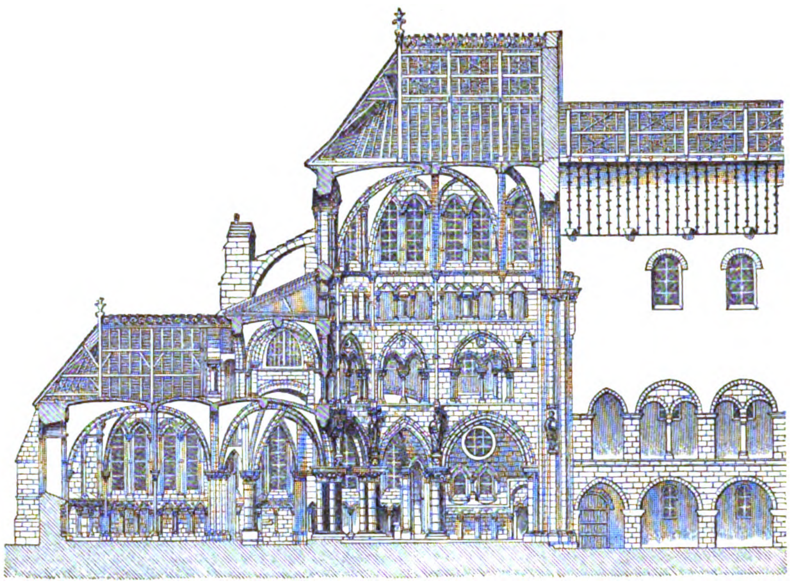
A History of Architecture in all Countries, from the Earliest Times to the Present Day. Vol. 1. By James Fergusson, F.R.S., &c. London: Murray.

It is not often the case that an author enjoys, or makes for himself, the opportunity of revising his work, not only while in the form of manuscript, or while passing through the press, but after it has been published and criticised, and calm reflection has been possible. And yet, to those who know how important the results of repeated revision and correction renewed after an interval has been allowed to elapse, often prove, it is a subject for regret that this process should not oftener be possible.

The work now given to the public presents what we may term a third edition—a revised revision—of the views expressed, and the materials collected for publication, by Mr. Fergusson, in his work on 'The Principles of Beauty in Art.' This book was to have contained three volumes, but the success of the first volume was not such as to encourage the author to continue it in the form in which it was begun. 'The Illustrated Handbook of Architecture,' published in 1855, gave to the world the materials prepared for the earlier work, with no doubt many additions, and something of the theoretical views propounded in that volume of it which actually appeared, in a condensed but highly systematic form, and in popular language. A new edition of that work being now called for, the following extract from the preface explains in what way the author has replied to the call.

"Under these circumstances the question arose, whether it would be better to republish the Handbook in its original form, with such additions and emendations as its arrangement admitted of, or whether it would not be better to revert to a form nearly approaching that adopted in the 'True Principles,' rather than that followed in the composition of the Handbook, as one more worthy of the subject, and better capable of developing its importance. The immense advantages of the historical over the topographical method are too self-evident to require being pointed out, whenever the object is to give a general view of the whole of such a subject as that treated of in these volumes, or an attempt is made to trace the connection of the various parts to one another. If the intention is only to describe particular styles or separate buildings, the topographical arrangement may be found more convenient; but where anything beyond this is attempted, the historical method is the only one which enables it to be done. Believing that the architectural public do now desire something more than mere dry information with regard to the age and shape of buildings, it has been determined to re-model the work and to adopt the historical arrangement. In the present instance there does not seem to be the usual objection to such a re-arrangement—that it would break the thread of continuity between the old and the new publication—inasmuch as, whichever method were adopted, the present work must practically be a new book. The mass of information obtained during the last ten years has been so great, that even in the present volume a considerable portion of it has had to be re-written, and a great deal added."

The first volume, as now issued, contains nearly half as many more pages as the first volume of the Handbook, and one-third more woodcuts; but the addition thus made to the bulk and richness of the work is not by any means the most important part of the change. The division of mankind into races, and the variations in art, consequent on the natural capacities or qualities inherent in each race, a subject slightly touched upon in the Handbook, is now made to form to a great extent the key-note of the treatment of the subject; and this gives a philosophic value to the re-issue greatly in advance of the older work, excellent though that undoubtedly was in many most essential particulars. It is true that on this score the work may be considered now more open to criticism that it was in the

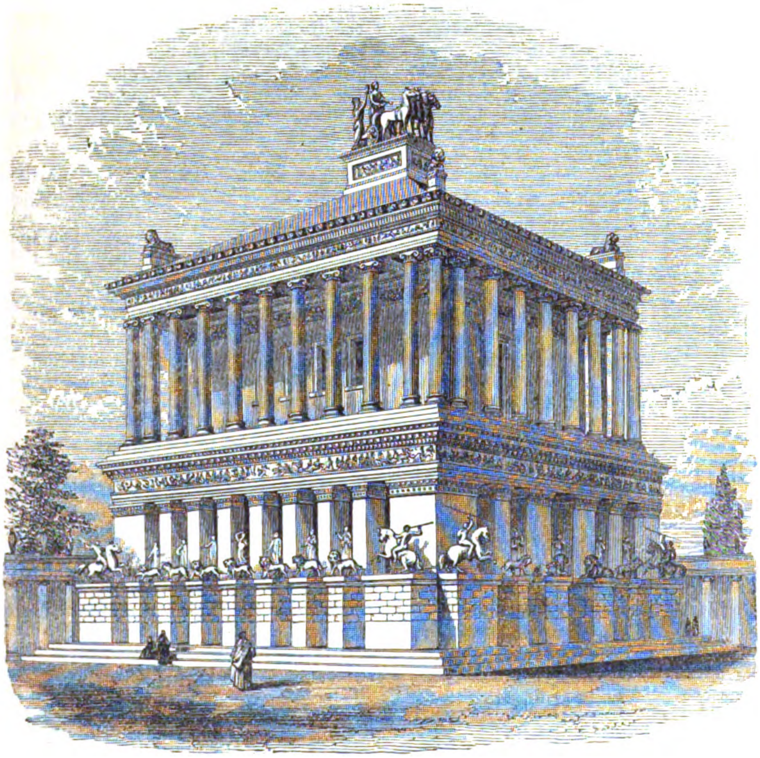


Section of Eastern portion of Church of Mortier en Der.

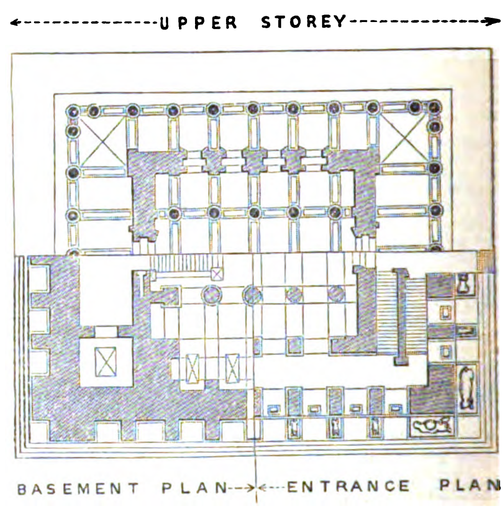
original form, but for this Mr. Fergusson is prepared, remarking, with great justice,

"My conviction is, that the lithic mode of investigation is not only capable of supplementing to a very great extent the deficiencies of the graphic method, and of yielding new and useful results, but that the information obtained by its means is much more trustworthy than anything that can be elaborated from the books of that early age. It does not

access to sources of information of which they do not suspect the existence. While they were trying to reconcile what the Greek or Roman authors said about nations who never wrote books, and with regard to whom they consequently had little information, I was trying to read the history which these very people had recorded in stone, in characters as clear and far more indelible than those written in ink. If, consequently, we arrived at different conclusions, it may possibly be owing more to the sources from which the information is derived, than to any difference



View of the Mausoleum of Halicarnassus, as restored by Mr. Fergusson.



Plan of the Mausoleum at Halicarnassus, from a drawing by Mr. Fergusson. Scale, 50 feet to 1 inch.

therefore terrify me in the least to be told that such men as Niebuhr, Cornewall Lewis, or Grote, have arrived at conclusions different from those I have ventured to express in the following pages. Their information is derived wholly from what is written, and it does not seem ever to have occurred to them, or to any of our best scholars, that there was either history or ethnography built into the architectural remains of antiquity. While they were looking steadily at one side of the shield, I fancy I have had a glimpse of the other. It has been the accident of my life—I do not claim it as a merit—that I have wandered all over the old world. I have seen much that they never saw, and I have had

between the individuals who announce it. Since the invention of printing, I am quite prepared to admit that the 'litera scripta' may suffice. In an age like the present, when nine-tenths of the population can read, and every man who has anything to say rushes into print, or makes a speech which is printed next morning, every feeling and every information regarding a people may be dug out of its books. But it certainly was not so in the Middle Ages, nor in the early ages of Greek or Roman history. Still less was this so in Egypt, nor is it the case in India, or in many other countries; and to apply our English nineteenth century experience to all these seems to me to be a mistake. In those countries and times, men who had a hankering after immortality were forced to build their aspirations into the walls of their tombs or of their temples. Those who had poetry in their souls, in nine cases out of ten, expressed it by the more familiar vehicle of sculpture or painting rather than in writing. To me it appears that to neglect these, in trying to understand the manners and customs or the history of an ancient people, is to throw away one half, and generally the most valuable half, in some cases the whole, of the evidence bearing on the subject. So long as learned men persist in believing that all that can be known of the ancient world is to be found in their books, and resolutely ignore the evidence of architecture and of art, we have little in common. I consequently feel neither abashed nor ashamed at being told that men of the most extensive book-learning have arrived at different conclusions from myself—on the contrary, if it should happen that we agreed in some point to which their cotemporary works did not extend, I should rather be inclined to suspect some mistake, and hesitate to put it down."

The arrangement of the work being now not geographical, but historical, so far indeed as an historical sequence can be followed in a narrative, which often is required to tell one after the other, things that really occurred simultaneously, though in different parts of the world; Mr. Fergusson has decided that the best arrangement available is one which divides the whole history of architecture into four great parts.

"The first, which may be called 'Ancient or Heathen Art,' to comprehend all those styles which prevailed in the old world from the dawn of history in Egypt till the disruption of the Roman Empire by the removal of the capital from Rome to Constantinople in the fourth century. The second to be called either 'Mediæval,' or more properly 'Christian Art.' This again subdivides itself into three easily-understood divisions. 1. The Romanesque, or Transitional style, which prevailed between the ages of Constantine and Justinian; 2. The Gothic, or Western Christian; and 3. The Byzantine, or Eastern Christian style. Either of these two last might be taken first without incongruity; but on the whole it will be convenient, first to follow the thread of the history of Gothic art, and return to take up that of the Byzantine afterwards. The Western styles form a complete and perfect chapter in themselves, based directly on the Romanesque, but borrowing very little and lending less to any other style during their existence. They also perished earlier, having died out in the sixteenth century, while the Byzantine continued to be practised within the limits of the present century in Russia and other Eastern countries. Another reason for taking the Gothic styles first, is that the Saracenic spring directly from the Byzantine, and according to this arrangement would follow naturally after it. The third great division of the subject I would suggest might conveniently be denominated 'Pagan.' It would comprise all those minor miscellaneous styles not included in the two previous divisions. Commencing with the Sassanian and Saracenic, it would include the Buddhist, Hindoo, and Chinese styles, the Mexican and Peruvian, and lastly, that mysterious group which, for want of a better name it may be convenient to call the 'Celtic styles.' No very consecutive arrangement can be formed for these. Nor is it necessary; they generally have little connection with each other, and are so much less important than the others that their mode of treatment is of far less consequence, and in the present state of our knowledge regarding them, a slight degree of reiteration may be considered advantageous. The fourth and last great division is that of the 'Modern or Copying styles of Architecture,' meaning thereby those which are the products of the renaissance of the classical styles, that marked the epoch of the cinquecento period. These have since that time prevailed generally in Europe to the present day, and are now making the tour of the world. Within the limits of the present century it is true that the copying of the classical styles has to some extent been superseded by a more servile imitation of those of mediæval art. The forms have consequently changed, but the principles remain the same. It would of course be easy to point out minor objections to this or to any scheme, but on the whole it will be found to meet the exigencies of the case as we now know it, as well or perhaps better than any other."

We have now indicated, and chiefly in our author's own words, the main points in which this recast of the Handbook differs from its original form, and it only remains to add, that anything which may have been said in favour of the earlier issue of the work, applies with equal, in fact, with greater force to this later one. Compendious, careful, and lucid in his writing, the author knows well how to seize the salient points of a large and intricate subject, and to bring them alone, separating them from much which it must often be most difficult to reject, under notice. For the purposes of ordinary men of letters, this book will probably long remain a sufficient text-book. For the architect, although it is not by itself sufficient to give him the knowledge he ought to possess on any one point, yet the 'History' now is, and will probably long remain, the best general manual accessible. To the student it will prove invaluable, as a systematic introduction to the study of his art. To the more advanced practitioner it will be a valuable assistance in many ways, not of course as a book of working examples, but as a manual of information, and a starting-point from which to commence any investigation proposed to be undertaken.

As specimens of the quality of the additional wood-cuts incorporated in this volume, we are enabled by the courtesy of the publishers to give the accompanying illustrations:—No. 349, the church of St. Mortier en Der, in France, a cut remarkable both for the excellence of its execution and the beauty of its subject; and No. 154 and 155, giving a view of the restoration made by Mr. Fergusson, of the Mausoleum of Halicarnassus, a notice of which appeared in our columns some time back.

The Homes of the Working Classes, with suggestions for their Improvement, By James Hole. London: Longmans and Co., 1866.

This book is a very superior essay on one of the most important subjects of the day, and enriched with a large amount of valuable information, partly incorporated with the text, and partly embodied in notes and an appendix, but remarkable for a clear, comprehensive, and well expressed statement of a case which has, it is true, been often stated already, but which still needs to be urged on public attention in every possible way.

In his first paragraphs, the author of this work observes, that "the improvement of the material circumstances of the working classes is the condition precedent to all other efforts for raising their moral character." This is undoubtedly true, and if any step could be taken which would more than another improve that material condition, it would be the placing within the reach of the working man a decent comfortable dwelling. The majority of the dwellings of our artizans, not to mention our labourers, are neither decent nor comfortable; they are a reproach to our much boasted civilisation, and call loudly for radical improvement; and the great importance of this question to the whole of the nation makes us welcome so well considered and thoughtful a contribution to the literature of the subject as this work of Mr. Hole, with great pleasure.

The writer appears to be familiar with the north of England, especially Yorkshire, and as some notable experiments have been tried there in cottage-building on a large scale, of which he gives details not previously published, his work acquires an additional interest from this circumstance, the more so as he has also taken care to inform himself of what has been done in the Metropolis, or by societies and benevolent associations having their headquarters there.

In approaching his subject our author begins, by showing that the accommodation for the poor is far from being what it requires to be, and points out in what respects it specially fails of fulfilling the requirements of health, decency, and comfort. Bad drainage, deficient air supply from without, deficient air space within, narrow streets, scanty light, deficient and bad water, want of suitable conveniences, are all in turns dwelt on, and the evils resulting from them are vigorously sketched; and then at greater length are stated the remedies applicable to this state of things. These remedies, after being considered separately and at some length, are thus epitomised towards the conclusion of the volume.

"To sum up briefly the conclusions to which all who are conversan-with this subject have arrived, it appears that what is now more part ticularly wanted to improve the sanitary conditions of the large masses of our population are the seven following:—

1. The supervision by a central authority of the local bodies who are intrusted with the management and control of sanitary regulations, so as to ensure that the powers intrusted to the local authorities are fairly and honestly carried out.*

2. The appointment of medical officers for each town, as is done at present in London, and in some other places, with this difference: that the appointment and payment of such officers should rest with the central, and not the local authority. Health inspectors also should be appointed, on the same plan as the present factory inspectors, who should report annually to Parliament on the sanitary condition of their respective districts.

3. A general Building Act regulating the minimum width of streets,† prohibiting cellar-dwellings, back-to-back houses, and the construction of all houses—at all events in towns—which did not comply with certain

* As the Poor-Law Board does with the Board of Guardians.

† No uniform rule, founded upon general principles, exists to determine the amount of open space to each house. The following is the amount of open space per house required in different towns, extracted from the Bradford Report on the Building Bye-laws:—

well-ascertained conditions of health, such as drainage, supply of water to each house, &c. The various legal provisions relating to the public health, such as the Public Health Acts, the Local Government Acts, Removal of Nuisances and Diseases Prevention Act, Common Lodging-Houses Acts, and others having reference to the same point, require consolidating, with such amendments as improved knowledge of the subject now requires.

4. Such an alteration of the laws relating to common lodging-houses as shall reach all the houses needing the application of them.

5. Government loans by way of mortgage on the property, to be granted on liberal terms to local authorities, public bodies, and private individuals, for the erection of improved lodging-houses and cottage dwellings, whenever a clear and urgent case could be made out for such assistance, with adequate security for repayment of the advances.

6. Inducements to the working classes to become the owners of their dwellings, by increased facilities in the purchase of land, by removal of legal impediments, by simplifying the process and cheapening the cost of conveyance; and giving also encouragement by conferring the privilege of the borough franchise on every working man who acquires such ownership.

7. Power to be given to owners of lands tied up by any legal disability, to dispose of it whenever required by the local authorities; and power, too, to be given to the latter to compel the sale of land within a certain radius, whenever the supply was inadequate to the growth of population or its sanitary exigencies.

The question of improving the dwellings of the working classes is intimately connected with other social questions, which it is not our object to discuss here, but which may be briefly indicated. As better houses would make better men, so better men would make better houses.

Into the consideration of all the heads of this inquiry we do not intend to follow our author; what is said on each one of them will repay any reader whose attention is devoted to the subject of ameliorating the condition of the poor. We have already taken up however one isolated part, and have quoted at some length the account of the buildings at Halifax, promoted by Mr. Crossley and assisted by a Building Society there, and we have given illustrations extracted from Mr. Hole's volume of the general arrangement of them. In our present issue we engrave the plans and elevations of some of the dwellings themselves, but the fulness of the descriptions already quoted renders it unnecessary to return to them here. We will instead conclude by quoting one or two passages, in which the very serious difficulty of conducting such enterprises in a manner to make them remunerative is fairly stated, a difficulty which must be overcome before an extensive improvement can take place.

Name of Town.		Area of Open Space required.	Distance across.
Bradford, Morley	1 Story ...	150 square feet ...	10 feet
	2 Stories ...	180 do.	12 do.
	3 Stories ...	225 do.	15 do.
Bangor, Brighton, Barnsley, Derby Doncaster, Dover, Grimsby, Leicester, Plymouth, Warwick	1 Story ...	150 square feet ...	10 feet
	2 Stories ...	150 do.	15 do.
	3 Stories ...	150 do.	20 do.
	Abve. 3 Stories	150 do.	25 do.
Bolton	1 Story ..	150 square feet ...	10 feet
	2 Stories ...	150 do.	12 do.
	3 Stories ...	150 do.	15 do.
Bradford, near Manchester ...	1 Story ...	80 square feet ...	10 feet
	2 Stories ..	80 do.	15 do.
	3 Stories ..	80 do.	25 do.
Cardiff	... ...	Four parts unbuilt upon to five parts built upon	
Coventry	1 Story	Breadth of the building by	40 feet across
	2 Stories and above.	Do.	60 feet across
Darlington ...	2 or 3 roomed houses.	Two-thirds of the entire area of the ground-floor.	
	Larger houses ...	One-half of the entire area of the ground-floor.	
Sunderland		One-third of the entire area of the ground on which the house shall stand.	

"The improvement of the dwellings of the poorer classes, to any appreciable extent, is not a work which can be accomplished by charitable subscriptions. Philanthropy can scarcely be expected to grapple with an evil of this magnitude. It may give the impulse, but the work must be conducted by wise organisation and on ordinary commercial principles. In short, unless experiments in this direction pay, they will not be repeated, and they must pay as much as any of the ordinary investments of capital, including compensation for the trouble and risks connected with undertakings of this description. The attempts hitherto made, though successful in some aspects, have not fulfilled this cardinal condition. Most of the model lodging-houses of London have not averaged 4 per cent. The Improved Industrial Dwellings Company (Limited), established in consequence of the success of Mr. Alderman Waterlow in the erection of Langbourne Buildings (paying 8 per cent.), have indeed a prospect of much better dividends. The four blocks of buildings they have built show a probable profit of from 6½ to 9 per cent., and the dividend already paid is 5 per cent.

The earlier London societies, while fully alive to the importance of making their undertakings pay, have found the conditions of the problem too strong for them, and hence it is benevolence, not commercial enterprise, that has found the capital. So, too, with single dwellings. However remunerative in other respects, the disagreeable fact remains that the return is only 4 per cent. upon the outlay of Mr. Salt at Saltaire, and Mr Akroyd at Copley. These experiments, however, are exceptional, because profit was intentionally made a minor consideration, and beauty and completeness a primary one. Good dwellings of the cottage class, however, cannot be built to pay a large percentage. To improve the quality, generally speaking, involves increased cost, a diminished rate of profit, and therefore lessens the motive to build proportionally."

The most promising mode as stated by our author for meeting this great difficulty, in circumstances where a building society like the Halifax one is impracticable, must be some plan which will cheapen the capital required. And from these pages it appears that Mr. Alderman Waterlow has actually obtained a promise from the Government of assistance, by way of loan at a moderate rate of interest, under certain conditions.

"At the instance of Mr. Alderman Waterlow, the Lords of the Treasury will apply to Parliament for the purpose of carrying out this proposal, on condition that the public bodies to whom the money of the State is lent shall be content with a maximum profit of 5 per cent., with the object of 'distinguishing their case from that of ordinary commercial enterprise.'"

Turning for a moment to the appendix we find several valuable documents; none more so than the one entitled "a Chapter on Leeds." Thinking men have been horrified by the descriptions of those London dwellings of the poor which are the chief haunts of typhus fever, that have lately appeared in the 'Times' from the pen of Dr. Jeaffreson, but here seem statements showing a condition of things almost if not quite as bad. One of the local physicians, writing to the 'Leeds Mercury,' thus graphically describes some of the districts where the fever nests may be found:—

"This is no description of a plague-stricken town in the fifteenth century; it is a faint effort to describe the squalor, the deadliness, and the decay of a mass of huts which lies in the town of Leeds, between York-street on the one side and Marsh-lane on the other; a place of 'darkness and cruel habitations,' which is within a stone's-throw of our parish church, and where the fever is bred. These dwellings seem for the most part to belong to landlords who take no interest whatever in their well-being. One block perhaps has fallen years ago by inheritance to a gentleman in Lancashire, Devonshire, or anywhere; another to an old lady; a third, perhaps, to an obscure money-lender. Meanwhile the rotten doors are falling from the hinges, the plaster drops from the walls, the window-frames are stuffed with greasy paper or old rags, damp and dung together fester in the doorways, and a cloud of bitterness hangs over all."

Melancholy indeed it is that so many of our fellow creatures should be doomed to the wretchedness of such dwellings as these and the more acutely we feel the pressure of this great and crying evil, the more heartily shall we welcome a well-judged and painstaking effort to contribute towards the improvement needed to be brought about; such an effort has been made by Mr. Hole in the work before us, and with very remarkable promise of usefulness.

The principal Ruins of Asia Minor. Illustrated and described by CHARLES TESIER and R. POPPLEWELL PULLAN, F.R.I.B.A. London: Day and Son, 1865.

This handsome and beautifully illustrated volume, contains a selection from the engravings accompanying M. Tesier's large work, and showing general views and details of some of the best examples of temples and other edifices which he measured. The descriptive letterpress gives short descriptions, taken from his writings and those of other travellers who have visited this interesting district, and includes a narrative of Mr. Pullan's journies for the Dilettanti Society and the Government. We cannot pretend in a short paragraph to do more than name a book of this importance as among the works recently received, but we shall give a full notice of it in an early number.

ARTIZANS' DWELLINGS, WEST HILL PARK, HALIFAX.

We give illustrations in this number of some of the dwellings composing the group of which a block plan, and perspective view were illustrated in our last.

By reference to the account there given, it will be seen that, of the two classes of dwellings forming the subject of our present illustrations, those of Class No. 4 have cost about £160 for each house, and class No. 3 are to cost £270 each, land and all contingent expenses being included in each case. Those familiar with the subject will recognise that the cost of Class 4 is very moderate; that of Class C probably provides for better finishing than is obtainable in such buildings, and in that case is not excessive. The planning and general treatment of both these designs are very good, and reflect credit on the architects, Messrs. Paull and Ayliffe, of Manchester.

INSTITUTE OF BRITISH ARCHITECTS.

At the ordinary general meeting of the Institute of British Architects, held on the 22nd ult., Mr. A. J. B. Beresford Hope, M.P., President, in the chair, after the usual preliminary business of the evening, the President presented to Prof. Thomas L. Donaldson, past president, Emeritus Professor of Architecture at University College, London, a gold medal bearing his portrait, struck at the instance of his professional brethren, to commemorate his earnest and zealous services in promoting the study of architecture.

In an eloquent address, the President referred to the distinguished services which Prof. Donaldson had rendered to the cause of architecture in this country during his lengthened career, and stated that it was mainly through his personal exertions that the Institute first took complete form and action in the year 1835, under the presidency of the late Earl de Grey, with Mr. Donaldson as the Honorary Secretary, and who at the request of the Council read a very able and comprehensive paper pointing out the various ways in which the members of the profession might make themselves useful to the cause of architecture. Fifteen years subsequently, the President added, Mr. Donaldson was presented by the same nobleman with the Royal gold medal of the Institute. Coming down to the period when Mr. Donaldson was appointed Professor of Architecture in University College, London, the President spoke of the distinguished manner in which the duties of that important position had been discharged by that gentleman, he having during his period of office educated 400 students in architecture; and in conclusion he expressed a hope that, although Prof. Donaldson had at his advanced period of life felt it due to himself to resign that appointment, it was not to be regarded as an intimation on his part of his intention to retire entirely from that sphere of usefulness, study, and research which had characterised him from earliest life until the present day.

The President, amid the loud plaudits of the meeting, then handed the medal to Prof. Donaldson, who expressed his high sense of the distinguished compliment, that had on this occasion been paid to him by his professional brethren, whose friendship and esteem he so highly appreciated—an honour for which he said he felt that the humble services he had rendered to architecture were wholly inadequate. The learned Professor then gave an interesting sketch of his career from early life, pointing out the difficulties which in his younger days existed in the pursuit of studies cognate to architecture, and even architecture itself. He adverted with feelings of pleasure to the humble part which it had been his privilege to take in the formation of the Institution, which he had always felt would be a great means of promoting their art, and he rejoiced in having been permitted to witness its present high standing and efficiency.

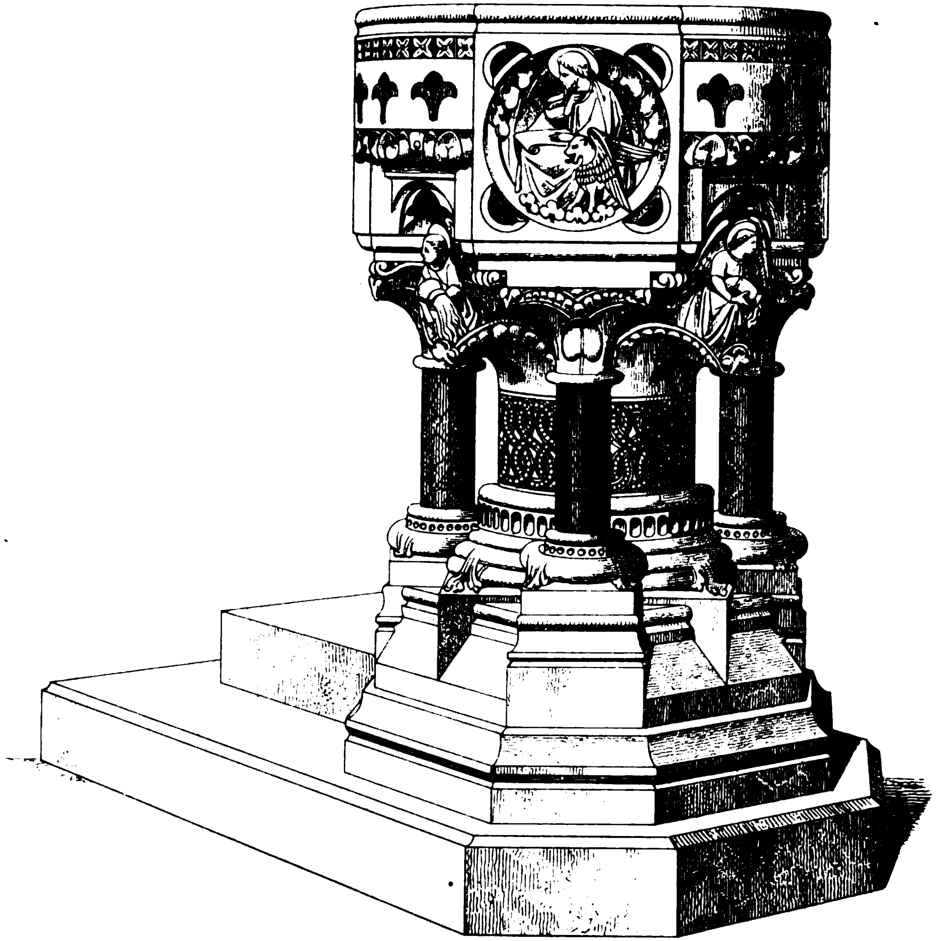
Mr. John W. Papworth, Fellow, then read an interesting paper "On the Roofs of the Hypœthral Temples at Bassæ and Ægina."

THE LOCKE MEMORIAL.

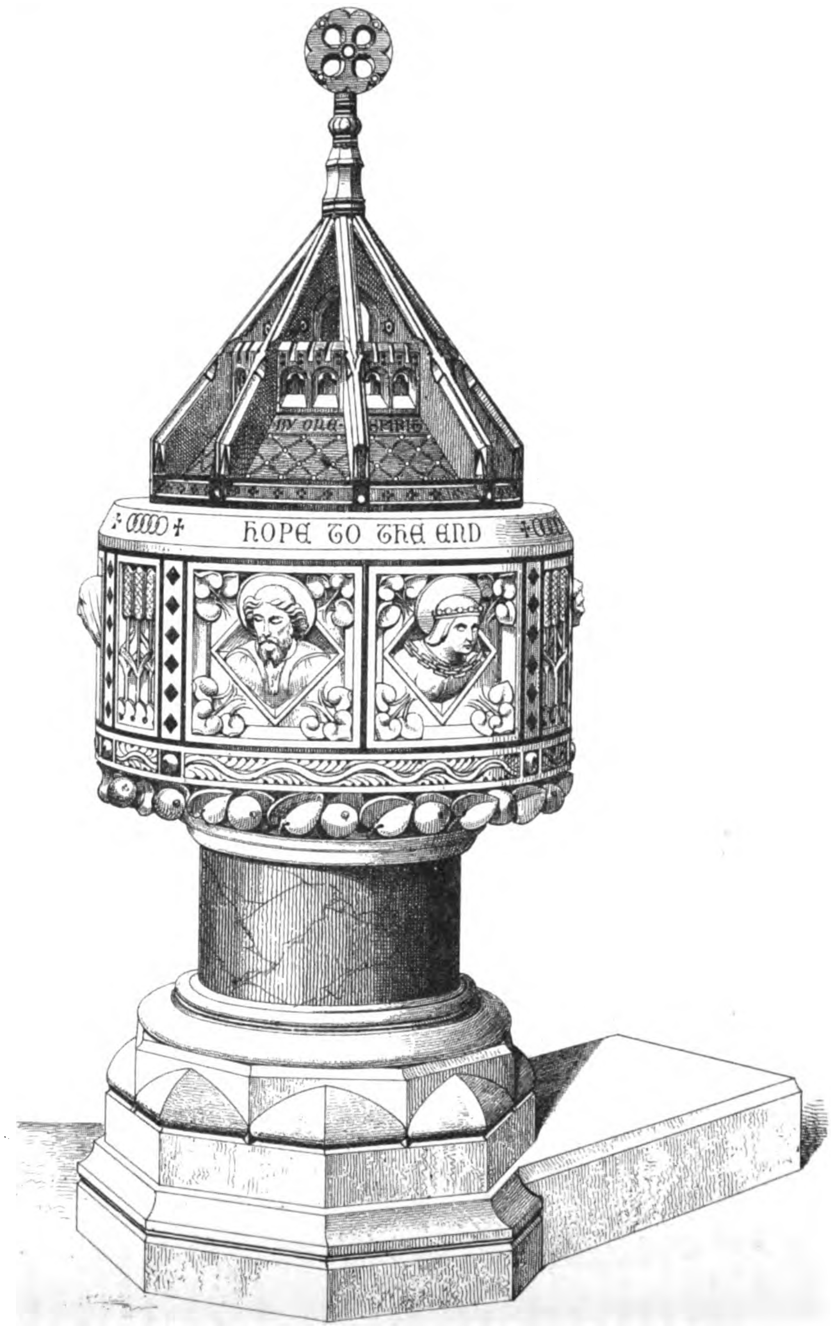
On the 18th ult., the ceremony took place of unveiling a statue by Marochetti of the late Joseph Locke, C.E., M.P, erected in the People's Park, at Barnsley—a plot of ground presented to the town by Mr. Locke, with a liberal endowment for its maintenance. The ceremony was performed by Lord Alfred Paget, assisted by the authorities of Barnsley, supported by Mr. Fowler, President Inst. C.E., and many engineering friends from London

Lord Alfred Paget, as chairman of the memorial committee, said, It is not without considerable hesitation that I have consented: to take an active part in the proceedings of this day. I had hoped that some celebrity in the scientific or political world would have performed the duty which appears to have devolved upon me, in the capacity of chairman of the committee of the friends of the late Mr. Locke, who had combined to raise this not unworthy tribute to his memory. I was, however, easily persuaded, as I entertained a personal regard for our late friend—and having the good fortune to be thrown much into his society, I fully appreciated the good qualities he possessed. No task could, therefore, be more agreeable to me than aiding in paying a public tribute of respect to his memory in this locality, whence he sprung—where he was so well esteemed, and is now so deservedly regretted—and where, also the joint names of Mr. and Mrs. Locke will be long gratefully remembered, for their judicious and munificent endowments of your public charities. The public career of Joseph Locke is before the world in the great works of public utility projected and accomplished by him. We may, however, be permitted to cast a retrospective glance to the antecedents of the well-known public man, and in this case we shall find that in his father he had before him a model upon which he properly and sensibly formed his own character; for it is clear that the father and son were equally remarkable for energy and stedfastness of mind, combined with economy and sagacity in worldly affairs. Joseph Locke was born at Attercliffe Common, not far from hence, in the year 1805, and at a very early age came with his family to Barnsley, where he enjoyed the advantages of the tuition of the grammar school. But in these days the period devoted to education was not long, and he was soon sent to learn the profession of surveying, at Pelaw, and afterwards at Rochdale, and was then engaged in assisting his father. In the year 1823, by a fortunate combination of circumstances, the attention of the late George Stephenson was directed to the son of his old fellow-workman, and young Joseph Locke was admitted into the engine works at Newcastle-upon-Tyne. To a hard working and studious youth the opportunity thus afforded of participating in the great and novel works of the day, and in company with such a man as George Stephenson, was not to be neglected. Self-help was all he had to rely upon, for in those days there existed but little of the ideas so readily found at the present time. He shaped out his own course, and the energy of his character led him on to fame and fortune. Joseph Locke, already an accomplished surveyor and an active colleague of Robert Stephenson in asserting the superiority of the locomotive over the proposed stationary system of traction, was soon permitted to take his own course; and in 1835 he constructed the Grand Junction Railway, which by its great commercial success first strongly attracted the attention of capitalists to railways as a highly profitable kind of investment. The career of Locke, thus auspiciously opened, soon became one of incessant occupation, as mercantile men and the bonâ-fide shareholders demonstrated their confidence in him by subscribing largely to the lines on which he was engaged. The South-Western, the Sheffield and Manchester, and then the Scottish lines uniting the two capitals, London and Edinburgh, were commenced and successfully carried out. In 1837 he began the railways north of the Tweed, and thus were forced upon him works of greater magnitude than he would otherwise have undertaken, for the great characteristic of his engineering mind was to avoid all works, however interesting, which were not strictly essential to the welfare of the undertaking. In these connecting links between north and south the features of the intervening country forced upon him the construction of steeper gradients, which he henceforth adopted. In 1838, at the instigation of M. Lafitte, he turned his attention to the construction of railways in France, and with Messrs. McKenzie and Brassey as the contractors, he successively executed the Paris and Rouen, the Rouen and Havre, and the Cherbourg Railways, as well as co-operating in other lines and giving the impetus to the introduction of the railway system into France. These services were recognised by Louis Philippe and by the present Emperor, when they successively created Mr. Locke a Chevalier and Officer of the Legion of Honour. About the year 1849 he became the representative in Parliament for the borough of Honiton, for which he sat for thirteen years, and enjoyed the full confidence of his constituents. We have not to deal with Joseph Locke as a politician or a legislator, or I might be tempted to enlarge upon the consistent support which he gave to the free trade movement, his sensible opposition to the Sunday bill, and the pertinacity with which he urged upon the House the importance of obtaining full and careful estimates for the public works which were sought to be authorised. The time must arrive when the strongest mind and the most active frame require repose, and Mr. Locke gradually relaxed his business and Parliamentary avocations, still, however, continuing to be the valued adviser of certain railway companies; whilst at other times he appeared at the annual public meetings as a severe critic of their proceedings when their policy was not identified with his views. He interested himself in several useful charities, and devoted to the Institution of Civil Engineers even more attention than he had previously done, probably with an inward feeling that in the removal of Cubitt, Rendell, Brunel, and Stephenson, it was incumbent upon him to watch over that institution which had been their constant care. His address from the presidential chair should be in the hands of every young engineer. Gradually, however, he withdrew more from public life, and devoted himself to country occupations and field sports, which on the Scottish moors he highly enjoyed. You, men of Barnsley, always occupied much of his thoughts, and when he visited this place you gave him a most cordial welcome, listened to his advice and pleasant jokes, expressed to him the wants of your town, and in all ways treated him as a trusted friend and counsellor, and right well he merited your confidence. He went home fully imbued with the feelings of what should be done for the benefit of your town, and Mrs. Locke has religiously carried out his views; you know how thoroughly she has acted in accordance with these views in the free gift of this ground, the Locke Park, with an endowment for its maintenance, a most liberal endowment for the grammar school—whence he derived the rudiments of education—a munificent gift to the Roman Catholic schools, and other well-considered and well-bestowed charities. These all attest the kind intentions of Joseph Locke, and the noble manner in which that excellent lady, Mrs. Locke, has carried them out. My mission must end with the expression of regret we all feel at the too early removal of the last of the trio of Brunel, Stephenson, and Locke, all men who had done and were still calculated to do good service for their country. Allow me, in conclusion, to congratulate you on the auspicious inauguration of this noble monument to the memory of your distinguished townsman in the centre of this beautiful park, and in the sight of your children, who may be taught by it lessons of energy, self-reliance, and public usefulness—and to express my admiration of this fine work of art by Baron Marochetti, which we now entrust with confidence to your safe keeping.

To a resolution thanking the donors for the statue, Mr. John Fowler, President of the Institution of Civil Engineers, said:—"Gentlemen, on behalf of the donors who have presented the statue to the town of Barnsley, permit me to thank the inhabitants for the resolution which has just been read, and at the same time to assure them that, in the opinion of the friends of the late Mr. Locke, the statue has now been placed in its best and most appropriate position. Such a memorial of such a man can scarcely fail to exercise a beneficial influence on the future career of many young men of this busy district, besides being in itself an ornament to the town. The admirable address which we have heard from Lord Alfred Paget, has left little to be added by those who follow him. Personally I esteem it a great privilege to be present at the interesting proceedings of this day; and I am sure it must be a subject of peculiar gratification to the friends of the late Mr. Locke, as it is to myself, that one who knew him so well and valued him so highly, and who is himself so much respected by the engineering profession, as Lord Alfred Paget, should have consented to take such vivid personal interest in the realisation of this record of our late friend, and also in taking the chief part, this day, in the inauguration of the 'Locke Memorial.' I can assure the inhabitants of Barnsley, and the numerous friends and admirers of Mr. Locke now assembled here, that the members of the Institution of Civil Engineers of England, of which I have now the honour to be president, take a deep interest in these proceedings, and that they sympathise cordially in the respect thus rendered to the memory of a man whom they will long remember as one of their most distinguished and useful presidents. The world justly thinks that the days of Stephenson, Brunel, and Locke, were 'days of the giants' of the engineering profession; and, gentlemen, allow me to say that we, in the present day, entirely agree with the world at large in that opinion. Locke was truly one of those giants. His far-seeing and strong common-sense, his comprehensive grasp of all the bearings of a question, were so powerful, that the capitalists of Lancashire, of London, and ultimately of France and the continent of Europe, placed faith in his judgment, and then followed him with such confidence as to entrust almost unlimited capital to his disposal, in every undertaking in which he engaged. In France he was the pioneer of the railway system of that country, and had the good fortune to be accompanied and seconded by Mr. Brassey, whom we are all delighted to see present with us this day. What more fitting representatives of Englishmen could be found than the prudent but energetic Locke, and the modest but lion-hearted Brassey? What, indeed, but a lion heart had enabled Brassey to meet the great catastrophe of the fall of the Barentin Viaduct?—an accident, a pure accident, for which he was neither legally nor morally responsible. 'Well, Brassey, what is to be done?' says Locke. 'Why, my dear Locke, of course I must build it up again;' and build it up again he did. Those were the true kind of men, gentlemen, to be the pioneers of a new enterprise, and to impart confidence in Englishmen amongst foreigners. But, gentlemen, let it not be supposed that Locke was merely a commercial engineer. I believe that, to some extent, injustice has been done to his memory by those who did not know him well, arising, no doubt, from the prominent development of the common-sense and commercial element in his character. Locke was, however, an eminently scientific engineer, and it is to his scientific knowledge we owe one of the most important discoveries and improvements in our railway system. He it was who first abandoned the use of the fish-bellied rail and adopted the I form of rail, and he was enabled to do this entirely from his scientific knowledge of the true value of what engineers call 'continuity.' He it was who, in conjunction with Robert Stephenson, combated the advocates of fixed steam engines as a means of obtaining locomotive power, and by their thorough knowledge of the locomotive engine and its capabilities, obtained the victory in the contest. He it was who, by the confidence which perfect knowledge of the subject gave him, first advocated the lines over the mountain ranges between Lancaster and Carlisle, and between Carlisle and the north, by which means long tunnels at a ruinous cost were avoided, but, at the same time, obtaining perfectly good working lines, and thoroughly adapted to the nature and extent of the traffic required to be passed over them. At that time no engineer but Locke would have dared to make the proposals for such lines, and certainly no other engineer would have been followed and supported in them by adequate capital; and yet we all now know and acknowledge his views on this question to have been sound, notwithstanding the vehement opposition which they encountered at the time. What but scientific knowledge could have enabled Locke to have arrived at such admirable conclusions? because, at that time, there was little or no experience to guide him upon such questions. Many similar instances could easily be given, but they would not here be in place, and I have only enumerated one or two prominent cases to correct the erroneous impression which has appeared to exist in some few minds, that Locke was not eminently a scientific engineer. Will you permit me, in order to illustrate one of the characteristic traits of our departed friend, to refer to the kindly feeling, and almost I may say affection, which many of us have so often witnessed between himself and Robert Stephenson when they met? They were, as is well known, frequently professional rivals, but always attached friends; and no one who had the privilege to hear it will never forget the alternate 'Robert' and 'Joe' of their familiar social intercourse in their late years, as in the old days long gone by. In conclusion, gentlemen, permit me to say, that from the career of the late Mr. Locke we may draw many useful lessons, and I hope, as a Yorkshireman myself, his example and success will stimulate other young men of Yorkshire to similar efforts for the good of mankind, and for their own reward. Amongst civil engineers, and in the annals of the Institution, the name of Locke will ever occupy a distinguished position, and I believe the record of this day's proceedings will be memorable as long as a great and useful man continues to be appreciated by England and Englishmen.



Font in St. Mary's Church, Winkfield, Berks.



Font in St. Mary's Church, Barbados. W.I.

JOHN F. BENTLEY, ARCHT.

J R Jobbins

EXAMPLES OF FONTS.

(With an engraving.)

The first of the fonts illustrated in the accompanying plate was erected three years since in St. Mary's Church, Winkfield, Berks. The base and bowl are executed in Caen stone, the shaft in red Mansfield stone, relieved with a guilloche ornament delicately cut, and the four surrounding columns in green serpentine marble. On the predella line the plan is an irregular octagon, the smaller bases emerge from the sides, and the square plinth under circular portion of centre base, intersects and loses itself on the splayed cants. Broad angle leaves, little more than moulding, spring from the principal cap, and support allegorical figures, representing the rivers Phison, Gihon, Hiddekel, and Euphrates. The caps to columns are carved with simple leafage, flatly and severely treated. Directly over, in moulded and carved panels, having sunk spandril-pieces filled in with marble, occupying the four cardinal faces of the bowl, are seated figures of the Evangelists sculptured in high relief; the intermediate and diagonal sides are brought forward by angle canopies and hollows, carved with the apple and leaf of a very conventional character; and are further enriched with inlaid marble, fleur-de-lis of two colours, and bands of carved diaper, capped by a moulding, which surrounds and completes the font.

The second font, in the church of St. Mary, Bridgetown, Barbadoes, is of Norman-transitional character: its base is composed of red Mansfield stone, octagonal in plan, the cants alternating with the angles of, and intersected by, a second plan of the same form, terminating with a bold moulding, which follows the line of the shaft of polished Pyrenean deep green marble, having a cap of Caen stone, effectively carved with conventional apple, intended to symbolize the "Fall of Man." The bowl, also of Caen stone, is circular (a figure of Eternity), richly sculptured, incised with coloured cements, and interspersed with bosses of Derbyshire red spar, upon grounds of Irish light green marble. A conventional wave encompassing the lower part of the bowl, and flatly-cut bulrushes in three panels, are emblematical of the origin of Baptism by water in the Jordan: three compartments contain busts in alto-relievo, illustrating three Christian Graces as fruits of Spiritual regeneration, treated Biblically and allegorically thus—Faith, by St. John the Divine, and a veiled female; ("we walk by Faith, not by sight.")—Hope, by the prophet Isaiah, and a helmetted female chained; ("putting on for an helmet the hope of salvation,"—"for the Hope of Israel am I bound with this chain.")—Charity, by St. Stephen the Martyr, and a female wearing a celestial crown, ("the greatest of these is Charity.") Upon the upper bevelled edge of the bowl are incised the following Apostolic exhortations; "Stand fast in the Faith;" "Hope to the End;" "Have fervent Charity."

The oak cover, chromo-relieved and slightly gilded, is likewise of Norman-transitional style, and constructed light enough to be easily lifted by the hand: it commences on a circular plan, from which springs an octagon, whose moulded ribs converge at a centre-post; and on traceried splays is inscribed the Sacramental truth, "By One Spirit are we all baptized into one Body." A feature of embattlements and a cruciform finial, speak, symbolically, of "Christ's faithful soldier" in the Church Militant, and of the token in "the sign of the Cross."

Both fonts were executed by Mr. T. Earp, from the designs and under the superintendence of Mr. Bentley, Architect, London.

ACCOUNT OF THE RESTORATION OF THE DUTCH CHURCH, AUSTIN FRIARS.*

By Edward I'Anson.

The church and convent, as rebuilt in 1354, must have been of considerable extent, for the buildings and grounds extended from Broad-street northward to London-wall, and from the north corner of Broad-street to the church of St. Peter-le-Poor. The church consisted of nave, north and south aisles, north and south transepts, south porch, choir, chapels of St. John, St. Mark, St. James, St. Thomas, chapter-house, and cloister, which last appears to have been on the north side of the church; the churchyard was on the south side. At the intersection of the cross there was a spire or fleche, which was regarded as one of the remarkable objects of London; for Stowe, writing in 1593, says, "The church is a large thing, having a most fine spiral steeple, small, high, and straight; I have not seen the like." This small spiral steeple was overthrown by a tempest of wind in the year 1362, but was forthwith raised again. It so remained until the end of the sixteenth century, when it became dangerous; for we find the Lord Mayor and citizens, writing to the Marquis of Winchester, to whom the property then belonged, on the 4th August, 1600, requesting him to restore the steeple, as it appears he had promised to do, and threatening legal proceedings if did not; but promises and threats appear to have been alike unavailing; so the steeple with the east part of the church was taken down, and, says Stowe, "houses for one man's commodity raised in the place, whereof London hath lost so goodly an ornament, and times hereafter may more talk of it."

As to the part of the church which was westward of the transepts, and which still remains to us, we find that Edward VI. in his Diary has the following minute: "29th of June it was appointed that the Germans should have the Austin Friars for their church, *in purum et liberam elemosynam*, to have their service in for avoiding of all sects of Anabaptists, and such like." It was thenceforth called the Temple of Jesus, and some glass quarries, which at the late restoration were preserved from the old windows, bear the legend of Jesus Temple, are dated 1550; two others bear the legend, Temple of the Lord Jesus; these were all replaced in the two windows at east end of the north and south aisles. From the date of the first minister, John a Lasco, in 1550, to the present time, this church has remained in the hands of the Dutch, and has been managed by consecutive elders of that church to the present time. The sequence of the ministers, from the date of the first appointed up to the appointment of the present minister, Dr. Hendrick Gehle in 1830, is recorded by a tablet in the church. As the church existed within the last twenty years, it will be remembered by all who frequented the busy purlieus of Threadneedle-street and Broad-street, in a retired thoroughfare, hemmed in by the houses of London merchants, which within the last few years have been converted into offices.

The west front of the building, together with part of the north aisle, were the most conspicuous; the other portions being surrounded by buildings. Its large west window, not remarkably good in character, and its decorated aisle windows, formed one of the most noticeable remnants of Mediæval architecture which the City contained. The exterior had been carefully repaired about 1828, but owing to the want of knowledge which prevailed on this subject in the early part of the century, not in the careful manner which characterises restorations of the present day. It was, however, then a matter of comment, and the subject was warmly discussed in the 'Gentleman's Magazine' of that date.

The old water-tables of the buttresses appear to have been removed, and the decaying mullions and tracery—chiefly of Reigate fire-stone, and much perished—were restored with Roman cement, and the surface of the walls rendered over with the same material, whereby nearly the whole of the old work was covered up. Over the west door a canopy appears to have been added. Some further restorations were in progress in the year 1862, when a fire destroyed a large portion of the work, and left the building in a condition which appeared ruinous. Nearly the whole of the roofs of the north aisle and nave were destroyed, and the upper parts of the masonry much injured, but fortunately the tie beams of the nave were left remaining, although damaged. After the fire the building was surveyed by the fire office surveyors, who considered it past repair, and such was also the opinion of the district surveyor, who officially condemned it as a ruinous building.

At this time I was professionally consulted. I found the building in the state I have partially described. The pillars on the south side of the aisle were not only as much as 17 inches out of the perpendicular, but the whole church had taken a southward settlement. On plan at the level of the top of the walls having assumed a bow form, gradually increasing towards the middle, where on the north side of the south aisle the versed line of the arc was, and still is 17". On the north side of the aisle it was somewhat less, and on the inside of the external walls of the north and south aisles it was less still; the external walls having suffered the least movement, especially the wall on the north side.

Having reference to the extremely dilapidated, and, as it appeared to me, ruinous condition of the church—to the very great value of the land in Austin Friars—to the inconvenient size of the church for the purposes for which it was required, its size

* Paper read at the Royal Institute of British Architects.

being utterly disproportionate to the requirements of its congregation, I came to the conclusion that it would be in all respects more desirable to pull down the existing—as it appeared—ruinous fabric; the restoration of which would necessarily be very costly, and to build another church more suitable to the requirements of the congregation. I accordingly so advised the trustees; but being desirous not wholly to lose the tradition of the ancient church, I proposed the erection of a building of mediæval architure, and engaged the services of my late esteemed friend and pupil, William Lightly, who had long worked with me in other matters, to co-operate with me in preparing a design for the proposed new church. This was accordingly done; when it having become known that it was the intention of the trustees to remove the old building, so strong a manifestation of public feeling was evinced by letter in the daily papers, of July 1863, and very influential and pressing representations made to the minister and elders of the church, that the trustees were led to re-consider the question. Although I still held unaltered my views as to the practical utility of erecting a building more consonant with the requirements of the congregation, I felt there was no absolute impossibility in preserving the work as it stood, and in effecting a restoration. The committee of the Dutch Church, feeling that they were trustees, not only to a limited congregation, but to the general public, who they believed, by the strong expression of opinions which were made, were seriously desirous of retaining the old church, resolved in deference to the opinions so expressed to abandon their original intention, and, if practicable, to restore the church. I therefore, in conjunction with my late friend Mr. Lightly, undertook the task of retaining and repairing the existing portions of the church, and of restoring such portions as were destroyed. Having once come to that determination, we endeavoured conscientiously to restore the building as it stood, retaining every part of the ancient fabric, uncovering and restoring such portions as were hidden and masked by the work of the seventeenth century and later times.

As to the arrangement of the church as we found it, at the west end were vestries, an organ loft, and a library. The general arrangement was picturesque, but of the worst character of the seventeenth century. The lower part of the stone piers was lined with wainscoting, as also the external walls. The altar table was raised on a platform enclosed with a wooden balustrade, with wall linings at the back of a more ornamental character; all of the work of the end of the seventeenth or beginning of the eighteenth century. The altar was decorated by a painting representing an arcade of the Ionic order, containing the Creed and Commandments. On entering on the work we recommended the entire removal of the vestries, organ loft, and libraries, which entirely filled up the western bay of the church, the wall linings, and the altar decorations; and we proposed to remove vestries to the east end adjoining the altar, one of which is used by the minister, and the other by the elders of the church; keeping the vestries low, so as not to interfere with the building or to abridge its apparent size. We also proposed the removal of the south porch (which was not without its picturesque aspect), and to replace it by a doorway more in accordance with the style of the church; for this we had no precedent, and it is strictly an addition. We also recommended the enclosing by wooden screens of the bays at the east end of the church, which affords ample space for the congregation; and we recommended the decoration of the broad wall space at the east end by a fresco painting, but this being inconsistent with the service of the church was not carried out, nor were we allowed (as was also suggested) to use any coloured glass for the windows. After the resolution which the trustees came to at the end of July 1863, to restore the ancient building, and certain arrangements necessary in consequence of the altered plans, some time necessarily elasped before contracts could be obtained for the restoration, and it was therefore not until October of that year that the tenders were received and the work was actually commenced.

Seeing the extremely critical condition of the piers of the arcades, our first attention was directed to an examination of the foundations of this part of the building. We therefore had the substructure of the piers exposed, and found that they rested on brickwork, having apparently been underpinned, and that the foundations were perfectly sound and sufficient. Having fully satisfied ourselves on this point, we resolved to retain the walls and arcades out of the upright as we found them, deeming it, in fact, impracticable to effect any alteration in this respect short of rebuilding the whole, and to put on the new roof without rebuilding them. The old vestries, library, and organ loft, which disfigured the western end of the church, having been removed, the first step was to shore up the old walls, and place strutted shores between the arcade walls, and the walls of the nave and the aisle walls, and then to make good all the unsound parts of the walls and arcades which were in a defective state.

It was resolved to retain the flat over the south aisle, which was little injured, and the plaster and ceiling which concealed it internally was removed. This roof was constructed with very imperfectly trussed principals, and some which had no bearing on the south wall were removed and new ones introduced, with a proper bearing on the south side, and made to run completely through the arcade wall of the nave. The old king-posts and braces were re-framed, and the spaces filled in with pierced panelling. This work was necessarily done with great care and caution, one truss only being removed at a time. The old timbers were then wrought as they stood, and new boarding was added to the under-side of the rafters. A new flat, corresponding with this, was then placed on the north aisle, the tie beams being carried through the arcade wall as described above. Three of the six tie beams of the nave roof, though they remained in their places, were found on a close examination to be completely burnt through at the ends; and the wall plates, which were large pieces of timber, were found to be in many places so much decayed that it was necessary to replace them, and the great size and weight of the timbers to be moved on the top of the injured overhanging walls, and the removal of and substitution of new tie beams, caused some anxiety. Eventually, however, this was accomplished, and new plates and tie beams were inserted and framed, by means of wall pins and braces, to the tie beams of the aisle roofs, which had been previously brought through the walls, and a strong king-post truss formed on each tie beam, the whole firmly bound together by strong wrought-iron straps, uniting the tie beams of the nave with the principal rafter of the aisle roofs.

Six large dormer windows were introduced as a sort of clerestory at the east end, and as but little light could be got at that part of the church, being the part where the service is performed, owing to the adjoining buildings having been brought close up to the walls. On the outside the roofs are covered with rough boards, felt and slates, on the inside with white deal, formed into panels by mouldings, to cover the intersections and joints, and a moulded and embattled cornice fixed on the face of the wall plates. The whole of the internal boarding is varnished, without any stain. The building having been thus covered in, the shores, by which the arcade and external walls had been sustained whilst the roof was being re-formed, were struck, and though the walls and piers have been carefully watched, no further settlement or movement has been detected.

The internal masonry was now cleaned, and the chalk facing re-pointed. The tracery of the windows, which it was intended to retain, on examination proved to be impracticable, for all mouldings of the windows had been chipped off, nails driven into the joints of the mullions, round which twine had been twisted, and the mouldings run in cement. The tracery also was so much defaced, and so injured by decay, that it was found necessary to restore the whole, which has accordingly been done, and a careful and faithful restoration made in Portland stone, The old tracery was of several kinds of stone, principally Aubigny and fire stone. The graves with which the area of the church was covered, and of which many had been burst in by the falling of the roof timbers at the fire, were filled with concrete, and the stone paving re-laid, care being taken to retain every old stone, including those in which brasses had been inserted, of which there is a goodly number, principally of Purbeck marble, but every brass had disappeared. The eastern part of the church is now enclosed by an oak screen, and the pulpit, organ case, and seats required for the congregation, are constructed with oak.

The east wall of the church now demands our attention; this was originally the arcade between the nave and the transept. Previously to the present restoration it was concealed by a plaster screen before referred to, on which was painted the Creed and Commandments, and behind this, on its removal, was found another lath and plaster construction, painted with a curious perspective interior. The removal of these screens revealed to us the construction of the east end, from which it would appear that the great arch which partly supported the steeple or fleche had failed, and that another inner arch and piers had been added beneath it. This was probably done when the spire was rebuilt, after it was thrown down in 1362. This inner arch we completely unmasked, and restored as much of it as is left uncovered by the brick wall by which the east end of the church is enclosed. Externally, two only of the bays on the south side have been re-faced with Kentish rag stone, all the rest remain covered with plaster. No variation has been made in the form of the church, except the removal of the old porch on the south side externally, and the substitution of another porch. With the view of obtaining light to the enclosed parts of the church, six dormer windows have been formed in the roof. To both of these additions I have before alluded.

Since the restoration of the church was commenced, a large area of ground has been excavated to the south of the church, towards the east of the present building, just at the point where the traces of the former transept may have been expected to have been found, but no indications whatever of any former building has been met with. At the east end, adjoining the church, is a house belonging to our fellow, Mr. Arthur Ashpitel, and there may still be seen in some recesses in this house the arch mouldings on the east side of the arch which now terminates the church at its eastern end.

To a great extent I have in the preceding notes followed the memoranda which was left by my deceased coadjutor, to whose ability in conducting the works, and of whose unceasing interest in it whilst he still lived, I am glad of this opportunity of recording, and also of my own deep regret that so promising a member of our body should have been so prematurely taken from us. Allusion is made in Mr. Lightly's remarks to the similarity between the Temple church and the Austin Friars church, and to the one having been built shortly after the other, but if I am right the Temple church was built nearly a century earlier. The size of the two churches is very different, the Temple church, between the walls, being 58 feet by 82 feet, whilst the Dutch church is 80 feet by 150 feet. The former has also only five arcades, whilst the latter has nine. The height of Austin Friars church to the under side of the tie beams is 40 feet.

The works of restoration were begun late in the autumn of 1863, and the church was opened for public services in September of last year—1865. The total cost of the work executed will not be less than £11,000. There still remains portions of the external masonry, and particularly the west front, and some of the buttresses on the south side, which require restoring and part rebuilding. It is the intention of the committee gradually to complete the work they have begun, so that it will be seen they have responded cordially to the opinion so warmly expressed, calling for the preservation of the ancient church. The work has cost already as much as would have sufficed for a new building; the outlay is not yet completed, and the sacrifice in value of land, which might have been otherwise appropriated, is at least equal to, if not more, than the cost of the works. Now this monument, which contains the mortal remains of some royal and many illustrious men, and which from its large size alone entitles it to be called a noble building, will probably remain for generations to come a record of former generations—of those times when large monastic establishments occupied a site now densely covered with houses devoted to the purposes of trade and commerce—and of the truly conservative spirit of the present guardians of the church, who, at no small sacrifice, have preserved the ancient church of Austin Friars.

THE NEW ATLANTIC TELEGRAPH SCHEME.

On the 2nd ult. a meeting was held at the London Tavern, of gentlemen interested in the question of laying the most efficient and economical lines of telegraphic communication between England and America and the colonies, and the advantages to be derived from the adoption of Macintosh's system of constructing deep-sea cables. The Earl of Shrewsbury presided.

The chairman said it would be needless for him to explain the causes that led to the failure of the two attempts to establish this telegraphic communication by the Atlantic Company. They were too recent and too well known to those interested on the subject; the Atlantic Company, nothing daunted by their failures, were again in the field, and not only for the purpose of laying another complete cable, but with a confident hope of grappling the one they had lately lost, repairing it, and completing a second line to Newfoundland. Another company was, he was informed, in the course of formation for carrying out what was called the Northern route, and for which they had obtained the concession from the Danish Government, first granted to Colonel Schaffner. He believed it was their intention to lay a cable to Norway, and from thence to Labrador, *viâ* Iceland and Greenland, a route that certainly had the advantage of short sections. It would be seen from the advertisement calling this meeting that another candidate was in the field, with another route and a new cable—not exactly a new cable, for his patent was dated some years back, but owing to the inventor (Mr. Macintosh) having been connected with the Gutta Percha Company, his patents have been in a manner tied up. He thought the best course to adopt on this occasion would be to give Mr. Macintosh the opportunity of explaining the nature of his cable and of the advantages which he claimed for it over other cables, electrically, mechanically, and commercially; and then, taking those advantages in the same order, he should be glad to hear the remarks of any electrician present on the electrical properties; and on that important part of the subject he had no doubt the meeting would prefer to hear the result of practical tests rather than theoretical hypotheses. He should then be happy to listen to the remarks of any telegraphic engineer or cable manufacturer on the other points; and if any practical gentleman desired to make any remarks on the cables or routes, he had no doubt the meeting would be glad to hear them, and finally, he hoped that the discussion would be conducted with that temper and forbearance so necessary to enable them to derive absolute benefit from it.

Mr. Macintosh proceeded to explain the advantages of laying a cable direct from England to the United States, *viâ* Falmouth and Cape Cod. The proposed route was divided by shallow water into four parts—Chaucer's Bank, Milne Bank, and Newfoundland Bank, so that in case of accident the cable could be readily recovered for repairs. The peculiarities of the Macintosh system of constructing telegraph cables consisted in using a new insulating material of superior efficacy to any known substance, which enables a rate of 80 per cent. more signalling power to be obtained than in the case of the late Atlantic cable. All external iron-wire sheathing, whether alone or in combination with tarred hemp, as in the late Atlantic cable, and all steel wire spiralled round the conductor, would be dispensed with, and thus one great source of danger and expense was avoided. The mechanical strength requisite for the cable was obtained from the materials employed in insulating its conductor, which material was applied in numerous thin coatings or films, under tension and a pressure of several tons, so that all superfluous weight was avoided, and such an excess of strength was obtained that the cable would sustain twenty miles of its length in water; and three cables could be constructed by Macintosh's system for the price of one such as it was lately attempted to lay across the Atlantic. The conductor of Macintosh's cable consisted of a series of fine copper wires, laid longitudinally, and held together by the insulating material; the cable was constructed in one continuous length, without welds or joints, and, when finished, was at once the smallest, lightest, least expensive, and most effective submarine telegraph cable known; and, moreover, it could be laid with a decreased risk of failure by the adoption of Mr. Macintosh's compensation apparatus for paying out cables with an uniform tension in all weathers. The soundings by the proposed route were very favourable, the cable could be made very inexpensively, and its greatest safety would be in getting into the deepest possible water. He had not brought forward his project on the wreck of the Atlantic Company's scheme, for it was submitted to the Leeds meeting of the British Association, nearly eight years ago, in the section over which Mr. Fairbairn presided, and his opinion was that all deep-sea lines should be made with a conductor and insulater alone. The result of experiments already made shows the weight and capabilities of equal lengths of the late Atlantic cable and of Macintosh's cable in the following manner:

	New Atlantic.		Macintosh's.
Conductivity in lbs. copper ...	300 lb.	...	300 lb.
Weight of insulating material ...	400 lb.	...	400 lb.
Inductive resistance in lbs. of gutta-percha	400 lb.	...	2000 lb.
Diameter of cable	1$\frac{1}{16}$ inch	...	$\frac{1}{2}$-inch.
Weight per nautical mile in air ...	35$\frac{3}{4}$ cwt.	...	6 cwt. 28 lb.
Weight per nautical mile in water	14 cwt.	...	1$\frac{3}{4}$ cwt.
Specific gravity	2·1	...	1·3.
Breaking weight	11,000 faths.	...	17,000 faths.
Weight of 2300 nautical miles of cable	4,111 tons.	...	718 tons.

From the above statement it will be seen that 2000 lb. of gutta-percha are only equal, for purposes of insulation, to 400 lb. of Macintosh's compound, and the respective cost of the materials per pound is at least three to one in favour of the compound.

Mr. Macintosh said he could lay his cable down for £100 per mile, and he had made that offer to the Atlantic Company. If they persisted in their old course he had no doubt that another line would be laid down long before their line could be completed.

Captain Selwyn wished to know what sort of cable could be constructed for £100 per mile, and what would be the rate of speed? Would the cable be of the same length and with the same speed, or of greater length with the same speed?

Mr. Macintosh said the cost of the line to Newfoundland would be £100,000, and with the same sized conductor he could get at least 80 per cent. more signal power.

Captain Selwyn regarded with interest the development of a new material of so much promise. He believed that the statements of the inventor as to the advantage of the material could be proved, and he considered it was as applicable to underground electric telegraph lines as submarine cables. The route proposed by Mr. Macintosh was one in which there was no deep water for any great length. The distance to the first sandbank was 900 miles, the next distance was 500, then came another 500, and then one of 430. In no case was the depth more than from 100 to 200 fathoms, so that the cable might be easily recovered if broken, and the risk to the shareholders was consequently diminished under any circumstances to 900 miles, which was the greatest loss it could incur. The Northern route had also the advantage of being divided into sections, but it had the disadvantage of having nine shore ends, and all electricians knew that shore ends were the great difficulty.

Captain Davis, as a nautical man acquainted with laying deep-sea cables, would prefer taking the responsibility of laying three of Mr. Macintosh's cables to one of the Atlantic Telegraph Company's cables. He remarked that, as there was nothing to pay for concession, the advisability of forming a company to carry out the scheme was well worthy of consideration.

The chairman inquired whether Mr. Macintosh had any certificates as to the electrical condition of the cable? Mr. Macintosh replied that he had those of Mr. Desmond FitzGerald and Prof. Miller.

After a lengthened discussion relative to the various materials employed for insulation, Mr. Harry Lobb moved the following resolution:—"That, having heard Mr. Macintosh's statement, this meeting expresses confidence in the advantages of his system, and of its applicability as a means of direct telegraphic communication with America and the colonies."

Captain Symonds seconded the resolutiod, which was carried unanimously; and it was agreed that another meeting should be held for the purpose of further considering the matter.

THE MONKS' CHAPEL, NORWICH.

The Monks' Chapel, off Elm-hill, is the most recent building of importance which has been erected in this city. It is the first erection for what will be a large missionary establishment, comprising schools and cloisters, and an industrial home for the congregation of "St. William, the boy Saint of Norwich."

It stands 16 feet parallel to the longest side of the premises, and 10 feet from the north end; thus there is room for an aisle some day, when the intrados of the nave arcade will be cleared away, opening four bays of 14 feet by 20 feet high. The buttresses will then be carried over the aisle, and cut away from their present position. The ground on the other side is irregular, but the adjoining property is very narrow, so perhaps the aisle will be completed on the other side as well, some day: then the chapel will be 60 feet wide, interrupted by six pillars. It is now 30 feet clear by 78 feet in length, 34 feet by 92 feet outside. At the north gable, where the tower will stand, there are sacristy and vestry on the ground-floor, and monks' choir and organ-chamber above; the gable is pierced with five openings to admit the sound; these are screened from view by the baldachin over the high altar; the upper portion of the gable is panelled for frescóes of the Annunciation, Manifestation, and Ascension.

The monks reach the choir by a flight of stairs outside the building, under which stairs is a doorway and passage between the north gable and the raised footpace of the high altar. Under an arch which carries the super-altar are two doorways 4 feet apart; the wall between them, with the partition-wall between sacristy and vestry, as a buttress as far as the doorway communicating between these two, forms the pier, which, together with the wall on which the slab rests forming the high altar, will, it is intended, carry a spire of stone on marble shafts, as canopy to the throne and tabernacle.

This passage also communicates with the opposite outside of the chapel, and by a flight of steps with the chancel floor, which is 4 feet above that of the chapel.

The high altar, 10 feet in length, is raised on a triple footpace. A staircase leads behind the sedilia to the floor of choir and organ, and on the other side of the chancel stairs lead from this floor to the top of the screen, on which are the ambones for the gospels, &c. These stairs are screened from view, and hidden by piers of chancel arch. The side altars are under the screen, which entirely covers them, forming two separate baldachins.

The chancel-arch, 25 feet span, 40 feet high, is tied across on a level with the floor of the screen with an iron rod, and one reaches from the crown of the arch to this rod, and is partly hidden by the rood crucifix. The arch passes behind one of the principals of the roof, the framing of which is boarded. The first bay of the nave is appropriated to lay choir, footpaces of side altars, and ascent to chancel. It is divided from the rest of the nave by a plain brick wall, leaving about 50 feet by 30 feet for the congregation. The wall-plates are 23 feet, the ridge 50 feet. The clerestory windows above wall-plate are couplet lancets with a circular aperture above, entirely carried out in splayed bricks. The south gable is a handsome piece of brickwork, as the buttresses which project inwards divide three archways, also temporarily blocked up. Over the centre one is a wheel window, over the side ones panels for frescoes. The tracery of this window consists of three lancets, over which is an elongated vesica, and a circle above, on either side of which two more vesicæ pieces, and a fourth on the top; the four spandrels contain drain pipes, which admit light and reduce the heaviness. The window is 9 feet wide, 13 feet high, and 14 inches deep. All mullions are 14 inches; all the bricks next the light are splayed. The buttresses are arched over it.

The roof is framed like the pons asinorum in Euclid, and boarded and slated. All arches are semicircular, and stilted on from one to four courses, excepting the chancel arch, which is three-quarter, and the lights in the windows and the arch over the high altar, which are equilateral. The spandrels and arches of the nave overhang the 4½-inch pilasters 2¼ inches, and thus help the buttresses to keep up the roof. The style is simple and solid, and pretty evenly divided between Norman and First Pointed. "Brother Brannock" was the architect; Messrs. Lacey and Son were the builders.

New Masonic Hall, Ipswich.—The New Masonic Hall in Brook-street, Ipswich, has been consecrated and opened. The building stands back from the street, and abuts upon the passage leading to St. Stephen's-churchyard. It is of red brick, and has no external pretensions to notice. The building consists of entrance-hall, banqueting-room, lodge-room, ante-room, and robing-room, a committee-room (upstairs), and a hall-keeper's residence, which fronts the churchyard. The whole building is 93 feet in length. In the centre of the floor of the entrance-hall is a diamond stone, bearing in illuminated characters the names of the various donors whose gifts embellish the hall. There are various emblematic designs about the building. The lodge-room is 45 feet long, 22 feet wide, and 17 feet high. At the eastern end is an alcove, consisting of two Doric columns of Parian marble, supporting an enriched arch, with pomegranates, lilies, and emblems pertaining to the various degrees in masonry, keyed in with a masonic stone, in which is sculptured the All-seeing Eye, the radiations of which will, when finished, be enriched with gold. The canopy of the alcove is studded with stars, which will be gilt, on a ground of cerulean blue. The ornaments upon the span of the arch will also be in gold. A dais will be erected, on which will sit, beneath the canopy, the W.M. of the lodge and brethren who have qualified themselves to occupy that position. The means of lighting the room by day is by two large margin ceiling-lights, with masonic mouldings, and fluted and coloured glass. At the western end is the organ gallery. The furniture of the room harmonises with its character. Masonic colours—crimson, purple, and sky-blue—have been used throughout. The builder was Brother J. A. Pettitt. The stonework was done by Brother Chinnock (Tovell, Chinnock, and Co.); the gas, &c., by Brother Lucas. Brother C. T. Townsend designed many of the decorations.

THE ARCHITECTURAL ASSOCIATION.

The ordinary fortnightly meeting of the Association was held on the 2nd ult., Mr. R. W. Edis in the chair. Messrs. P. A. Hammond, E. Purdy, and C. E. Jones were elected members of the Association.

Mr. Lemon then read his paper, as follows:—

ON THE PROSPECT OF IMPROVED DWELLINGS IN LONDON.

By James Lemon, Assoc. Inst. C.E.

The object of this paper is to draw attention to the present system of constructing modern dwellings; and to offer a few suggestions which may tend to check the present evils, and indicate the way towards the improvement of the domestic architecture of the Metropolis.

In the suburbs houses are springing up in all directions, yet how few, if any, have been designed by an architect, and are being erected under his superintendence. Does this not suggest a want of public confidence in the profession? But, says the architectural student, I have not turned my attention to domestic architecture; there is not sufficient scope for the practice of the art: I wish to design a building which shall be at once an illustration of my professional skill. I would answer to this, that the young architect may find some difficulty in obtaining the area for the exercise of his skill which he thinks he ought to have; whereas he may easily build a house for his neighbour if he only shows him he is competent to do so. To return to the subject before us: what are the defects, and the prospect of improvement?

The freeholder, as soon as the increase of population causes a corresponding increase in the demand for houses, and his ground becomes eligible for building purposes, places himself in the hands of an agent, who uses every means in his power to let the land on lease, by the offer of liberal advances to builders as the works progress; and in order to obtain as much ground rent as possible, crowds as many houses upon the site as he possibly can, to the great detriment to health of the subsequent occupiers. In some instances an architect is employed, but this is the exception.

The speculating builder who only takes ground where there is money advanced, in many cases, is deficient of the necessary capital to complete the houses, or even to roof them in, but has enough to pay the wages until the houses are floor high, the materials are easily obtained on credit. As soon as he obtains the first draw, he is enabled to refund himself the amount of the wages spent, and also to go on until he obtains a second advance, and so on until the work is completed, if the houses let and sell readily: if not, the mortgagee forecloses, the builder, having nothing to lose, is well paid for his time and trouble, and the tradesmen who supply the materials are left to suffer the loss. Although there are many instances to the contrary, where men of capital have covered large estates in a satisfactory manner, yet, generally speaking, it is by this pernicious system that the suburbs of this Metropolis are being built.

How then is it to be expected that the workman, or the small tradesman, or clerk, can obtain a dwelling fit for occupation, when the only object of the builder has been to erect the greatest amount of covered cubical space, which he calls a dwelling, at the least possible cost? I do not lay so much stress on the want of proper homes for the clerks or other persons following a sedentary occupation, because they can live three or four miles from their office without much inconvenience, and therefore it is merely a case of supply and demand; but with the workman it is a very different matter, it is most advantageous to him to live near his employment, consequently he has no other resource but to inhabit the wretchedly-built, badly-drained, and ill-ventilated hovels which we see in all the poor districts of the Metropolis. The lamentable results of these wretched dwellings, have been so accurately and forcibly shown by the public press, that it is unnecessary for me to recapitulate them.

It has often been urged on behalf of scamping builders, that the public who buy are alone to blame—if there were no buyers of cheap houses there would be no builders. That is true to a certain extent, but how many of the purchasers are in ignorance of the construction of the houses, and who are prevailed upon to buy by the plausible statement of the builder, that everything has been done in a substantial manner. Another, and a very large class of buyers, are those who will buy anything which shows a good per-centage for the capital invested: with those there is only one remedy, and that is very stringent building regulations. The general public have very erroneous ideas of the Building Act, they imagine that the district surveyor is responsible for all the structural defects in a modern building, and therefore, if they are pleased with the arrangement and external appearance of a house they wish to purchase, they conclude that they are right about the walls and timbers, as the district surveyor has looked after all that.

With the view of showing the defects in the regulations as to new buildings, I will give a short abstract of some of the evils of cheap building. I do not mean to say that everything is necessarily bad which is cheap, I only include those concealed parts of a building which are scamped in order to reduce the cost, and increase the builder's profit.

The foundation is the portion of a building which should receive the greatest amount of care and attention, yet how often do we see it otherwise. The Building Act stipulates that the foundation shall rest upon the solid ground, or upon concrete, or upon other solid superstructure. In practice it does not bind the builder to use concrete if the ground is solid, so that we have houses built upon clay, loam, and other soils, without any provision against damp by the insertion of damp-proof course, or slates in cement; the result is, the damp rises up the walls like the sap up a tree. I was employed about nine years since, to make an estimate for finishing some carcases at Notting-hill; when I found the damp had risen half-way up the lower story, the necessary precautions not having been taken in the construction. Another evil often perpetrated is the omission of proper space under the lowermost floor for ventilation. I have known instances where the joists have been laid on the ground, and the footings cut away to receive the ends. Yet when this floor was laid everything appeared satisfactory, and if a surveyor examining the premises neglected to have a board taken up he might be easily deceived as to the real state of the case. No building should be erected with less than one foot clear space under the ground joists, there should also be a connection with the external air back and front, so that there may be a direct current right through. Care should be taken that the ground does not rest against the walls above the level of the damp-proof course: provisions should be made for either an open area or dry area with good ventilation.

Another defect of modern building by which the lives of the occupiers may be endangered is insufficient timbering. Modern builders have found out that the element of strength in a beam is the depth, and they have carried this principle to such an extent, that we now see boards on edge made to answer as joists. I do not so much object to the deficiency in thickness in joists if they are well strutted as to the want of sufficient depth in proportion to the span. Many persons are so ignorant of the strength of timbers that they have a stereotyped scantling for joists, which they use for all spans in small houses. The result of such a system may be easily imagined, in some cases they have more than sufficient and in others the deflection is considerable. Of all portions of timbering there are none so often scamped as the lintels, and when we consider the small proportion they bear to the total quantity of timber in a building, it is surprising that men will injure the stability of a structure by crimping their scantling. Gutter plates in V roofs also afford a grand opportunity to the cheap constructor to save timber; it is unnecessary to state that he does not hesitate to avail himself of it, consequently in a short time there is a permanent set; this is one of the causes of leaky roofs.

Light rafters, of long span, are amongst the things to be avoided in construction. A really good, strong roof may be easily constructed by the introduction of a light truss, or by trussing two of the rafters, and placing the purlin upon the crutch formed at the junction of the strut with the rafter. By this means in small houses the span of the rafter is reduced to a minimum, and one of small scantling may be used with beneficial results. The construction of roofs by judicious trussing is a matter in which scientific knowledge will give the architect an immense advantage, enabling him to design a stronger structure with the same quantity of, and in many cases less, material.

In the present mode of designing shop-fronts the brestsummers are mostly formed of a baulk of timber, resting upon story-posts of small scantling, and in many cases without any ties to the joints, to prevent the entire front from pitching into the street. About two years since an accident of this kind occurred. It is a common practice to construct gutters of zinc or light lead, imperfectly laid, without sufficient turn-up under the slates or tiles. With respect to zinc, I have not that prejudice against it which many members ot the profession have. I am of opinion that it is a material which requires to be better known to be more appreciated. It has been used in this country of a thickness which is almost unknown on the continent; hence the failure. If, instead of using No. 12 gauge for gutters, No. 15 or 16 were used, you would have a material which would last fifty years without repair, at one-third the cost of lead.

I am satisfied that we should have roofs which would keep out the rain more effectually than they do now on many of our dwellings, if more attention was paid to the disposition and fall of the gutters, if the number of drips were increased, and the metal laid loose, and not fixed in any way, to prevent the expansion and contraction. Box gutters are much better than the gutters which are furred up on the rafters, as a better fall is easily obtained, and by reason of their greater depth and less width a greater hydraulic mean depth, and therefore increased velocity, thereby sweeping away deposits of loose mortar.

The structural defects of our modern dwellings are too numerous to relate in detail in a paper like the present. I must, therefore, conclude this portion of the subject, and pass on to the consideration of the defects of plan and design.

The present mode of planning workmen's dwellings is capable of considerable improvement. I do not here include the various *model* dwellings, which have been designed by Mr. Darbyshire and others. I more particularly allude to those buildings which have been constructed without professional assistance, either on speculation, or with the view of securing a high rate of interest for the money expended.

In the districts of Bethnal Green, Bermondsey, and some parts of Lambeth, we find dwellings in a most deplorable state. They were originally built for one family, but are now occupied by several. I know it would be a difficult matter to prevent the tenants of small houses sub-letting, but it is a question which is seldom taken into consideration when the houses are planned. When it is known that the locality will not command tenants, who are in a position to pay the whole of the rent of the house, and in order to do so they must sub-let, why not construct the dwellings for two or more families, and let each have the necessary conveniences for domestic comfort.

In the modern houses of Paris, the workman can obtain one, two, or more rooms complete in themselves, at a very moderate rent, whereas in our Metropolis, he must pay a higher rent for wretched apartments and no accommodation. One of the defects of plan I wish most particularly to point out is the system of designing two rooms with only one entrance to the passage, so that the occupants of one room must pass through the other; also, the common mode of placing the back kitchen as an out-building, so that, in order to go into the garden or yard, the occupiers of the other rooms must pass through it.

With regard to basements, I am of opinion that they are objectionable in any case; but, if unavoidable, they should be at least half their height above the level of the street, and should not be less than 7 ft. 6 in. high in the clear. Amongst the disadvantages of basements, I may mention that they entail increased cost of drainage of towns. For example, in Southampton there is an annual expense for pumping, solely on account of a few basements, which induced the surveyor to place his sewers at a lower level than he otherwise would have done Why architects and builders should have such a great desire to go down below the level of the street with their rooms, and burrow under the earth like the North American Indians, I cannot conceive. There is plenty of room upwards. Streets in time are raised above their old level; therefore to obtain that amount of light and air so necessary to health, by all means keep your buildings well up. It is argued that you cannot obtain the necessary offices without basements, but in answer to that, I would say, in town houses they can be much better disposed on a mezzanine story. They are equally easy of access from the street, and are more centrally situated with regard to the other rooms: also the ground story may by that means be used as a shop, as in Paris, entirely distinct from the other portion of the house. Then again, it is a custom to use the basements for stores; of course, if you go down with the walls to get a good foundation, it is economical to utilise the space; but why not utilise the space in the roof? In the mediæval buildings of some parts of France and Germany, the attics were used for the provision of grain and other stores, where they were kept dry (the roofs being strongly built did not let the rain through); we, on the contrary, place our stores in the cellars, where they, in many cases, become damp and musty.

It is extremely desirable that each living room should be provided with a good larder connected with the external air by means of an opening fitted with perforated zinc; also sufficient space for one ton of coal, not underneath the larder as in Peabody-square, which I think objectionable; a good sink and sufficient water-supply are also important, if of rain water, as well as spring or river water, so much the better. It is to be regretted that the question of storing the rain water does not receive that amount of attention which it merits; it is very useful for washing purposes, and, according to Mr. Rawlinson and others, would effect a large saving in soap.

The cooking arrangements in the houses in London are much neglected; there are now many small ranges and grates manufactured, which can be obtained at a low price, and are much to be preferred to the old-fashioned stoves in ordinary use; the economy of fuel is a subject which should engage the attention of every architect.

The planning of bedrooms also requires more consideration than is usually bestowed on the subject, the position of the bed should be determined, and not left to chance; I think the French plan of placing it in a recess has some advantages, because it enables a person in indigent circumstances to make one room serve the purpose of two, as the bed can be screened from view by folding doors or by curtains, and at night the occupants have the benefit of a much larger cubical space than can be obtained in the ordinary-sized bedroom. With regard to the cubical space necessary for a bedroom occupied by two persons, I am of opinion that it should not be less than 1000 feet, although the rooms in the model dwellings designed by Mr. Darbyshire contain less than 800 feet each, and the rate of mortality is very low.

I now come to a portion of my subject upon which I hold somewhat strong opinions, viz., ventilation. I consider that it is of as much importance that some means of exit should be provided for the vitiated air, as that a fireplace should be provided with a flue. Every architect should make himself acquainted with the principles of ventilation, and not put himself in the hands of patentees, some of whom know very little of the subject, and endeavour to give a scientific colouring to their inventions by elaborate diagrams, and all kinds of complicated contrivances.

Ventilation in an ordinary building is really a simple matter, and only requires a knowledge of natural laws to successfully carry it out at a small cost. If an outlet be provided from each room into a flue adjoining that from the fire, so as to create an up-draught, the vitiated air being at a high temperature will pass off, and fresh air, which may be introduced at the lower portion of the room, will supply its place. I believe a 3-inch cast-iron pipe fixed in the chimney flue, iron being a good conductor of heat, would answer admirably; or an iron flue from the kitchen in a brick chamber, as adopted at the Langham Hotel, I have no doubt would answer very well.

In the planning of improved dwellings in London, in my opinion, there is an objection which makes them less popular than they otherwise would be, they are too much like a barrack, several families are mixed up together, and there is a want of privacy which is distasteful to the English feeling. They are likewise as at present constructed ill adapted for children; a great number of rooms being placed on a floor, with one corridor common to all; in the event of the appearance of those contagious diseases to which children are liable, there is considerable danger of the whole of them being affected. With regard to the arrangement of the conveniences some objections may certainly be raised. I consider that in improved dwellings not more than eight rooms should be placed on a floor common to one staircase, they can be so planned that four rooms can be let to one family, and form as it were a small house, with an inner hall communicating with each room; also a separate water-closet, space for coals, larder, and other conveniences. Such buildings I am convinced could be built to pay 7 per cent. interest on the capital invested, and would be eagerly sought after by good tenants. Another plan of constructing improved dwellings is what is called the external gallery system. This mode has some advantages, for instance, there is more privacy than in the corridor system; on the other hand there is a deficiency of window light from the projection of the galleries; likewise the convenience of a drying room and bath rooms, which Mr. Darbyshire has placed in the top story of the houses in Peabody-square, is not so easily obtained.

I believe that those gentlemen who have erected model dwellings on expensive freehold sites have deterred capitalists from taking up the subject. Many of the buildings so erected pay so small a per-centage, that persons who have embarked in the scheme have done so from pure benevolence. To the credit of the poorer classes in this country, there is an independence of character, which causes the idea of living in houses erected by charity, alone sufficient to prevent many from occupying them. The capitalist should adopt the same means which he would if he were to build any other structure purely for investment; that is to say, select a piece of uncovered ground at a reasonable ground rent, on a long lease, and erect his dwellings thereon by contract.

With respect to design in an artistic point of view there is much to be done. I fear the public are not sufficiently educated to appreciate art-work; they know that a picture or a statue is a work of art, but they do not know that a building may be, or ought to be, equally so: they weigh only their market price, that is to say, the cost of the material and labour, and the profit thereon; they do not appear to understand that a building produced by an architect, who is an artist in every sense of the word, is as priceless as the works of a painter or sculptor, and should be paid in proportion to its artistic value as a work of art. In treating my subject I have not placed architecture as an art last on my list, because I think it of secondary importance, but I have merely followed the ordinary professional custom, viz., the plan first, and the elevation afterwards. If we criticise the ordinary outline of our dwellings in the Metropolis, we shall find them to resemble so many square blocks, with openings therein for doors and windows: there is a total absence of shadow and relief, all is bare and monotonous; and to repeat the words of that celebrated critic, the late Cardinal Wiseman, one could imagine that the builder's bill was as follows:—To one house as per pattern, so much money; to ditto ditto, so much; and so on. I must confess there is an amount of truth and honesty in a Gothic dwelling which does not exist in those plaster abominations which we see in the suburbs of London; in the one case the architect or builder has constructed his ornament; and in the other he has endeavoured to ornament his construction by covering an inferior material with cement, in imitation of stone; and what is worse, has attempted to reproduce the grandeur and refinement of Greek and Roman architecture, without any knowgledge whatever of their beauty of proportion. I know of nothin more melancholy than the decay of some of our squares and streets, which were once considered respectable, built in a style which requires constant renovation in the shape of painting or colouring. Directly the new gloss has disappeared the occupiers begin to think of moving to some more enticing quarter, whereas, if they had been designed, as some of our mediæval domestic buildings were, with honest materials, without any attempt to conceal the constructive features, they would have mellowed with time, and improved with age.

Amongst the defects which are most notable is the common practice of placing piers over openings in the arrangement of the elevation of the first floor. Then again, there is a want of effect in the sky-line by the introduction of high parapets and V roofs. Why conceal the most beautiful feature of a building?—that is to say, if well treated. Why not bring the roofs boldly forward to public view, and not hide them behind a high wall, as if you were ashamed for any one to see them? Not wishing to slaveishly copy mediæval domestic architecture, still, I think, with the many improved materials which we now have, which our forefathers had not, we ought to be able to produce a convenient honestly-built dwelling, in an artistic form, at a moderate cost.

With regard to materials for cottage building, I wish to call attention to Portland cement concrete. The manufacture of Portland cement has now arrived at that state of perfection that its use is greatly extended. Portland cement concrete blocks have been substituted for masonry in the construction of sea walls, with most satisfactory results. Mr. Hawkshaw has found it to answer the purpose admirably, both in England and on the continent, and I believe he is about to carry out extensive works with Portland cement concrete blocks, without any facing whatever, which will be exposed to the alternate action of sea-water and the air. The inference I draw from this is, that concrete might be more extensively used for walls of our dwellings in lieu of brickwork, at half the cost. It is certainly a material well worthy of trial, as it would make a most important difference in the cost of workmen's dwellings. The question of improved building materials has been so well treated by Mr. Mathews,* that I feel I can add nothing, and therefore am well content to leave it in his hands.

Having, to some extent, pointed out the present defective mode of building, I will now give my ideas as to the means which should be adopted to effect some improvement. I confess that I see very little prospect of improvement under the present mode, but if the architectural profession generally, more especially the younger members, will give the question their consideration, with a view to reform, I think they may effect a radical change. I consider that no building, however small, should be erected without the assistance of an architect; but you will naturally say, the fault does not rest with the architect; he would only be too willing to extend his practice if the public would employ him. Herein lies the gist of the whole question. The architect must show the public, who now dispense with his services, that it is to their interest to employ him. Then how is this to be effected? I submit that it is to be done by enforcing a higher standard of education, and by giving the young architect greater facilities for acquiring a practical knowledge of the details of his profession. Architectural students are not deficient in artistic skill, as the drawings of our Class of Design bear witness. I wish I could say the same of their constructive talent. I admit that the chief thing an architect has to acquire is a thorough knowledge of drawing, but still he must not forget that drawings are only the means to an end; it is the *buildings* themselves by which he will be judged hereafter, when the drawings are, perhaps, mere waste paper.

It is very essential that an architect should have a thorough knowledge of the nature and value of buildings materials; also the value of labour, as I know from experience that the rock upon which an architect is often wrecked, is the estimate. Nothing tends so much to secure the confidence of a client as a correct estimate; many persons have told me they prefer to buy a house, to have one designed and built under an architect, because it is sure to cost more money than they anticipated or were informed by their architect. Next in value to the employment of an architect, as a general rule, to design our dwellings, I would place more stringent building regulations, and, in fact, what is required, is a thorough revision of the Building Act. I am opposed to restrictions generally, as they are in some cases impediments to business, but it is absolutely necessary in building if we wish to improve our dwellings. The Building Act answers the purpose for which it was specially framed, viz., the prevention of damage by fire; but as regards the durability of buildings, the strength of timbers, and sanitary precautions, it is sadly deficient,

The Local Government Act is in some respects a much better measure, as it gives powers to local boards to make bye-laws as to the regulation of buildings. In some towns builders are obliged to deposit plans for approval; also ventilation is made compulsory; and in a few cases the builder or owner is obliged to obtain the certificate of the surveyor that the house is fit for occupation, before he can let it.

I hope we shall soon see some reformation in this respect in the Metropolis. I think that it would be beneficial, if builders and others before commencing to build were compelled to deposit a plan of the ground story, a front elevation and transverse section of the proposed building, for the approval of the district surveyor; it would then be the duty of the district surveyor to examine such plans, and, if satisfactory, give notice to the builder to proceed. By this means, we should secure one important point. viz., that all persons before building would be obliged to prepare the necessary plans, and not build by rule of thumb, as in many cases they do now. They would to a certain extent be obliged to engage professional assistance, which is a step in the right direction, and would certainly lead the way to better things. By an extension of the present powers the district surveyor would be in a position to remedy the defects of modern buildings pointed out in this paper.

With reference to the supervision of buildings during their progress, there appears to be room for improvement in many ways. District surveyors should devote their whole time to the subject, and be paid by salary, according to the district, and not as at present, by fees. The present system is objectionable in various ways; the district surveyor in private practice is necessarily unable to give that attention to the matter which he would do if he had no other duties to perform. No man can engage in two separate occupations, and give each that amount of study which he would do if he had only one. Then again, the payment by fees direct from the builder places the district surveyor in a false position; it is certainly an anomaly that an officer should be paid by those over whom he is expected to exercise control and

* See this Journal, pages 8 and 43 *ante*.

supervision. Certain fees must necessarily be charged the builder, but they could be paid to the Metropolitan Board of Works when the builder receives the order to commence, andhis plans are approved of. The district surveyor should also have an efficient staff of assistants under his control, so that a proper and regular supervision of buildings could be maintained, whereas at present the supervision is most imperfect. I do not cast any blame on those gentlemen who hold the position of district surveyors, the majority of whom are an ornament to their profession, but they are the exponents of a bad system. Neither do I wish to propound schemes which would impose duties upon those gentlemen, which I am not prepared to carry out myself.

Before concluding, I must urge upon the younger members of the profession the desirability of so extending their professional influence, that the public may rate their services at their proper value. I am not one of those who would stay the making of new streets, new railways, and other improvements, because they take down old dilapidated hovels which are occupied by the working classes. I hope that the work of improvement will go on; that new lines of aëration will be opened up through the courts and alleys which now disgrace this Metropolis. It is one of the principles invariably followed by railway companies and by other public bodies, in forming new streets, to pass through small property, from motives of economy,—it is well it should be so. Without these improvements, and the consequent demolition of small houses, the question of improved dwellings in London would never have been raised. Out of evil comes good. The poorer classes are at present put to much inconvenience from the loss of their homes, to which they had become associated, and were of course very loath to leave. Rents have increased, as they always will do, in proportion as the demand is greater than the supply. But an impetus has been given to the movement; a desire has been evinced by many that the position of the working classes in London should be improved; and if the capitalist only see, which I feel he must do, that the erection of improved dwellings is a good and safe investment, we may look to the future with fair hope of success. By improving the homes of the workman you raise his social standing, you imbue his mind with thoughts of emulation and industry, and excite him to feel that he may improve himself, and thereby improve his position. There is no doubt that this is an indirect means by which the mechanical skill of the workman may be increased, that with a better social standing we may ultimately obtain that which is so necessary to improve our architecture, viz., a race of art workmen having a love for the calling they pursue.

What the condition of this Metropolis is to be in another decade will depend on the architectural ability, business tact, and perseverance of the architectural profession. I trust the younger members, to whom we look for the future status of an architect, will study architecture as an art, as a science, and as a business. If they do so, assisted by more stringent building regulations, I think we may say we shall have a very fair prospect of improved dwellings in London.

Mr. Blashill observed, that the present unsatisfactory state of London dwellings was mainly owing to speculative building, a system which, however bad it might be, was in some ways found convenient. He thought the sooner workmen's dwellings were removed from the Metropolis the better. In the immediate neighbourhood of valuable warehouses and public buildings there often existed houses in a wretched state of repair, each inhabited by a number of different families. In the course of events these houses got worse and worse, till they were pulled down, and other buildings more suited to the locality erected on their sites. But what, he asked, becomes of the working men thus driven out? It seemed certain that large blocks of houses, like those erected out of the Peabody fund, were not a good investment for money. He (Mr. Blashill) had examined the report issued by the managers of the Peabody fund, and found that the buildings in Spitalfields were only yielding a return of one-half per cent., he however thought it possible that there might be information not given in the report which would modify this conclusion. He considered that the provision of dwellings for working people would only be provided when a hope of sufficient profit existed. Property let to working men furnished as good security as that occupied by any other class of the community, as he had lately seen in examining the accounts of a society for building workmen's houses, which had a rent roll of several thousand pounds per annum. The loss through bad tenants was not 10 per cent. All houses in London were built with the intention of being occupied by one family only, whereas, in fact, they were frequently occupied by several different families. It seemed desirable to acknowledge this fact, and build accordingly, as people would enjoy more real privacy by living in separate flats, than they do under the present system. A large number of persons would always desire to live and sleep in the centre of London, and good blocks of dwellings for all classes were therefore required. Mr. Blashill observed that inaccessible closets and spaces should be avoided in house-planning, as they tend to harbour dirt and disease. He moved a vote of thanks to Mr. Lemon.

Mr. Potter seconded the vote of thanks. He thought it desirable workmen should, if possible, be enabled to live in London, and although important thoroughfares like the Strand could not be used for Peabody houses, the cross streets might be available for such a purpose.

Mr. Gilbert Redgrave referred to the valuable labours of the Society of Arts, with regard to workmen's houses. A committee of that body had arrived at the conclusion that it was not likely to be profitable to build such houses in London; he however thought having workmen's towns in the suburbs might succeed. From a number of reports he had examined some years ago, he had found that 4 per cent. was the highest rate of interest received on new buildings of this class, while the average was barely 2¼ per cent. In the barrack system, he believed, what people most objected to was having the staircase in common, perhaps the difficulty would be obviated by having external staircases and galleries.

Mr. J. H. Christian said that the barrack system seemed to be repugnant to the English feeling of independence; perhaps the barrack-like appearance might be removed if the galleries were made broad enough to give the idea of a street; this would make it practicable to introduce small shops. He had, however, little faith in the system, and rather favoured the plan of workmen going out of town, to which he did not see any reasonable objection. He could not reconcile the low return received for the new workmen's houses, with the fact that houses let by single rooms to poor tenants are very paying property. He could not understand that if new houses were erected on the sites of old ones, such as exist between Oxford-street, and Charing-cross, a return of 5 or 6 per cent. could not be realised. This per-centage would not attract speculative builders, but it might satisfy a large class of philanthropists. He believed cottages would yield a better return than the large barrack buildings, which require thick walls, and fire-proof floors and stairs.

Mr. North coincided with the previous speaker as to the demerits of the barrack system, and confirmed from experience the profitable character of old weekly property. If, however, this property were rebuilt, it could not be so closely packed, and a less return would consequently be obtained.

Mr. J. D. Mathews thought speculating builders taught architects how houses could be built to pay. The question to solve was, how to build cheaply without building badly. Mr. Fowler, in his presidential address at the Institution of Civil Engineers, had advised young men to see first how cheaply a structure could be produced, and then how expensively. In the suburbs there were many neat houses with six or seven rooms, which let at annual rents of £20 or £25, which were sometimes built (badly enough no doubt) for £130 to £160. Whereas, if an architect were employed, a similar house would not be built much under £300. The builders' house contained bad materials, but on the other hand there was a vast amount of meretricious ornament, which was byno means necessary. This waste in ornament should enable architects to compete successfully with speculating builders; many pieces of good construction are often too good for the purpose required. In building on leasehold property, he did not consider they were bound to study the interest of the ground landlord so much as that of their own client; as for instance, on a piece of land held by land for forty years he did not think they were bound to erect a house to last 300 years. Mr. Mathews went on to show that, though houses built by speculating builders might be cheaper at first than those erected under an architect, still in the former case a constant outlay was required for repairs. He stated his opinion that, the more stringent building regulations were made, the more they would be evaded by that class for whom they were specially framed.

Mr. Riddett called Mr. Mathews' attention to the fact, that all leases from ground landlords stipulated that the houses should be built substantially.

The President considered it would be a great hardship to the workmen to be obliged to come 8 or 10 miles daily to their work. In all matters pertaining to working men, it was most desirable to secure their own co-operation as much as possible. In visiting builders' yards he had been struck by the vast extent of ground covered with low one or two storied shops or stabling, and it had occurred to him that these spaces might be made more available, and productive of greater profit, by the erection of buildings containing workshops on the ground-floor, the upper portions being devoted to dwellings for the workmen. The President put the vote of thanks, which was carried.

Mr. Lemon, in reply, said, the question of workmen's dwellings seemed to turn on the per-centage obtainable. He certainly thought good houses could be built to pay well. He disapproved of the barrack system, and of the action of philanthropic societies; the natural law of supply and demand must be trusted to. He considered building on uncovered ground more likely to be remunerative, than pulling down old houses and rebuilding. He had examined the houses of speculating builders, and was sure that architects could erect better buildings at the same or at a slightly increased cost.

THE GAS SUPPLY OF PARIS.*

By G. R. Burnell, C.E., F.G.S.

Amongst the wonderful adaptations of physical science to the daily usages of life, there is hardly one which is calculated to excite greater attention than the application of carburetted hydrogen gas to the purposes of illumination. It is essentially a discovery of modern times; for there must be many here present who can recollect the "darkness visible" that enshrouded London streets in the days when oil lamps were in vogue; but we get so soon accustomed to the enjoyment of luxuries, that very often the first steps that attend their acquisition are forgotton, and we take them as matters of course. Somewhat of this kind of reasoning has been adopted with respect to the use of gas; and the public are inclined to expect that the manufacturers of this article, which has now become almost a necessity of life, should give them the benefit of their experience, without taking into account the cost they must have incurred in acquiring it. The discussions that took place on the occasion of granting the new concession for lighting the city of Paris, and the movement that is at present going on in our own Metropolis, seem to have been marked with this spirit; and though the Paris Gas Company has succeeded in obtaining what may be considered as favourable terms in return for the supply of gas, yet the inhabitants of London evidently are disposed to expect that the companies should supply them at such prices as would hardly leave them a fair profit. It therefore struck me that a statement of the conditions under which the Gas Company of Paris have contracted to supply the town with that article of consumption might be of interest, if only to enable the engineer to compare the systems adopted in the two countries with respect to public works; the more especially as it would appear that considerable misapprehension exists with respect to the rights and privileges of our neighbours in this particular matter. It is proposed also, in the course of this paper, to notice the points wherein the manufacture and distribution of gas in Paris differ from those which are followed in London.

The formation of the one gigantic monopoly that has the privilege of lighting Paris took place in this manner. There had been several companies that were formed for the supply of the city, which had, from the period of their first establishment, enjoyed a species of districting arrangement, as we should call it, and they agreed to merge their separate capitals in the six companies that had treated with the municipality in the month of December 1846. In the year 1852, when the empire was first established, the government thought it to be its interest to encourage the formation of great companies who should possess the means of employing large numbers of workmen, and give rise to the profitable investment of capital. The hygienic effect of the establishments for the manufacture of gas in the interior of the city also weighed with the government; and they were desirous that at least three or four of these should be removed from their original positions in the centre of the town. Under these circumstances it was suggested to the shareholders of the six companies that their union would be received with pleasure; and then that their application for the prolongation of their concession, which expired at the close of 1863, might be entertained, upon conditions that were to be the subject of future deliberation. The consequence of this proceeding on the part of the government may be described, in substance, to have been that the concession for lighting Paris was granted to the united companies on these terms. The three establishments in the interior of Paris, at the Avenue Trudaine, the Rue du Faubourg Poissonière, and the Rue de la Tour du Temple, were to be suppressed, and their manufacture was in future to be conducted in the new gas station that was to be erected at La Villette. The canalization of the interior of Paris (understanding by that term the lines of mains and distributing pipes) were to be altered, and made so as to correspond with the probable future demand upon them; the company agreed to pay the town the sum of £8000 for the privilege of laying their pipes in the public ways; also it agreed to pay the town two centimes a mètre cube, or about 5½d. per 1000 cubic feet, as a compensation for the *octroi* dues; it moreover agreed to share the profits of the working above 10 per cent. with the municipality of the city of Paris after the expiration of the first sixteen years.

The material and plant that were employed, and all the land and buildings devoted to the manufacture, were to remain the property of the company at the expiration of the lease, which was fixed at fifty years from the 1st of January, 1856, and the company bound itself, in the meantime, to alter the position of their mains, &c., whenever the town might require to execute works for the water supply, sewerage, &c.; so far, indeed, has the lease forseen the probability of future operations of this nature, that it provides for the company's removing their pipes into any subways that the town may construct, without thereby giving rise to any claim for compensation. For these terms the company agrees to supply gas for the public lighting at the following prices:—There are three sets of flames, that are respectively 2¼ inches wide by 1⅛ inch high, which is paid per hour, 0·015f.; 2⅜ inches wide by 1¼ inch high, which is paid per hour, 0·021f.; and 3 5/16 inches wide by 1 1/6 inch high, which is paid per hour, 0·030f. When the gas is sold to the town by metre, it is paid for at the rate of 0·15f. the metre cube, or about 3s. 4½d. per 1000 cubic feet; the company is obliged to fix, paint, and repair the lamp posts and candelabra, but the town furnishes them. For private consumption, the company was entitled to charge for the gas supplied at the rate of 0·30f. per metre cube, or about 6s. 8¾d. the 1000 cubic feet, upon agreement of three months' date, terminable at the option of either party; but the parties so receiving the gas cannot employ it without the production of the certificate of the person employed by the town to examine (and who exercises the right of approving) the fittings and other apparatus. The company is at liberty to modify the terms of payment, in this sense, that it is allowed to receive the payment in monthly sums, but this must be on the condition of its being paid in advance. No subscription whatever can be refused by the company, provided the demand be drawn up in accordance with the model that is approved by the municipality. The company is at liberty also to charge at so much per hour, or by the metre. A model of each set or series of meters is deposited at the town hall, and every meter must correspond with the details of these; they are bound to be verified as often as the administration may require. All expenses attending these meters are at the cost of the consumer, whether in the first place or in the subsequent maintenance of them; practically, they all come from the stores of the gas company. It is to be observed that the gas company is not bound to deliver gas to the private consumer at other periods than those in which the mains would be under charge for town lighting. It was moreover stipulated that if during the period of fifty years, for which this lease was granted, there should be discovered any new system of lighting, the gas company should be bound to introduce it, under conditions that were to be fixed by the municipality; or the municipality reserved to itself the right of granting a fresh concession for the new system of lighting, without being bound to compensate the company in any way whatever. There are in the lease various provisions as to the amount of coal, &c., that the company is obliged to hold in stock, and as to the payment of the mains, valves, cocks, syphons, &c., that are placed in the public ways; these are estimated, in block, to be worth the sum of two millions of francs, or £80,000, which sum would have had to be paid to the company, in case of the town taking the conession into their own hands, or at the expiration of the concession. The quality of the gas is provided to be such, that a lamp of the first series mentioned, which would consume 100 litres per hour, should give a light equal to 0·77 of a carcel lamp burning 42 grammes of rape oil in the hour; for the lights of the second category, burning 140 litres an hour, the light is to be equal to 1·10 of that above given; and for the lights consuming 200 litres in the hour, it is provided that they shall lead yield 1·72 of the light of a carcel lamp described. It may be stated that this standard corresponds very nearly with the English one, of what we should call seven sperm candle gas.

To enable anyone to appreciate the position that the company occupies under this contract, it is necessary to observe that the coal used in Paris is mostly of Belgian and north of France origin; a small portion of cannel, or boghead, is only introduced when the illuminating power of the gas is below the standard. The average yield of this coal is about, per hectolitre (according to the figures that were published by the company in the course of the discussion that took place before the treaty was signed), gas, 22·94 metres; large coke, 31·11 kilogrammes; breeze, 12·07 kilogrammes; tar, 4·50 kilogrammes; and ammoniacal liquor of the value of 0·036 francs. The quantity of ammonia compounds that are present in the coal is considerable, and the company is

* Read before the Society of Arts.

obliged to exercise great precaution in ensuring the purification of the gas, in order to comply with the clause in their treaty which provides that the means they adopt for that purpose should be the best that are known. Yet with all these drawbacks upon the commercial results of the operation, the Paris Gas Company has always paid a good dividend, and the last distribution of profits was at the rate of 19 per cent.; whilst the average rate appears to have been of about 16 per cent.; a result that would cause great heart-burnings with the municipal reformers and the political economists of our own country, who will not allow any company to divide more than 10 per cent. The capital that is invested in the works consists of share capital, 4,000,000 francs, and of bonds of the company about £3,200,000 sterling; or, in all, about £4,000,000, for a total population of 1,600,000 persons, which would make the rate at which the gas service of Paris is performed about £2 10*s.* per head of the inhabitants. This calculation however is somewhat in excess of the facts of the case, as the gas company has lately undertaken to supply some of the external villages of the Department of the Seine, such as Romainville, Puteaux, Charville, St. Denis, Maisons Alfort, &c., which form the subject of a separate treaty; but the above calculation may be taken as representing the proportionate price that is incurred in this service. It may be added that the price that is agreed to be paid by the communes beyond Paris for the lighting is, for the public lamps, 20 centimes per metre cube, or about 4*s.* 3½*d.* per 1000 feet cube; for the private lighting, 40 centimes per metre cube, or 8*s.* 7*d.* per 1000; upon a descending scale that may reach finally, 6*s.* 8¾*d.* per 1000, in proportion to the consumption. The high price that is agreed to be paid for this service may be explained by the length of main that is unproductive to the company in these cases; but it certainly seems to be exorbitant, when the freedom of the gas from *octroi* dues and other municipal taxes is taken into account. The company is bound to conduct, in every instance, the gas to the front entrance of the subscriber, and the latter is entitled to employ whomsoever he thinks fit to execute the distribution of the gas in his interior; and, provided the subscriber presents the certificate of the prefect or his delegate, that the works are well and properly executed, the gas company is bound to supply the subscribers with gas. The expense of branching upon the main and leading to the meter is, of course, borne by the subscriber; the meters, as was said before, are bound to be of approved patterns, and verified as often as may be required by the police; they are furnished by the company, but are at the charge of the housekeeper, as far as regards their first cost and repairs, if those are taken at his request.

It may be remarked that the system of regarding the supply of the gas consumed in Paris as a municipal service, has entailed upon the private consumers the necessity of paying a higher price for the gas they consume than they would naturally do if the service were left to be regulated by the ordinary rules of trade. The municipality, in the exercise of its rights over the surface of the roadway, in fact, has only consented to grant the monopoly of the gas supply to the company, on the condition of their supplying the public lamps at reduced rates, and of sharing in the profits of the concern after it has been established such a time as is sufficient to relieve it from any chance of failure. It is true that in this manner the town authorities will be enabled to devote a portion of the profits arising from the sale of gas to the relief of the other taxation of the town; but this is only an indirect way of making the consumers of gas pay for the water, paving, or other municipal services; and it is objectionable, as the control of those services can never be efficiently performed so long as the total expenses of them are not distinctly brought under discussion. The worst of this system is, that the price of gas can hardly ever be reduced, as the municipality is directly interested in the maintenance of the rate of profit. The precautions then taken to ensure the delivery and the quality of the gas are, therefore, quite illusory, and they seem to be intended rather to lull the suspicions of the consumer than to exercise any real influence upon the operations of the company, for so long as the quality of the gas is equal to the average quality that is distributed in the French towns, there is no probability that much fault will be found with it, let it be ever so bad.

At present there may be found a great amount of the ammonia compounds in the gas, and it is rather deficient in the illuminating power when compared with the London gas, but this may be owing to the quality of the coal that is used. The effect of the participation of the town in the profits of the company must, however, be such as to superinduce a carelessness on the part of the *employés* who are charged with the verification of the quality of the gas, and of the means adapted for ascertaining the quantities supplied. There is now apparently a great deal of anxiety displayed by the town authorities about the illuminating power and the purity of the gas, for they have organised a complete system of control and superintendence of both the public and private lighting, that appears at first sight to be most efficient. There are twenty-one persons who are constantly employed in testing the gas, and who are paid at salaries varying from £200 a year to £48, the total sum voted for the salaries of these people for the next year being about £1060; there are also 130 inspectors of the public lighting, at salaries varying from £200 a year to £48, who figure in the town budget for a total sum of £10,480; and 32 inspectors of private lighting, who are charged with the verification of the meter; these are paid salaries varying from £240 to £40 a year, and they figure in the budget for £2600. The superintendence of this service is, theoretically, very well arranged; it remains to be seen whether it will really operate for the protection of the inhabitants when the town has a direct interest in the successful results of the company, which it will have when the period of sixteen years, during which the company has the enjoyment of all it can make, shall have expired. All these questions, of the power of a municipality to interfere with a private company, however, form part of the greater question of the organisation of the relations between the public body and the private citizens, that admits a question of widely-different solution, but it would be somewhat out of place to discuss them here, as they would be better treated in a separate paper. The object of the present one is to endeavour to trace the system adopted by our French neighbours in the supply of gas to their capital; and therefore, after having stated the conditions that the company and the municipality have agreed upon, it is proposed to state the manner in which the former of these parties has endeavoured to fulfil its part of the contract.

There are in the neighbourhood of Paris, and within the lines of the fortifications, ten gas stations, of different capacities, but all subordinate to the great station of La Villette. These stations are—1. La Villette; 2. Les Ternes; 3. Passy; 4. Vaugirard; 5. Ivry; 6. Charronne; 7. Belleville; and the three that are situated in the surrounding communes of St. Denis, Boulogne, and Charenton. As was said, the station of La Villette is the most important of these; it suffices for the manufacture of one-third of the gas that is consumed in Paris; the stations of Passy and Vaugirard supply together almost another third; and the other stations contribute about equally to the total consumption. The centre of the consumption is about the Church of St. Eustache, and the positions of the stations have been so chosen that they are mostly situated upon a circle, whose radius would be about that of the distance of the station of La Villette from that point. The station of La Villette is situated on the extreme verge of the town, being only separated from the fortifications by the military road; but the other works are often situated in the densely-peopled parts of Paris, to the great dissatisfaction of the Conseils de Salubrité, who complain very much of the smells given off in the process of manufacture. As, however, all the operations connected with the conversion of the residual products of gas-making are carried on at La Villette, there seems to be little reason for finding fault with the company on this score; but the tendency of the sanitary reformers to hunt up, as it were, the factories that have been moved once in accordance with their suggestions, is not the less worthy of remark. The preference for La Villette as the principal station for the manufacture of gas may, however, be easily explained: it is situated in the quarter that is entirely manufacturing, and is in the immediate vicinity of other similar establishments; it is immediately upon the canal that brings to Paris the produce of the northern coal-fields of France; it is traversed by the Northern, the Eastern, and the Central Railways; and though it is somewhat high as compared with the level of the lower part of the town, it is only a little above the average level of Paris. The coal stores—which by the way are bound, by the treaty of the town, to be large enough to hold two months' stores—the retort houses, the coke stores, and the purifying houses, are situated on the north of the Chemin de Ceinture; the gas-holders are situated on the south-eastern side of that line; and the establishment for the conversion of the waste products is situated towards the north-west of the retort house, being separated from the latter by the Chemin d'Aubervilliers. The total area of the establishment is from 120 to 130 English acres.

On this plot of ground the retort houses are erected, and are provided with, each, a set of condensing pipes immediately adjoining the retorts, and a set of coke towers or scrubbers, and the purifiers, that are within a series of buildings parallel to the retort houses, but separated from them by a paved court. The retorts are set in beds of eight each, back to back; the group of eight having seven retorts in each that are double, so that the total number of retorts at work at present is about 1076; but the quantity of gas that the company makes is considerably increased by the product of the ovens, from which it obtains smothered coke, for the use of iron and brass founders, railways, &c. The style of retort used is a clay retort, of the usual D shape, that is about 8 ft. 2½ in. long, by 2 ft. 4 in. wide, and 1 foot high in the clear; and it is to be observed that the French engineers prefer the use of the closed retort over the fire-clay ovens to that open at both ends (as in some of the London companies' works), for they contend that it is impossible to maintain an equal temperature in the ascending mains that must be used in the latter case, so that the gas escapes up one of these, to the detriment of the illuminating power, or to the destruction of the dip pipe, according to the temperature. The gas in the Paris works passes from the retorts into an hydraulic main, and thence through a set of condensing pipes, that are placed outside the building, in sets of three rows of ten pipes each, to the set of double retorts. An exhauster here takes the gas, and thus relieves the retorts of the back pressure; this exhauster is set in motion by a steam engine of 16 horse-power. There is a second machine for the purpose of relieving the pressure upon the coke ovens, and this gives rise to special arrangements for condensation, purification, &c., to be noticed hereafter, and quite distinct from the ordinary service of the gas factory. The exhauster takes the gas from the condensers, which are made particularly large, so as to effect the greatest possible amount of condensation (which the French engineers attach great importance to, as a means of ensuring the purification of the gas), and passes it to the scrubbers and the purifiers. In the scrubbers, or the coke towers, the gas is subjected to a system of washing, for the purpose of extracting as much as possible the ammoniacal liquor, the tar, and the sulphur compounds, that it may still retain; and then passes, without any intermediate process of washing, to the purifiers, where it is exposed to the effects of a mixture of sulphuret of iron, lime slacked and in powder, and sawdust, in the proportions of 1 metre cube (about 1⅓ yard cube) of sawdust to 0·10 metre cube of lime in powder, with about 2 cwt. of sulphuret of iron. This mixture is found to be preferable for the purification, as it is capable of being renewed several times, and is especially used in France, because there the agricultural interest does not appreciate the employment of the lime refuse of the purifiers. The gas here is passed through four successive layers, or rather series of layers, of the description above given, and is then passed through the station meter to the gas-holder, where it is stored for distribution.

There appear to be differences of opinion amongst the Paris engineers with respect to the conditions of the distillation of their coal, and with respect to the methods to be adopted to prevent the formation of the sulphide of carbon in the gas. The present practice of the gas company is, however, that of effecting the distillation with great rapidity and at great heat, and combating the tendency of the gas to the formation of the sulphide of carbon by means of a most energetic condensation. The charges that are generally employed are four-hour charges, at high initial temperatures, of about half a ton to each retort; the French engineers obtain from this quantity of coal the average yield of 9300 to 9500 cubic feet of gas (which is more than the London companies on the average do from the superior coal of Newcastle), and about 13 cwt. of good marketable coke per ton. The proportion of condensing surface that is found necessary under the French system of replacing the washing by an energetic condensation, is about 20 feet superficial to every 1000 feet cube of gas made; and the surface of purified medium that is used is about 4 feet for the same quantity; formerly the washing was performed by an additional process before the gas passed through the purifier, and it consisted in the gas being forced to bubble through a solution of ammoniacal liquor after it had passed through the coke towers, but now this process is dispensed with, so far as regards the passage of the gas through the ammoniacal liquor. The gas passes through the station meter, and from thence it passes into the gasholders preparatory to the distribution; these are eight in number at the station of La Villette; they are 107 feet in diameter, and 46 feet rise in a single lift, and are supported by a scaffold in the centre when down. The distribution of the gas from these reservoirs takes place under the pressure of rather more than 1½ inch during the day time, and in the night time of 3⅜ to 3¾ inches. It may be that this pressure may be required to overcome the difference of level of the factory, which is somewhat above the points of delivery in Paris; or it may be accounted for by the small dimensions of the distributing mains. The efforts of the company are, however, directed to the remedying this cause of loss, which must always, to a certain extent, act to prevent the due proportion between the mains of distribution and the quantity of gas they would discharge in a given period of time being observed, owing to the interest the company have to continue their working through the pipes that they are bound to yield to the town at the expiration of their lease. By the peculiar arrangements adopted, the Paris Gas Company has reduced the loss that ensues from the excessive pressure that accompanies the distribution of the gas to a minimum. We shall have occasion to revert to this subject; but it may be as well to state that the loss of the gas registered by the station meters, both in private consumption and in public lighting, was, in the year 1864, only 10 per cent.—a most insignificant proportion, if the quantity that is lost by the condensation in the mains, the amount that is not carried to account by the private consumers, and the thousand causes of loss that the gas must be exposed to, are taken into account. The average loss of the London gas companies is at least from 15 to 25 per cent. of the quantity they register at the stations.

There are at La Villette numerous contrivances for the preparation of marketable coke, that are well worthy of attention, but which it is not worth while to describe at present, inasmuch as the care with which this branch of the manufacture is conducted is essentially a local necessity, called for by the habits of the Parisians. The same thing may be said with regard to the conversion of the tar, ammoniacal liquor, and other waste products, all of which the Paris Company is obliged to convert to useful purposes themselves, but which we in England find can be more economically converted by the means that our manufacturing chemists make use of. There is, no doubt, immense skill displayed in this detail of the Paris fabrication, but it may be passed over, together with the brick, tile, and retort factory that forms an important part of the establishment at La Villette, and which manufactures for all the other stations in Paris. In Paris the gas company had, in fact, to organise every detail of the service, and to create the industries that are connected with the disposal of the coke and the refuse, and that were necessary for the making of the gas; they, therefore, were deprived of the advantages that the English companies possess in the greater division of labour that prevails in this country, and which permits them to concentrate all their attention upon the strict object for which they are established. The coke ovens mentioned above may be cited as a proof of this; they are calculated to convert about 6 tons at a time, that yield about 8000 or 8500 cubic feet of gas to the ton, and 13 cwt. of smothered coke; but both the gas and the coke that are thus obtained are of inferior qualities, of the respective kinds; both tend to lower the lighting and heating power of the gas and coke they yield. The brick and fire-clay manufacture of the Paris Gas Company, however, yields products of a superior kind; but it is to be suspected that it does so without much reference to trade profit; and the same may be said of the engine factory, where the company manufactures for sale the Lenoir engine, so extensively used in building operations in Paris. It is found that, with all the disadvantages that the Paris Gas Company has to encounter in the disposal of their waste products, they manage to derive from their operations upon the coal they consume about the proportions of 1000 for the gas, 200 for the coke, 20 for the tar, and 2 for the other residual products. The tar, it may be added, is never burnt under the retorts; it is too valuable, and meets with too ready a sale, to allow of any such application; the ammoniacal liquor is principally used for the preparation of sulphate of ammonia, that meets with the readiest sale in England.

It is calculated that the total yield of the La Villette station is about equal to five millions of cubic feet per day when the works are in full operation; and the distribution of this quantity takes place in the busiest and most bustling part of the town. The other works do not present anything very particular, excepting perhaps the station at Vaugirard, which is specially reserved as an experimental station, and where the company have been at work for the last three years upon Mr. Siemens' system of economising the heat that is employed to produce the distillation of the coal; hitherto without success, it must be observed. The Paris Gas Company, by their monopoly of the supply, are enabled thus to "try all things" that are proposed in the matter of lighting with the best means and appliances that can be disposed of.

The distribution of gas takes place through mains that are of as a large a diameter as $3\frac{5}{16}$ feet, exactly one metre; they are all of wrought-iron, upon Chameroy's patent, and in that respect the Paris supply differs from that of London, which, in consequence of Mr. Michael Angelo Taylor's Act, is compelled to receive its gas supply through cast-iron mains. The Chameroy pipes are put together in lengths of 15 or 16 feet; the joints are rivetted and brazed; the whole is then coated with a preserving coat of bitumen, and the joints are made with a male screw on one end, and a thickening out, formed on a mandril, to receive a female screw on the other, which is then packed with gasket and white lead. The opinions of English engineers are unfavourable to this style of pipe, but the experience of the Gas Company of Paris for the last twenty-seven years seems to be decisive as to its merits in all cases where the soil is of an alkaline nature, and is not charged with water. I was informed by M. Camus, the sub-engineer of the works, who is also an engineer of the Ponts-et-Chaussees, that he had ascertained the wear and tear of 1000 metres of wrought and cast iron mains of the same diameter respectively, in the course of the year 1861, and he found that they presented the following results. He found that the cast-iron showed that the proportion of the leakage that was owing to accidental breakage in the pipes was 1·000, whilst that quantity was, for the wrought-iron, 0·460; the proportion of loss through the use of the pipes by time or depreciation was, for cast-iron 0·353, for wrought-iron 0·198; the proportion of loss by shaking of joint was, for the cast-iron pipes 1·77, for the wrought-iron 0·520. There may be greater care and attention paid in Paris to the repairs and maintenance of the pipes, but the results of the experiments tried in this case seem to indicate that the cause of the diminished loss upon the registered quantity of gas must be sought for in the use of these mains; and at the present day, when so much attention is forcedly turned to the question of the leakage of gas pipes, on account of the construction of subways by the Metropolitan Board of Works, the subject acquires additional interest. The house distribution also takes place in Paris through lead service pipes, that must be another cause of diminished leakage; but the private consumer is at liberty to employ whatever system he may think proper after the passage of the gas through the metre. From the report of the gas company to its shareholders last year, it appears that the total consumption of gas in Paris was about 3567 millions of cubit feet, for a population that was estimated at 1,650,000; and the company had, in their provision of an increased demand, increased their manufacturing powers to 4141 millions. The length of pipes that were employed in the lighting of Paris was 546,861 metres; that of the annexed zone, of 424,985 metres; that of the banlieu and the surrounding district, 165,346. The number of public lights supplied by the company for the account of the municipality was 26,849; the number of private consumers was 59,554, in the year 1863, the last for which I have been able to procure the returns. It may be added that the lamps that are used for the lighting of the Boulevards are placed at distances of 25 metres apart on the same line; in the Rue de Rivoli they are about 14 feet apart; in the courtyard of the Louvre they are about 20 feet apart; the burners being, in the majority of cases, at 10 feet above the pavement. The lighting of Paris is, in fact, most brilliantly and lavishly executed, in the best quarters of the town at least; it leaves, however, much to be desired in the poorer portions, which are about as badly lighted as the analogous parts of London.

I have mentioned the desire that the public seem to have at present for the laying of the pipes in the subways that have been constructed by the Metropolitan Board of Works, and have hinted at the provisions that have been introduced into the treaty that prevails between the city of Paris and the gas company, with the object of facilitating the laying of the pipes in that manner. The treaty contains, indeed, a clause to the effect "that the town reserves to itself the right to displace, and even remove altogether, at the expense of the concessionaires, and without any indemnity, the pipes every time that it may think the public interest may require it. If it should suit the municipal administration, during the continuance of this lease, to relieve the public ways of the excavations necessary for the laying of the gas pipes, and to dispose the sewers so as to receive them, the concessionaires shall be bound to remove their pipes to the positions prepared for them, at their own expense, upon all the points where the city shall have executed the works for this purpose." Yet with this precaution and this right the city of Paris does not think of calling upon the gas company to remove their pipes; nay, the water pipes are in Paris carried into the sewers, which are there rather subways than simply sewers, and the engineers of the city most energetically oppose the introduction of the gas pipes into them. Experience has shown that there are fatal causes at work to produce the explosion of the escaped gas in these cases, which all the care of the engineers cannot guard against. There have been three accidents, as M. Belgrand informed me, in the gallery of the Rue des Martyrs; there have been two accidents in the courtyard of the Louvre; and the accident that took place last year, the consequences of which I myself saw, on the bridge of Austerlitz, was a fatal commentary upon the danger of the system of laying the gas pipes in subways. In this case the pipes were carried over the haunches of the bridge in a gallery, that had an entrance at either end that served as a means of ventilation, and it had a means of escape at the middle; the gas was shut off at both ends, and the quantity there was in the pipes was allowed to burn off; yet an explosive mixture was formed, and it was set on fire, probably by a workman throwing down a match. Fortunately this occurred in the early morning, and the few people there were passing the bridge were attracted to the side where they could witness the passage of a steamer that happened to be passing; there were consequently no passers-by injured, but two workmen were killed, and several others were carried off to the hospital; the whole length of the pavement of the bridge was blown up for the length of 180 or 200 metres, and about 12,000 francs' worth of damage done to the bridge. M. Belgrand was, in fact, quite borne out in his opinion, that "in no city where there was anything like a regard for human life, would the notion of carrying the gas-pipes in a covered way be for an instant tolerated." He had, it must be observed, more than eleven years' experience in the Paris subways, and yet, with all the advantage of the most careful superintendence by the engineers of the Ponts-et-Chaussées, and the effect of the French law of compensation for accidents to enforce the observance of the necessary precautions, he did not scruple to come over here to London to give evidence against the scheme of the Metropolitan Board, that is again brought before the public with so much persistency. The fact is, that without a regular system of ventilation, that would entail an enormous outlay, there cannot be any safety in the syst m of subways as applied to gas pipes; and the Metropolitan Board do not seem to have contemplated the execution of even the smallest precaution for this purpose.

The Paris Gas Company is managed, as all the important operations of that country of a similar nature are, upon the strictest principles of discipline, order, and superintendence. The administration is composed of a certain number of directors, who are chosen from the body of the shareholders, generally speaking from amongst the original proprietors in the various gas companies that were amalgamated together, and they are assisted in the management by M. Gayffier, ingenieur-en-chef of des pont-et-chaussees, and M. Camus, ingenieur-ordinaire of that body, who have under their orders a numerous staff of engineers, chemists, practical men, and clerks, that would frigh any English board of management. Thus the expenses of salaries to the various people employed in the factory, in t maintenance and laying of the mains, and in the office of company, was not less than about £88,000 in the course of t year 1863; but at this charge the service is performed with degree of perfection that we in England have no conception The cost of every detail of the manufactory is known to the la centime; the waste that attends the operations of the *Londc* companies is unknown; the accounts are kept in the most ela borate manner, and the gas company provide for their ow servants with a liberality that we in England have no conceptio of. The result of the system is, that in Paris the gas works a managed at about 58 per cent. of the total receipts; which m be accounted for by the fact of the great success of the speculati that the directors manage, and by their having no inducement introduce any great economy in their working, in consequenc the participation of the town in the profits of their concern after a certain time. There is, indeed, every inducement for the directors to indulge in expense in the management; none to induce them to save; and as the city of Paris has also a direct interest in knowing the cost of every detail of the fabrication of gas, it is questionable whether at any time the frais d'administration, or the office expenses, will be much decreased. This is certain, that the Paris Gas Company is managed with consummate skill; and though we in England would do very unwisely, as I think, to adopt the system that prevails in the neighbouring capital with regard to the supply of gas—because it is founded upon principles of political economy which are, I think, wrong, and it would involve an interference with our private habits, which I think would be intolerable—yet there are many things that seem to be well deserving our study, and our imitation, in the manner the Paris Gas Company carries out its contract. The system at Paris is, in fact, designed for the atmosphere of France; it would fail if introduced here, where "every man does what he likes in his own eyes."

In the discussion upon the foregoing paper,

Mr. GEORGE GODWIN said he was not able himself to agree with what appeared to be the leading object in the paper, viz., to make us more satisfied with what was done for us in England. It was not likely that Englishmen would put up with such an arrangement as was made for the inhabitants of Paris. The notion of tying themselves down for fifty years to take their gas at 6s. 8½d. per 1000 feet (with allowances and deductions), notwithstanding any inventions and arrangements for cheapening it, seemed unreasonable. The people of Paris at that moment paid very little more for their light than in London. He was assured that the light there was much superior. It was true the municipality of Paris partook of an advantage to the extent of 5½d. per 1000 feet, and divided the profits beyond 10 per cent. after sixteen years; so that they had an interest in keeping up this price. It was not likely that we should permit such an arrangement; although we were, perhaps, not much better off with our arrangement than the Paris people. He regarded it as idle to say that the escape of gas could not be guarded against. They were told that the escape from the mains was still very great, as was manifest from the state of the soil round the joint of an old gas pipe; the loss to the companies was great; the damage to health would be great, by-and-bye; and in order that they might go on laying down pipes with bad joints and other careless arrangements, they brought forward the evidence of one solitary French engineer, to prove that explosions were a necessary consequence of pipes being laid in subways. In the case of Nottingham the system had been carried out without damage, and he was satisfied that this plan was a perfectly practicable one, and it would be a disgrace to the companies if they persisted in opposing its adoption. In many buildings he had seen as much as half-a-mile of pipes of iron and of softer metal running through the different rooms, but there was no escape of gas, because the joints were properly made. He was satisfied if the gas mains were laid in the subways, and a proper system of ventilation provided, no better plan could be adopted. At present the public were subject to the perpetual annoyance of disturbances of the streets. All that nuisance might be avoided by using the subways; and, notwithstanding Mr. Burnell's endeavours, they must persist in pressing this matter on the attention of the gas companies; and if they would not afford the public redress, it was to be hoped that the legislature would do so.

Mr. THOMAS HAWKESLEY entirely disagreed with the gentleman who had last addressed the meeting. He (Mr. Hawkesley) had had thirty-five years' practical experience of this subject, having been the engineer of the Nottingham Gas Works, to which Mr. Godwin had alluded. He would tell them the real state of the case. The subway at Nottingham was a little pitiful channel, of about 200 yards in length, and the gas-pipe which was laid in it was four inches in diameter, the street having very few houses, and, consequently, there were very few branches from that pipe. It so happened, also, that this little channel had a rise in the short length he had stated of very nearly 40 feet, and consequently it ensured for itself a tolerably good ventilation. He need hardly say that these were circumstances which did not apply at all to such a place as the Metropolis. It was remarkable how great were the apprehensions of the workmen of the gas company in reference to this subway, for they would not go into it unless the gas was shut off, and even then they used a safety-lamp. They were told that gas had been laid in subways, and that gas had been lighted in them without danger, but the danger was occasioned by the insidious escape of gas by leakage; and when this occurred in any confined space, an explosive compound was formed, which was liable to produce a most serious disaster, particularly in a subway, where the whole street might be bodily raised up, and the passers-by would run the risk of being injured, if not killed. A good deal had been said about the escape of gas in the streets, but he would assert that it did not reach to anything like 5 per cent.; in general it was much less. What was called leakage was simply the loss which a gas company sustained upon the gas, as ascertained, in the first place by the meter at the stations, and in the second by the money which the gas company received. A thousand and one things happened between the station meter and the receipt of the money by the company. In the first place there was leakage at the works, which was very considerable. In the next place there was the consumption of gas upon the premises, which was to be counted by millions of feet a year, and which very few gas companies took into account. Then the gas went into the mains, from which there was a very slight escape indeed, and that escape passed into the soil, where it was absorbed without danger. A great loss occurred from the service-pipes, much more than from the mains of the company. That was a loss which ought as far as possible to be prevented; and if gas companies generally used lead pipe instead of wrought-iron for services, as was done in many places with great success, they would not suffer in this way. The gas eventually went to the meter, which professed to measure the whole that passed through it, but it often did not; and any defect of the meter, whether wet or dry, was against the gas company. Then there was all the surreptitious and fraudulent consumption of gas, which in a great city was not inconsiderable. Then, further, there was the waste in the public lamps, which was greater than any other, for this reason: each lamp was a consumer with only one light, and the pipe must be as full of gas for that consumer as for a private consumer using ten or twenty lights, and thus there would be a greater proportion of leakage. All these things put together went by the general name of leakage, whilst the escape from the mains of a well-managed company was not more than 2½ per cent. Mr. Hawkesley instanced the case of a gas company in Denmark, whose works he superintended, and in which the whole leakage, over a period of three years, did not average 5 per cent., and at Nottingham, before the introduction of Lord Redesdale's Meter Act, the leakage was as low as 8 per cent.; but owing to the operation of that Act it had latterly been as much as 14 per cent. The way in which accidents would happen in subways was this:—A gas company alone could not control all the operations of the subway; other workmen would be employed there who might be the occasion of accidents. If the streets of London were generally subwayed, he had no hesitation in saying that with 2000 miles of subway, there would not be a day without an explosion, if the gas mains were laid in them; and it would be impossible, in the nature of things, to prevent this. Passing to what had been said with regard to the gaslights in Paris, he would say he did not find anything better there than we had at home. The quality of the gas, the mode of manufacture, the amount of production, and the system of distribution, were in every respect inferior to what we had here, and, above all, the price of gas was 50 per cent. higher than our maximum price. The French system of political economy was the worst that could possibly be adopted. It was a system by which the municipality was bribed to participate in the profits on high prices; and the consequence was, that those who consumed gas were made to pay a portion of the taxes of those who did not do so. The same thing had been attempted, with various degrees of success, and want of success, in this country, a notable example of which existed—and to a certain extent still exists—at Manchester, but under modified circumstances. For many years the corporation of Manchester charged a very much higher price for their gas than the companies in the surrounding towns, and the money so obtained was applied to municipal purposes. The consequence was, a certain portion of the community were taxed for the benefit of the other portion. For a time that system went on very well, but it ultimately gave rise to a violent class agitation, which it was always desirable to avoid; one portion of the community was arrayed against the other on the price of gas, and that went on for several years, and at last resulted in the gas consumers beating the non-consumers, and then the price of gas was brought down to something like a reasonable amount. Paris was a much better lighted city than London, but the Paris gas in illuminating power was inferior to ours. The fact was, in Paris the people lived, not as we did, one alongside the other, but one above the other, and the consequence was the population there was distributed over a much shorter length of streets. In Paris they had one lamp to every sixty persons; the consequence was, that in the principal streets the lights were brought very close to each other; but it did not thence follow that because the city was better lighted, the gas was better. Its inferiority was accounted for by the description of coals they used; they, nevertheless, made as good gas as they could under the circumstances, and they took good care to use the kind of burner which gave the most perfect combustion. This was a matter which was neglected in London, but we were improving in that respect; and when we paid as much attention to these details as was done in Paris, the London gas would give a greater amount of light than that in Paris.

Dr. Wylde remarked that in the present advanced state of science there might be no practical difficulty in the employment of the subways of cities as channels for the laying of gas and water mains, so as to prevent the constant annoyance arising from breaking up the streets for those purposes.

Mr. Gore, having had experience in the laying of gas mains in this country and abroad, was inclined to think that the promoters of the subway system were at the present moment somewhat in the dark on that question. He could quite understand that in situations where there was a sufficient current of air to carry off the escaped gas there could be no explosion, but it did not follow that in a subway the current of air would be so rapid as to have this effect. Having been engaged, in 1861, in laying down gas mains in Valparaiso, the geological formation in some parts was such that at six inches below the surface of the soil granite was reached, and through that material a channel had to be chipped away of sufficient depth to admit of the gas main being laid down. Theoretically that would be supposed to form a very beautiful channel in which to lay the pipes, but a reference to the books of the company would show that the cost of repairs in that channel alone amounted to 75 per cent. more than in double the length at other parts of the town where the pipes were laid in a different material. Mr. Hawkesley had very properly said that the soil was the best safeguard against the escape of gas, and at the same time it formed the best elastic cushion on which to lay pipes. In laying pipes in a subway, there must be a number of rigid fixed points or brackets on which they must rest, and there would be a severe vibration occasioned by the traffic passing overhead; the effect of which on cast-iron mains so supported would, in a very short period, be very serious, in causing leakage at the joints. He (Mr. Gore) was now engaged in preparations for lighting with gas the city of Mexico, and he had visited every establishment at which he thought he could gain information. Amongst others he had met gentlemen connected with the subways in Paris, and on his mentioning the subject to them, they strongly advised him not to carry the mains through subways.

Mr. W. Macfarline was not satisfied, upon the evidence adduced by Mr. Burnell, as to the undesirability of the employment of subways for the laying of gas mains, nor did the observations of the last speaker satisfy him more on the same point. He thought, if they were not prepared to alter the material of the pipes, they must alter the construction of the joints, for if they put pipes in a subway with the present system of jointing, there would be a liability to great escapes of gas. There was, however, no reason why an improvement should not be made in this respect. The question was, whether iron was the proper material for the pipes, unless the interior were coated with a preservative substance; and if, besides this, a better system of joints were introduced, he had no doubt that subways might be used for gas-pipes without danger.

Mr. Burnell, in reply upon the discussion, would simply refer to the observation of Mr. Godwin, that the practical objection to the use of subways for gas mains rested on the sole testimony of one French engineer, M. Belgrand. Upon that he would remark that he had referred especially to that gentleman because he was the principal engineer in that department in Paris, and had had the largest practical experience in the laying of gas pipes in subways. He might mention that M. Belgrand's evidence on the point was confirmed by the opinions of M. Dupuit, who formerly occupied the position of M. Belgrand, by those of MM. Mouton and Huet, engineers of the ponts-et-chaussées and also by M. Leloup, inspecteur des eaux, as well as MM. Gayffier and Camus. The only evidence in Paris anything like favourable to the subways was that of the architect of the Louvre. Therefore, on the one side they had the evidence of engineers who had been practically concerned in the laying of pipes, and on the other side they had only the evidence of an architect. He could only say further, as to the quality of the Paris gas, it was very much below that of London. In the former city the gas was called seven-candle gas, and in the latter the standard of illumination was eleven candles.

The Chairman said he was not at all afraid, though he had heard of explosions in the Paris subways, of such occurrences taking place in this country. A strong current of air would not be agreeable in a house, but it would not be objectionable in a subway. He had been present when gas was lighted in a subway, and when, according to the views of some of his friends, an explosion should have taken place; but there was a sufficient current of air through it to almost blow out the flame of the gas. While that was the case there could be no fear of explosion from confined gas; and he was surprised to hear gentlemen say that proper attention had not been paid to that matter in the subways already constructed. He was sure all would agree that subways if safe must be of great public advantage. They could not fail to be a great benefit to the gas companies. While so many advantages were held out he was persuaded that nothing would prevent this improvement from going on. Since this subject was first mooted he had seen great changes in public opinion, and in the minds of gas engineers themselves; and many who were opposed to subways—even amongst the engineers of Paris—were now looking forward to a better state of things, and even made propositions for introducing gas-pipes into the subways.

INSTITUTION OF CIVIL ENGINEERS.

*President's Address.**

Having now enumerated in some detail the various descriptions of work which engineers are called upon to carry out, I will next proceed to point out the kind of preparation which, in my opinion, is requisite to enable them to perform their work in a proper manner. I am aware of the difficulty of the task, and of the wide difference of opinion which exists on the subject; but I feel unable to resist the opportunity of bringing this question under the consideration of the Institution, because I feel convinced that at no period in the history of the profession has it been so important as at the present time. Those who may not be disposed to coincide in my views may at least be led by the description of them to throw new light on a subject which is of vital consequence. We of the passing generation have had to acquire our professional knowledge as we best could, often not until it was wanted for immediate use, generally in haste and precariously, and merely to fulfil the purpose of the hour; and therefore it is that we earnestly desire for the rising generation those better opportunities and that more systematic training, for which in our time no provision had been made, because it was not then so imperatively required.

The preparation and training for the civil engineer may be shortly described as follows:—1. General instruction, or a liberal education. 2. Special education as a preparation for technical knowledge. 3. Technical knowledge. 4. Preparation for conducting practical works. All this preparation and training will have to be acquired at some time or other, and in some order or other, and it is known that in the cases of some successful persons of great perseverance, they have been acquired in a very remarkable order; but at the present time, and with all our modern opportunities, there is no reason why they should not be learned in the most convenient and methodical manner.

I will begin by supposing a boy of fourteen, in whom his parents have discovered a mechanical bias, who has made good progress in his general education, and especially in arithmetic, is of strong constitution, and possessed of considerable energy and perseverance; and unless a boy possesses these tendencies and qualifications it is quite useless to destine him for an engineer,—taking the boy of fourteen, however, who possesses the requisite qualifications, and with a determination on his own and his parents' part that he shall be made an engineer, the period from

* Concluded from page 36.

fourteen to eighteen should be devoted to the special education required by an engineer; during which, mathematics, natural philosophy, land surveying and levelling, drawing, chemistry, mineralogy, geology, strength of materials, mechanical motions, and the principles of hydraulics, should be thoroughly mastered. To accomplish these studies, and, in addition, to make considerable progress in the living languages, French and German especially, it will be necessary to sacrifice to some small extent his classical studies and pure mathematics; and it is, in fact, the partial omission of these studies, and the prominence of those I have enumerated, which constitute a "special education." If from fourteen to eighteen the boy has made all the progress in these studies which can be reasonably expected from fair abilities and more than average perseverance, the next step is of great importance, and is one respecting which some difference of opinion will exist.

At eighteen a boy, if duly prepared, may either be at once placed in the office of a civil engineer for a period of four or five years' pupilage, or he may be placed in a mechanical workshop, or he may be sent to one of our great universities,—and any one of these courses may be the best under particular circumstances, such as local convenience, or as the social position of parents may dictate. It cannot be doubted that a period of twelve to twenty-four months may be very profitably spent in manufacturing works, before passing into a civil engineer's office; but in that case the greatest possible care must be taken that the works selected are adapted in themselves to impart the desired information; and that proper organisation exists for carrying out strict office discipline, regularity of attendance, and due diligence; and that assistance be given systematically to the pupil to enable him to obtain all the advantage possible from his stay at the works. It is of the greatest importance to the future success of the engineer that during his professional preparation he should continue his studies of mathematics and scientific works relating to his profession, and also of modern languages.

In the case of its being intended to send the boy to Cambridge or Oxford, it is indispensable that all preliminary professional work, such as a practical knowledge of mechanics, mechanical drawing, surveying, and levelling, should be mastered before going to the university, because it can scarcely be expected that he will submit to the drudgery of learning them after his return from a three years' university course, then at the age of, say twenty-two: probably the best plan will be to take him away from his scholastic studies somewhat earlier than eighteen, if it be intended that he should go to the university, and to take especial pains to make him accomplished in the preliminary work of the draughtsman, the surveyor, and the mechanic; so that when he has taken his degree, and enters as a pupil in a civil engineer's office, he will at once commence useful and interesting employment, and will not require more than three years' pupilage. If arrangements can be so made, and assuming a boy has worked well at school with his general studies, and subsequently with his special studies; and if from the age of seventeen or eighteen he does justice to his opportunities in a good workshop, keeps up his knowledge of the modern languages, proceeds to Cambridge or Oxford, taking a good degree, and afterwards completes his studies as a pupil with a civil engineer, probably such a course would constitute the best possible preparation and training which could be obtained; but at the same time it cannot be doubted that it is a somewhat hazardous combination, and can only be successful with great determination on the part of the pupil, to keep his future career always in view, and to prepare for it accordingly, as well before going to the university, during his college career, as after he leaves it.

With respect to the special preparation of young men between the ages of fourteen and seventeen or eighteen, several of the largest and best proprietary schools and colleges in this country have special classes and departments for the study of the applied sciences; and thence well-prepared pupils are annually sent out to commence their career with engineers, architects, and surveyors; but still the character of this special preparation, in its theoretical branches, is nôt considered quite equal to that of France or Germany for the civil engineer.

It is true that nearly all Continental nations have an advantage over this country in the power which the nature of their government gives them of concentrating, in one recognised official school for the preparation of civil engineers, all the best available talent of their country. This plan does not exist in our country, and on the whole we rejoice that it does not; neither does the inducement of government employment form the chief stimulus to our exertion, for which we are also thankful; but at the same time no good reason can exist why the opportunities of acquiring theoretical preparation in this country should be inferior to those of the Continent; and I have the confident hope, from the anxiety which is now manifested to increase the ranks of our profession, and the desire to have the best possible preparation for it, that even in the theoretical branches we shall shortly have to acknowledge no inferiority to any other nation. In the practical branches we are admittedly superior.

In drawing attention, however, to a comparison between our own and other countries, let me be guarded against the possibility of being understood to suggest that this theoretical equality ought to be obtained by any sacrifice whatever of our undoubted great practical knowledge; indeed, on the contrary, I think that the attention to the greater opportunities which young engineers in this country enjoy, by reason of the number and character of our new public works, than is attainable in other countries, should be constantly encouraged to the utmost possible extent, and that our old superiority as practical engineers should be ever maintained.

We will now suppose that the general education and the special instruction have been completed, the short probationary pupilage in workshops has been gone through, languages and mathematics kept up and improved, the university course in certain cases completed, and the period has arrived for entering a civil engineer's office. In selecting such office for a pupil, it is important that it should be well organised and not be too large; that the engineer should be a comparatively young and rising man, and be accustomed to take pupils; but these should be few in number, and bear some proportion to the number and extent of the works in usual course of construction under the engineer's direction.

It is not necessary to follow the pupil when once the engineer's office is entered with any detailed advice, because he is no longer a boy, unable to appreciate his position and duty; we assume that he has been highly educated and carefully trained, well knowing that his future success or failure will depend on the degree of diligence with which he avails himself of the opportunities of acquiring knowledge during his pupilage. The work in the office and in the field should be done to the best of his ability, and after the pupil has become a skilful draughtsman, and is capable of taking out quantities of engineering works, and preparing detailed estimates methodically arranged, he will then probably proceed to work out details of designs, and make calculations of strengths and strains, and thus become of real value in the office, at the same time making substantial progress and rapid improvement for himself. He should avail himself of every opportunity of mastering the purpose and the principles of construction of the work brought to his notice both in the office and in execution; he should ascertain the cost price of all the materials and workmanship employed, separating the items into every minute detail; and he should continue this practice systematically with all works on which he is engaged.

The information which, amongst much beside, should be obtained during pupilage, and which is necessary to constitute a sound engineer, is—1. A fair knowledge of the most fitting material for any given work, under any given circumstances. 2. The power of designing any ordinary work with a maximum of strength and a minimum of material and labour. 3. A knowledge of the means of ascertaining the cost price of any ordinary engineering work.

The information or knowledge included in this brief enumeration may be called practical knowledge; and it cannot be too often urged upon young engineers that theory and practice must always go together, hand in hand, and that they are not only not inconsistent or conflicting, but that they are necessarily united, and must both be fully developed in the same person before he can become a properly qualified "civil engineer." The period of pupilage should be from three to five years, depending on the circumstances which have been previously indicated, and, in addition to his attention to the office, and outdoor works, it will be well, while keeping up his preparatory studies, especially mathematics, that he should improve his acquaintance with the French and German languages, and keep up his knowledge of their engineering literature, and also avail himself professionally and personally of the advantages offered by this Institution. In the case of the mechanical engineer, however, it will be seen that although all scholastic and scientific training should be the same as that previously described for all other branches, the period of pupilage of the mechanical engineer must necessarily be passed chiefly in large workshops or manufacturing establishments.

I propose now to consider in what manner this Institution can be made available in the preparation of this young engineer, and more useful to the profession generally, and as a first step allow me, very briefly, to trace its history and refer to its present prosperity. It will be remembered that the Institution of Civil Engineers was established on January 2, 1818, and Telford was formally installed president on March 21, 1820. The origin of the Institution was very humble. About the year 1816, Mr. Henry Robinson Palmer, who was then articled to Mr. Bryan Donkin, suggested to Mr. Joshua Field the idea of forming a society of young engineers for their mutual improvement in mechanical and engineering science. The earliest members were Mr. Palmer, Mr. Field, and Mr. William Maudslay, to whom were shortly added Mr. James Jones, Mr. Charles Collinge, and Mr. James Ashwell. When the society was constituted, on January 2, 1818, these six young men were joined by two others, Mr. Thomas Maudslay, and Mr. John T. Lethbridge, Mr. James Jones acting as secretary, and during the remainder of that year there was no increase in the number, and there were only three additional members in 1819. In the following year, 1820, when Telford became president, there were thirty-two elections. At the end of 1822, when the Institution had been established five years, there had been fifty-four elections. Telford's name gave a great impulse to the progress of the Institution, which grew rapidly in importance under his fostering hand, so that at the close of 1827—after an existence of ten years—there had been a total of 158 elections, and by June 3, 1828, when the Charter of Incorporation under the Great Seal was obtained, the number amounted to 185 members. Telford continued to be the president until his decease on September 2, 1834, and at that time the actual number of members on the books (as distinct from the number elected) was 200.

Mr. James Walker, the second president, was elected to that post on January 20, 1835; and after occupying the chair for ten years, he declined to allow himself to be again put in nomination, in consequence of a strong expression of opinion from several influential members, that a shorter period for the term of the office of president had become necessary. Accordingly, on January 27, 1845, Sir John Rennie was elected president, and served for three years. Since then the chair has been successively filled by Joshua Field, Sir William Cubitt, James Meadows Rendel, James Simpson, Robert Stephenson, M.P., Joseph Locke, M.P., George Parker Bidder, John Hawkshaw, and John Robinson M'Clean, each of whom has served for two years, the maximum time now allowed by the bye-laws.

It should be mentioned that in the ordinary course of rotation Isambard Kingdom Brunel would have succeeded Robert Stephenson, but Brunel requested that he might not then be put in nomination, owing to ill-health and the pressure of professional duties; and unhappily his early subsequent decease deprived the society of any future opportunity of electing him. It must always be a subject of regret to the profession, that in the annals of the Institution a member so gifted and accomplished should not appear on their list of presidents.

At the close of 1836, when the Institution had existed nineteen years, the number of members of all classes who had been elected was 369, and the number of those still remaining on the books was 252, or about five-sevenths of those elected. At the close of 1860 these numbers were 1535 and 930 respectively, from which it appears that three-fifths of all those elected still belonged to the Institution, being a decline of only one-seventh in the relative proportions after a further existence of twenty-five years. The average annual effective increase of members and associates during the ten years from 1840 to 1850 was 25, and from 1850 to 1860 it was 27, the actual increase in 1859 and 1860 being 37 in each year. The effective increase in each of the five years from 1861 to 1865 inclusive has been 20, 57, 42, 56, and 106.

The number of members of all classes on the books on November 30, 1865, were,

Honorary Members	20
Members	486
Associates	689
Graduates	8
Total	1203

or an effective increase in one year of 108 members of all classes.

It will thus be seen that a steady annual increase has been the characteristic of the Institution from its commencement; and it may be noted in this, the forty-eighth year of its existence, that when it had been established twenty-four years, the number of members was almost exactly one-half of the present number.

The experience of the last few sessions shows us clearly that we may expect the future rate of increase to be at least equal to the past; and the attendance on the Tuesday evenings' discussions shows that the interest attached to the proceedings of the Institution increases in at least an equal proportion with the augmentation of the numbers. It is now not uncommon to find our meeting-hall inconveniently crowded, and occasionally it is altogether inadequate to accommodate the numbers who desire to be present; and many persons who, from the public interest attached to some of the subjects, desire to hear, or take part in some of the discussions, are now prevented by our restricted accommodation from doing so.

For some years in the early history of the Institution it was a work of considerable difficulty to keep the disbursements within the receipts, and except for the admirable management of our late Secretary and now Honorary Secretary, Mr. Manby, it is hard to know what difficulties we might not have experienced; it was not until its income became sufficiently increased by the liberal donations of the council and other members, by trust-moneys and bequests, and by the increase in its numbers, that the Institution was in a financial position to give increased accommodation and assistance to its members. It may be stated that during the last ten years the average increase on the receipts has been forty per cent., whilst the increase in the disbursements has been only twenty per cent.; and that the present amount of the realised property of the Institution may be safely taken at £25,000.

It will have been observed that considerable improvements have been made in the library of the Institution, and in its arrangements and facilities; and no doubt the Council and Secretary will continue to give this important department their earnest attention, and we may reasonably expect that both the contents of the library and its accessibility will be still further increased. It is, however, somewhat remarkable that a greater number of members do not avail themselves of the additional opportunities of reference to the library which have been afforded them; and this brings me at once to the consideration of the important question of the manner in which this Institution may be made more useful to its members. The state of the finances as we have already seen, will prudently permit the expenditure of a larger annual sum than we now disburse, and therefore we are at full liberty financially to consider the question of additional accommodation for the members; and I believe the library of the Institution would be far more valuable if an arrangement could be made by which it might be kept open in the evenings for a certain number of days in the week, say until nine or ten o'clock. I have ascertained that no practical obstacle to this extension of use exists, and that the additional expense would not be considerable.

Most of the members of the Institution are necessarily engaged in their ordinary daily professional duties during the only hours when the library is at present available to them; and it is obvious that it is only in the case of a special reference being required, or for some statistical purpose, that the library can be useful to members generally under the present arrangement. I can say from my own experience that I should have felt it a a great boon, as a young man, to have had the opportunity of spending an occasional evening in the library, and of reading and consulting the rich record of professional learning and experience now collected there, and therefore I throw out this hint respecting the extension of the hours for reading.

Another step might probably be taken with great advantage to students and engineers generally, viz., the systematic collection of good working drawings, specifications, and contracts for important works in progress or completed, and with facility for reference to them in the library, and permission to make tracings or copies. There can be little doubt but engineers in large practice would permit copies to be taken of their working drawings and specifications for this purpose; and in addition to this assistance with respect to drawings it would not be difficult to obtain permission for the inspection of the works themselves, during their execution, so that young engineers might have the opportunity, especially during the summer months, of seeing works as they are carried out, and comparing them with the drawings and specifications to which they have had access in the library. I would also venture to suggest that, in addition to the greater advantages which may be conferred on those using the library by extended time of access to it, and to the collection of working drawings and specifications, with arrangements for inspection of practical works, a limited number of lectures would be very valuable, if given by members who were especially conversant with any given subject, on other evenings than those of the ordinary meetings during the session of the Institution.

I now approach a question in connection with the Institution and its functions upon which, in common with the profession generally, I confess I feel very strongly, and that is, the necessity of providing as soon as possible a building more commodious and more convenient than that which we now possess. Our rapidly-increasing numbers have already reached the point when, as I have previously stated, the theatre in which we are now assembled is admittedly insufficient for the accommodation of those who wish to attend our discussions; and in addition to inadequate space, there are conditions inseparably attached to the present building which prevent this room being properly ventilated and rendered comfortable. The other rooms of this building are also totally inadequate for the ordinary purposes for which they are required, and on the evening of our annual conversazione especially, the crowding and discomfort are such as to repel many of our best friends from venturing to be present with us. With a proper building and well-arranged rooms, we shall also be able to have many objects of professional interest for our inspection and study, of which we are at present deprived —such as models of work and machinery, new articles, or new combinations, or possibly even a good museum. I hope, however, we shall shortly be in a position to consider a proposal for a new building, worthy of the present position and the future requirements of the Institution.

Having now frankly brought before the Institution some of the more important matters which appear calculated to influence the future of the members of our profession, permit me to say, in conclusion, that I am not sanguine enough to expect that I shall accomplish more in this address than direct the thoughts and attention of my professional brethren to the subject, and induce others more able than myself to take it up. It cannot be doubted that the rapidly increasing prominence and importance of our profession imposes upon us grave responsibility, and the duty of vigilant watchfulness, so that the character of our members and the success of our works may be all that greater knowledge, wider experience, and more cultivated taste ought to make them, and that every new work of importance may be better than that which has preceded it, and remain as a monument of progress, of which all may be proud. It is not now sufficient that an engineering work should be durable and free from failure; but, with our present means of study and of knowledge, it will be expected that our works should display in a satisfactory degree the qualities of fitness, economy, and taste, in addition to that of durability.

With deeper study and more complete preparation, the love of our profession and pride in its noble works will become greater and greater in its students, and lead to that intense devotion and application which history teaches us has alone produced the greatest works in art and science; and we cannot doubt that far greater triumphs remain to be, and will be, achieved by those whom I now see before me, than have yet been realised by either ancient or modern engineers.

Amidst all the excitement of professional avocations however, let us constantly bear in mind and endeavour to imitate the example of the distinguished men who have been removed from amongst us during the last few years, in the happy manner in which they succeeded in combining personal friendship with professional rivalry, and in their never-failing interest in the prosperity and usefulness of this Institution.

January 30th.—The first paper read was on "*The Craigellachie Viaduct.*" By W. H. Mills, M. Inst. C.E.

This viaduct was constructed for the purpose of carrying the Morayshire Railway over the river Spey, at Craigellachie, Banffshire, the engineers being Mr. Samuel (M. Inst. C.E.), and the author. It consisted of three spans of 57 feet each on the north bank, and one span of 200 feet over the main channel of the river; ordinary boiler plate girders constituting the former, and the latter being of wrought-iron on the lattice principle. The piers and abutments were of solid ashlar masonry, and the works were arranged for a single line of railway.

It was stated that the Spey was one of the largest and most rapid rivers in Scotland, and was also subject to sudden and heavy floods, the water sometimes rising 6, 8, or 10 feet in as many hours. It was about 110 miles in length, took its rise amongst the Grampian range, at an altitude of upwards of 1100 feet above the sea level, and for 10 miles above the viaduct, which was situated 15 miles from the sea, its average fall was 14 feet per mile. No part of the river was navigable for boats, but it was much used for the conveyance of timber, which was floated down in rafts.

In designing this viaduct, it was necessary to provide an uninterrupted channel for the free passage of rafts, and to construct the piers and abutments so as to be able to withstand the blows and pressure from any blocks of ice, or floating timber, that might be brought down during floods. The channel of the river was at ordinary seasons 180 feet broad, and 4 feet deep in the centre. The height to the underside of the girders from the usual water-level was 20 feet. The bed of the river consisted of coarse gravel interspersed with large irregular boulders, overlying a compact layer of gravel and clay. A timber pile cofferdam could not, therefore, be advantageously employed, and it was decided to use cast-iron cylinder foundations for the main pier, small river pier, and main abutment, and thick beds of concrete for the small land pier and abutment. The cylinders in the main pier and abutment were 5 feet in diameter, and in the small river pier 4 ft. 3 in. in diameter. They were in two equal lengths, and formed, when bolted together, one complete cylinder 13 ft. 6 in. in length. Their size was sufficient to allow a man to work inside, the large boulders being broken up with wedges, and removed in pieces, with the excavated material. The operation of sinking the cylinders was carried on night and day, generally with four or five at the same time, and so expeditiously that the eighteen cylinders in the main pier were fixed and filled with concrete in six weeks, and the fifteen cylinders in the main abutment, where a larger force was employed, in three weeks. There were eleven cylinders in the small river pier, and, in all cases, the lower edges of the cylinder were 13 ft. 6 in. below the bed of the river.

The general arrangement of the plates, angle irons, and T irons of the lattice girders provided for a free circulation of air to all the ironwork, facility for getting at the parts for cleaning and painting, and avoiding any opportunity for the lodgment of water or snow. These girders were parallel throughout, and their depth was 17 ft. 4 in. The top and bottom members were T shaped, the width across being 3 feet, and they were composed of horizontal plates, a vertical plate, and four angle irons. In the section adopted almost every portion of the iron was brought into effective work, and took part in the strain. A single system of lattice bars was used for each girder, consisting of angle irons varying in section according to position and relative strain. The main girders were 17 feet apart from centre to centre, and they carried the railway on the lower flange. The cross girders were of wrought-iron 12 inches deep and 4 feet apart, the rails being carried upon longitudinal timbers bolted to the cross girders. The lattice girders were held together laterally by five wrought-iron diaphragms, securely fastened to the main girders at the top, bottom, and sides. The lattice girders and the plate girders for the smaller spans were rivetted together at the main pier, and formed thus one continuous system. At the main pier the girders were bolted down to the masonry, while at the other piers and at the abutments the girders rested upon turned cast-iron rollers.

The results of several experiments showed that the average breaking weight of the plates was 22·39 tons per square inch, and of the angle irons 24·16 tons per square inch. At the Government inspection, with a moving load equal to 1 ton per lineal foot, the deflection of the main girders was only $\frac{5}{8}$ths of an inch, and there was no permanent set in any of the girders. The effective sectional area of the bottom member, deducting for cover plates, rivets, &c., was 70 square inches, giving a tensile strain of 4·1 tons per square inch. The effective section of the upper member, without deducting for cover plates, was 75·74 square inches, which gave a compressive strain of 3·78 tons per square inch.

The quantities of materials used in, the time occupied in the execution of, and the actual cost of the different portions of the work, were given in detail. It appeared that the excavation of the foundations was commenced in May 1862, and that the viaduct was opened for public traffic in July 1863. The total cost had amounted to £12,199, or equal to £29 10*s.* per lineal foot.

The second paper read was on "*The Grand River Viaduct, Mauritius Railways.*" By W. Ridley.

It was stated that the length of this viaduct, from abutment to abutment, was 620 feet, and that this distance was divided into five openings of 116 feet each in the clear. The height from the level of the rails to the surface of the water was 129 ft. 9 in. Each pier was composed of two cast-iron cylinders, each 10 feet in diameter, resting upon masonry foundations, and filled with concrete; the works being for a single line of railway. Mr. Hawkshaw (Past President, Inst. C.E.) was the consulting engineer to the Government of Mauritius, and the contractors for these railways were Messrs. Brassey & Co., for whom Mr. Longridge (M. Inst. C.E.) acted as resident agent. In constructing the piers of this viaduct, cylindric rings 9 feet high were divided into five segments each, and were bolted together by internal flanges. The abutment on the Port Louis side was built upon hard tufa, and No. 1 pier rested upon a rock projecting on the side of the ravine. During the excavation for the foundation of No. 2 pier considerable trouble was caused, owing to the pier being situated close to to the edge of the river, and from the nature of the ground, which consisted of large boulders and fine river gravel, the water freely percolating on all sides. At first it was thought that the water might be kept out by a series of dams, but these proved insufficient, as the water found its way through the bottom in such quantities, that it became necessary to resort to steam-power. In order to render the working of the pumps more effectual, the straight discharge pipes, which were 4 inches in diameter, were tapered out at the discharge ends to 8½ inches. The effect of this alteration was, that nearly twice the amount of water was delivered. The two pumps made 300 revolutions per minute, and discharged nearly 3000 gallons per minute. It was next resolved that the foundation should be formed of blocks of concrete, and that sufficient excavation for one block only should be taken out at a time. Tarpaulins were laid in the bottom, and for 4 feet up the sides of the excavation, for the purpose of preventing the numerous springs of water from washing out the cement, and this plan was found to answer perfectly, five distinct blocks being thus successively laid. The foundation for No. 3 pier was of the same description as that of No. 2 pier, while No. 4 pier and the adjoining abutment were founded upon rock and hard tufa.

The segments for the first rings of each pier were lifted into their places by means of sheer-legs and tackle, and in two cases the second rings also; but subsequently a mast, with a cross-tree and struts, mounted on a frame inside the cylinder, and free to revolve easily when required, was employed. As each ring was completed, the mast, with its supporting frames, was lifted, the time occupied in effecting this being about four hours and a half. Eleven pairs of rings were thus placed on No. 1 pier, thirteen each on Nos. 2 and 3, and ten on No. 4. The heights to the top of the last ring on each pier were respectively 99, 117, 117 and 90 feet. The weight of each segment lifted was 32 cwt., and one set of men in one day completed one ring and raised the mast.

Piers Nos. 1 and 4 were filled with concrete from the adjoining abutments. A single contractor's rail, weighing 23 lb. per lineal yard, rested on two frames, that on the abutment being higher than the one on the pier, and on this rail a box with a false bottom was made to travel, by a sheave rolling over it. The box contained 7 cubic feet, and weighed, when filled, 8½ cwt.; as soon as the contents were discharged, the box was drawn back by a rope. At piers Nos. 2 and 3, the concrete was lifted by means of an endless ladder of iron, worked by a small engine. At every alternate joint was fixed, by angle pieces and diagonal stays, a light deal shelf, sufficiently large to hold a basket containing nearly a cubic foot of concrete. When these baskets arrived at the tops of the piers, they were lifted off and emptied, and were returned on the undersides of the shelves. By the former method 50 cubic yards were completed daily, whilst by the endless ladder about 40 cubic yards were deposited in the same time, with one hundred men working at each. The concrete was carried to a height of 3 inches above the tops of the cylinders, and consequently bore the whole weight, the cylinders merely serving the purpose of a casing, and preventing the concrete from crushing laterally.

The girders were sent from England in sections of about 12 feet long, which on arrival were transported to the Mahébourg side of the river, and were rivetted together in lengths of 36 to 48 feet. A gullet was here excavated to the level of the abutment, and extending backwards to a distance of about 280 feet, it then rose at a slope of about 1 in 5 to the formation level. In this gullet the first lengths of girders were to have been built, and, as they were pushed forward, the succeeding sections were to be brought down the incline and added on. The arrangement for launching the girders was, however, considerably modified in England; but this modification, simple and effective as it appeared to be, and good as it was theoretically, practically proved a failure, and had eventually to be abandoned. The original plan was then resorted to. A line of flat-bottomed permanent-way rails, laid on longitudinal timbers, resting on cross sleepers, was placed under the centre of each girder. At every 12 feet a balk of timber, forming a skid, was placed transversely across the rails, and the girders were wedged up upon these balks. On the undersides of these balks, and over that part which would bear upon the rails, a thin plate of iron was fixed by two bolts, the heads of which were flush with the surface of the top, whilst the nuts projected underneath, and came up close to the inside edges of the rails, acting as guides to keep the girder in line when travelling. When the girders were ready to be moved, the rails were well greased, and men were placed at the ends of each skid, with sledge-hammers to keep striking it, to prevent sticking, as well as to assist in starting. The rails were laid throughout the gullet, to within 5 feet of the face of the abutment, the underside of the rails being level with the surface of the masonry. When the skids arrived at the end of the rails, they dropped, and were removed. On the top of the bed plates, the bearing plates for the permanent expansion rollers were bolted. These plates were tapered off at the ends, so as to allow the rollers to enter and to pass freely in and out. The latter were linked together, and after they travelled over the plates were taken out and returned, and linked on to the rollers just entered, and were gradually drawn in under the girders. Short keel pieces were followed up on the rollers, as the girders advanced, by men stationed on a scaffold. The launching was accomplished by means of powerful tackle and winches, and was so effectual that in one day the girders travelled 12 feet every fifteen minutes; subsequently they were advanced 108 feet in four hours, and the last span was completed in six hours and twenty minutes, the entire length of the girders, 630 feet, moving quite freely. The roadway girders, plates, and permanent way were then laid, and in fourteen days after the launching was finished trains were running over the viaduct. The girders fixed to the centre pier, while they rested upon rollers at the other piers and at the abutments, and so were free to expand and contract. The total weight of the superstructure was 560 tons, of which the roadway weighed 147 tons; and the total weight of ironwork in the piers, including bed plates, expansion rollers, &c., was 993 tons.

February 12th.—The Paper read was "*On the Principles to be observed in the designing and arrangement of Terminal and other Railway Stations, Repairing Shops, Engine Sheds, &c., with reference to the Traffic and the Rolling Stock.*" By W. HUMBER, Assoc. Inst. C.E.

In this paper the author proposed to supply what he conceived to be a want in the records of the Institution, the details of the arrangements of some of the principal metropolitan and other railway stations, particularly of a class which might be called "terminal-intermediate," as being a combination of both kinds, such as that at New-street, Birmingham, as well as of goods yards, wharves and depôts, and locomotive and carriage sheds, manufactories and workshops, which, it was to be regretted, had not been dwelt upon in the comprehensive communication "On the Arrangement and Distribution of Railway Stations," by Mr. R. J. Hood, (M. Inst. C.E.) read at the Institution in the session 1857-8, and published in the "Minutes of Proceedings of the Inst. C.E." Vol. xvii., pp. 449-481. For this purpose the plans of the following existing stations, &c., were illustrated and described, as they were believed to embody the leading principles and requirements involved in the construction of such works:—the Victoria Station, Pimlico, for the London, Chatham and Dover and the Great Western Railways, as well as that for the London, Brighton and South Coast, and the Crystal Palace lines; the Euston, Birmingham, and Stafford Stations of the London and North Western Railway; the Newton Junction Station on the South Devon Railway; the goods station at King's-cross belonging to the Great Northern Railway; the workshops at Battersea, connected with the London, Chatham and Dover Railway; and the Railway Carriage and Waggon factory of Messrs. Brown, Marshall and Co., at Birmingham.

The author considered, that at terminal, terminal-intermediate, and junction stations, the through and the local traffic should be kept distinct; that excursion traffic should not be allowed to interfere with the regular booking offices, either for through or local trains; that the platforms for the through traffic at terminal and junction stations should be at least 30 feet wide, and for the local traffic, docks, with separate lines of rails, could if desired be taken out of the extreme ends of these platforms, as at King's-cross; that the in and the out parcels offices should be at the ends of the platforms furthest from the passenger and carriage entrances, as at King's-cross and at Paddington; that the position of the left luggage and cloak rooms at Paddington had been found to be convenient; that all closets, &c., should be well ventilated, and be designed to perform the maximum of work with the minimum of water, closets being arranged to flush both on the opening and the closing of the doors, and glazed basins being preferable to slate for urinals, and that lavatories should be provided at all terminal and junction stations, as at Perth, even if a small charge were made for their use, which was not however the case in the instance cited.

He thought that the carriage running and repairing sheds should be adjacent to terminal, terminal-intermediate, and junction stations, to avoid "dead" mileage, and that the best situation was possibly between the passenger and the goods station. A siding under cover should also be provided for engines in steam, with facilities for coking and watering. The goods yard and sheds might be either attached to and form part of the passenger station, though distinct from it, or a preferable plan was to place it at a distance, inclosed within its own wall. Its position, with regard to the main line, should be such, that trains might be run direct into and out of the sheds, &c., without the trucks having to be uncoupled. There ought to be separate arrival and departure platforms, provided with appliances for the rapid loading, unloading, and sorting of goods. It was desirable that mineral and goods traffic should be kept distinct, that sorting sidings should be provided for both, the arrangements being in all cases made with a view to avoid, as far as possible, the necessity of shunting with engines. At junction and terminal-intermediate stations, there should be two through lines in the centre, over which goods and mineral traffic might be worked; and all such stations should be on a level, with short descending gradients at each end, to assist in stopping and starting the trains. At small terminal stations it was convenient to have the goods shed close to the passenger station, and parallel to the line, that the trucks might be shunted into it.

The engine and running sheds should be devised to facilitate the ready admission and exit of engines, as well as for overhauling, cleansing, and the execution of repairs. The sheds should be lofty, well-ventilated, have plenty of light, and space for the passage of men between the walls and the engines. The engine pits should be paved and well drained, and there ought to be similar pits outside the sheds for rough and dirty work. A plentiful supply of water, with a good pressure, and accessible by means of hydrants, &c., was necessary for cleansing and washing out the engine boilers when over the pits in the sheds. Lifting shears and overhead traversers were deemed to be superior to jacks, and the waste heat from the coke furnaces was useful for drying the sand to fill the boxes of the locomotives, as well as for heating the sheds during the winter months. The coke platforms and the water cranes should be at the sides of the lines into or out of the sheds, so as to be accessible without shunting.

Three classes of establishments were needed on all important lines, first, that for the construction and renewal of locomotive and carriage stock; second, the running shops, where light repairs might be executed; and third, engine and carriage sheds for receiving the stock when not in use. The principal workshops should be situated where labour and materials could be most cheaply and easily obtained; and they should be so arranged as to avoid unnecessary handling and shifting of material, the aim being to let the raw material enter at one end, pass through its various stages, from one machine to another, until it came out in a finished state at the other end.

At the Victoria Station, Pimlico, two principles were illustrated, the booking offices being parallel with the London, Chatham and Dover, and at right angles to the Brighton line. The former plan was useful for trains of great length, at distant intervals, though it became a question whether the arrival platforms did not then exceed in length the longest trains. A long departure platform admitted of a second train standing behind one about to start, but without care this was liable to lead to confusion. Where the traffic was of a mixed character, with trains in quick succession, the end booking offices seemed to be the best, provided that there was sufficient width of frontage to allow of the several booking offices being distinct, and opposite to their respective platforms. At the Euston Station, the booking offices were situated on each side of the large central hall, from which access was gained to two departure platforms, one on either side. As the trains were started indiscriminately from both, it was submitted that this plan must lead to confusion. The great length of the platforms was a good feature, but the lowness of the roof was objectionable, and the frequent supporting columns necessitated many turn-tables. The London Bridge Station of the South Eastern was cited as an illustration of the way an immense traffic had been worked in an inconvenient position and a restricted space, by combining to a certain extent the three systems of having booking offices on the departure side, at the ends of the platforms, and in a fork between the lines; which alone it was believed had rendered it possible to accommodate the numerous trains for the main line, the North Kent, the Mid Kent, and the Greenwich traffic.

The New Street Station at Birmingham was an intermediate one for the London and North-Western and the Midland railways, and a terminal one for the Stour Valley. There were two main lines through the centre of the station, and the platforms were approached by sidings, so that the through traffic need not be interrupted. The station was situated in a cutting between two tunnels, and was so close to one, that the points for parting the trains were within the mouth of the tunnel, leading frequently to delay. The roof was in one span, and a considerable height from the ground, securing ample ventilation. The Stafford Station, recently erected, was terminal for the Trent Valley and Shropshire Union trains, and intermediate for the London and North-Western. Here also there were two main centre lines, the platforms being likewise approached by sidings, while there were docks at each corner of the station for local or terminal traffic. The goods station was only a short distance from that for passengers, and there were sorting sidings for the goods, but only on one side of the line. Newton Junction on the South Devon Railway was approached by a single line at one end, and was provided with three platforms, two for the main line traffic and one for the Torquay and Dartmouth Branch. The carriage repairing shops, engine and running sheds, smithy, &c., and the goods warehouse had all been proved to be conveniently arranged.

The Goods Station of the Great Northern Railway at King's-cross comprised goods warehouses, coal depôts and wharves, potato stores, engine shed, repairing sheds, stores, stables, and all the necessary offices for conducting the large goods and mineral traffic of that line. The Midland Railway had also a goods warehouse, and a circular running shed at one side of the centre of the station. The Great Northern goods shed was nearly in the centre of the yard, and there were fourteen lines of way running into it, with a platform on each side for the reception and dispatch of goods, space being reserved outside these, but still within the building, for the vans engaged in collecting and distributing the goods. The outer lines next the platforms were used, one, on the east side, for unloading the trucks with the inward goods, and the other on the west side, for the loading of the outward goods. The inner lines nearest to these were used for the arrival goods trains, and for empty trucks and making up trains for departure. After the trucks were unloaded they were taken by means of a turn-table and through cross roads to the departure side, whence they were removed as required, were loaded and dispatched. There were great facilities for the rapid dispatch of goods, both inwards and outwards. The goods were entirely under shelter, could be unloaded, loaded, and dispatched without the use of a locomotive in shunting, except at certain seasons when the traffic was very heavy. Hydraulic power was employed for working the cranes, and at all large stations it was found to be economical in every respect. The stables were under the platforms, by which a great saving of space was effected. The granary was at the south end of the goods shed, and was approached by two lines through the centre of that shed, two other lines, one on each side of the former, being reserved for full trucks. After being unloaded the empty trucks were removed by two lines, one on each outer side of the goods shed. There was a water communication between the granary and the goods shed and the Regent's-canal, so that lighters could receive or discharge their freights direct from or into these buildings. On the west side of the goods shed were the coal depôts and staiths, and a coal and a stone dock also connected with the Regent's-canal. Adjoining there were numerous private wharves for bricks, etc. On the north were the engine, repairing, and carriage sheds. These were laid out on the radiating or fan-shaped system. There were eleven lines in the centre, at the extremity of the fan, in the repairing shed, with shops in the rear, seven lines on the south in the locomotive painting shed, and seven on the north in the carriage shops. The running shed was placed in the centre of the fan, in front of the repairing shed, with which it communicated by means of a through line, connected with the repairing shed by means of a traverser.

The locomotive workshops of the London, Chatham, and Dover Railway, at Stewart's-lane, were conveniently arranged with a view to the saving of labour, but were not so extensive as those at Crewe, Wolverton, or Doncaster. A single line of rails connected the works at the entrance with the main line, by means of points and crossings. Two parallel lines of way, running east and west, were connected with the several buildings by turn-tables. Roads for spare trucks, etc., connected with the main line, were provided with a separate entrance. Adjoining were the repairing shops and a semi-circular running shed, struck with a radius of 150 feet. Only the outside 50 feet were covered, and in this building there were twenty-one stalls for engines and tenders. The turn-table was not covered, nor the forty roads radiating from it, each of which was sufficient for an engine with its tender. It was connected with the main line by three separate lines. The disadvantage of this arrangement was that, should the turn-table get out of order, all the engines then in the shed would be penned up until the defect was remedied. At the back of the running shed was a repairing shop, with smithy, engine and boiler house, etc.

The new shops of the London and South Western at Nine Elms, and the engine sheds of the Metropolitan at Bishop's-road, were supplied with traversers worked by steam power, by which a saving of space was effected. The employment of duplicate traversers, one for each end, to prevent delay in the event of an accident, would probably be ultimately adopted. Detailed particulars were given of the Britannia Carriage Works at Birmingham, belonging to Messrs. Brown, Marshall & Co.; and it was stated that they were conveniently situated in regard to railway and canal accommodation, and to facilitate the economical and rapid manufacture of railway carriages, waggons, etc.

The relative merits of the three kinds of engine and running sheds, the rectangular, the circular, and the radial or fan-shape, were then considered. The latter system required great space, but by placing the running shed in the centre, in front of the repairing shed, the area was utilised. Another disadvantage was that all the engines must pass over one pair of points; but this was not so objectionable as the single turn-table in the centre of the shed. To guard against delays from accidents, a few engines in steam should always be kept at the terminus. The accommodation afforded by the rectangular building in the centre of the fan was equal to that provided by the circular, while the area covered by the latter was nearly one-third more. The rectangular required a greater amount of permanent way, but the building was less costly. The only advantage the semi-circular possessed over the circular shed was that a portion of the radius only was covered, whilst a greater length of extra road was required between the turn-table and the shed.

THE CONSTRUCTION OF IRON VESSELS.

By James Lyall, Jun.

It is an existing necessary evil in our modern wrought-iron structures, that plates requiring to be fastened together must be perforated, that they may be united into one complete whole; for, as a natural consequence, that part of the plate so treated must be reduced in strength in proportion to the number and size of holes perforated, whether the same be done by drilling or punching; therefore all unions made by rivetting never can be equal in structural value to the entire plate, by at least the sectional area of the holes in the line furthest from the butt or joining. This objection may, to a great extent, be got rid of by a little reflection and care in arranging the number of holes necessary, and increasing the width of the butt strip, when such can be done, and by substituting a superior quality of iron for butt strips; or by making them thicker, when the plating is of the thinner class, the strength through the line of holes next the butt may be maintained when it is necessary to pitch the holes closer, for the purpose of making the seam water-tight.

It is also essential in uniting the parts of a structure together by rivetting, that the rivets be of the requisite form and size to suit and fill the holes tightly at all parts. The best mode of accomplishing this has been the subject of much discussion among engineers. Many advocate drilled holes, some prefer reaming them out after they have been punched, while others consider punching the superior plan. The author is of opinion, where plates are regularly punched from the proper sides, so that the smaller diameter of the holes shall adjoin each other in their respective plates, no mode at present practised can surpass punching.

It must certainly be admitted that a pin or rivet in its cold state can be made to fit a parallel smooth hole better than it could a hole made by a punching machine, but the circumstances are altered when red-hot rivets are substituted, as by the aid of the hammer or rivetting machine they may, while red-hot, be forced into the inequalities of unfair and very rough holes, and I think the rough surfaces which punched holes present assist to increase the adhesion of the rivet with the plate. Moreover, so long as heated rivets are used, drilling holes would be but a useless expenditure of money, seeing that by the quickest mode of drilling a greater expense would be incurred over punching an equal number of holes having a common diameter and depth, and it has yet to be seen that the rivets would fill the holes, even when they are drilled, as the holes require to be made larger than the normal size of the rivet, to allow for its expanding when heated. So it would under the most favourable circumstances, in a parallel hole, only fill that part near to the head in course of formation. This defect would be experienced to a much greater extent when three or four thicknesses had to be rivetted together; and would apply also to punched holes, but might be obviated without incurring additional expenses further than obtaining and supporting a few more punches and dies. When it is required to rivet several thicknesses of plate together, a hole of an uniform taper may be obtained by having a separate punch for each plate; and we would then be in possession of a mode of fastening equal, if not superior, to the fairest hole which could be drilled for the reception of a rivet.

In boring through a number of plates there is the further objection that the drill produces burs on the inner surface of each plate, and if these be bolted together, in a vertical or slanting position, the borings get between the adjoining surfaces, to rid them of which it is necessary to disconnect and in some cases remove the plates after they have been drilled; and then it is not to be expected the plates will be replaced exactly in the same positions as they were when drilled. Not that it cannot be done; but it is useless to expect that this class of workmen will exercise the same care as those engaged at a finer department of engineering work.

Drilling, on the other hand, has the decided advantage of being accomplished with the minimum deterioration to the plates. This fact has been borne out "in a series of experiments made many years ago by Mr. Fairbairn; the mean tensile strength of seven specimens was reduced from 52,486 lb. per square inch before punching, to 41,590 lb. per square inch of solid iron left between the holes after punching, more than 28 per cent. of the strength of the iron being destroyed by punching, a loss distinct from that of the metal actually punched out."

The tieing and stiffening, as well as the strength of the shell, and the fastening by which it is connected together and to the framework, are all more or less subject to changes according as the vessel approaches to the form of a sphere, or assumes that of a parallelogram, or other figure bounded by straight lines, and with the relative proportions of the same, while to both should be given a greater power of resistance at those parts which are subject to greater pressure from their greater depths.

It is here, I think, a mischievous mistake is made by stopping short the bilge stringers towards the fore and after ends, where, from the forms of our wooden vessels, and especially steamers, these parts have less power to resist the heaviest lateral strains, and hence that working called "panting," experienced to a considerable extent in the "peaks" of steamers going at high velocities, on draughts ranging from 16 to 22 feet water. Although the after end may not be subject to panting from the same cause as those producing it in the "entrance," yet in screw steamers it is of great importance that the "run" be as well tied and stiffened, that it may be a check to the vibration so much felt on board many of our screw steamers, If these can be lessened by a little outlay at first, it is gain in the end, even where the comfort of passengers and the preservation of valuable cargoes are not taken into consideration, as, where there is that liability on the part of a structure to work there is, so long as it continues, a costly and irreparable evil.

Now this panting action at the ends of sharp vessels, is principally confined to that class which requires to be immersed to a considerable depth in a rising wave, before displacing a sufficient volume of water to become buoyant, and as it is this immersion with its alternate releases which greatly augments this panting action, intensified by the high speed at which the vessel is going, it is requisite that this weakness be met, and the working prevented by placing material of a suitable form, and capable of uniting and extending over that portion of the vessel subject to the action complained of. The fuller vessel, although able to carry more in the ends, has, with the increased capacity, a greater displacement and consequent buoyancy, and therefore cannot be immersed to so great a depth as her finer opponent, nor yet so frequently in a given time, her speed being less than the other; besides, the rounded form of her ends is better suited to bear a greater lateral strain with less injury to her structural properties. It might, therefore, be questioned whether, with the same or even less lateral stiffening in the ends, the fuller vessel could not perform her work through a given time with less injury than could be obtained from the finer vessel.

The strain which exposes the great weakness in long iron vessels is that to which they are subjected when accidentally caught in the middle or by the ends, with the greater part unsupported, as in the narrow part of a river or on a submerged bank or rock, or when one of the ends, for a considerable length, may be overhung in a place where there is not at all times sufficient water to float the suspended part, and prevent the strain, due to the weight of that part with the cargo it contains and its length, affecting the upper works of the vessel. These are very unfrequent occurrences, it is true, but is it not the duty of the naval constructor to provide—so far as is within his power—for such emergencies? These strains—although of a shorter duration—are the same when the vessel is "pitching" and "scending" in a heavy sea, and perhaps, for the duration of each rise and fall, are far more severe,—the strain which is produced by the weight and length of the suspended part, and the cargo it contains, being now aggravated by the velocity at which it is raised, and the sudden shocks met with in its descent.

The straining of vessels does not at all times act in a vertical direction, as in a common girder, but at an angle due to that at which the vessel may be sailing while subjected to those strains. It therefore becomes a matter of equal importance to have the sheer or mouth strake as well as the deck stringers and ties of a superior quality of material, possessing a high elastic limit, and also the best arrangement of fastening known, so as to obtain the greatest possible strength which can be had with the material disposed in this part of the structure. If it were possible to connect the butts of the outer thickness or strake without reducing that of the inside strake, such a method would most unquestionably be of the highest importance to the strength of the vessel, but as it has to be rivetted through the inside strake, which becomes the butt strip, there is a great deal of unnecessary weight carried in the upper parts of such vessels, which is really doing no good to the tensile strength of that part. An extra butt strip is sometimes put on the inside of the inside strakes at such parts, by which the rivets pass through three thicknesses, the two inner of which are but butt strips for the outside one, and gives rise to a new evil in a structure exposed to the heaviest tensile strains, as the material is now fastened to the ends of rivets of more than ordinary length for their diameter. Could not the same strength be obtained by substituting a better class of materials for the sheer strake; or by using butt strips only, but of a size sufficient to form the liners of the adjoining frames to those between which the butt is, whereby the best possible arrangements of rivets could be made, supposing the butt strips to be of a quality having a tensile strength equal to the best manufacture?

According to Mr. Fairbairn's article on the strength of iron vessels, in his valuable work, 'Useful Information for Engineers,' the upper works of our mercantile marine are very far below the requirements necessary to meet such contingencies as we have already supposed; being suspended either by the middle, the ends, or with one end overhung, and not sufficient water at all times surrounding it to prevent the upper works being strained to their ultimate destruction; and in showing how the required strength might be obtained, proposes to place longitudinal cells or box girders in the line of the upper deck beams. The impossibility of having the inside surfaces of these girders periodically ex amined and painted is a great disadvantage, and one likely to stand in the way of their ever being adopted as a means of strengthening the upper works of vessels. A modification of the same might however be adopted—if such an arrangement should be desired—consisting of longitudinal girders of the H section, of the same depth as the athwart-ship beams, the ends of which would butt against the sides of the longitudinal girders, and be rivetted thereto by longitudinal plates on the upper and under sides, of sufficient width to allow of their being securely fastened together. But it would appear in this, as in nearly all engineering matters, each constructor has his own opinion as to what is a sufficient section of iron to effectually resist the "breaking" of a ship when exposed in the manner already described.

Mr. John Vernon, in a very elaborate paper on this subject, read before the Institution of Mechanical Engineers at Liverpool in 1863, showed that the strength of an iron ship of 1200 tons, built to take the highest class obtainable, was sufficiently strong to enable her to meet any of the above emergencies without being injured. To take the same example as that adduced by Mr. Vernon; and first, let the vessel be resting by the ends, with with the middle unsupported, and the distance between the supports as given, 185 feet. The sectional area in tension, which is made up on the assumption that all the strakes of side plating are effective to resist tension "in proportion to their respective distances from the neutral axis," is "547 square inches." The weight of the ship is "758 tons," that of the cargo "1945 tons," making a total amount of "2703 tons." "The length unsupported being divided into 14 equal portions, the respective cargo capacities or loads of these are in the proportions of 11, 20, 23, 23, 22, 14 respectively, proceeding from the stern to the bow. The result obtained by taking a mean effect of these several loads at the centre of the vessel, is that the strain produced at the centre by the distributed load amounts in this case to 74 per cent. of the total load instead of 50 per cent., or one half the load as would have been the case if the distribution of the load had been uniform throughout the entire length. Hence the total distributed load carried being 1945 tons, as ascertained above, the equivalent centre load will be in this case 74 per cent. of that amount, or 1439 tons; and the additional weight of the vessel itself, 758 tons, may be considered as equivalent to a load of one half the amount, or 379 tons at the centre, making together a total load at the centre of 1819 tons, one half of which, or 909 tons, is acting at each end by tension on the lower part of the vessel, with a leverage of 92½ feet, or half the length of the unsupported portion of the vessel." Following this up, we have 909 tons, the weight acting at each end by tension into 92½ feet, the distance at which this load is supposed to act from the centre, equal to a tension of 84,082·5 tons, to resist which we have "547 square inches," at a distance of "9 feet" from the neutral axis. Now, a double rivetted joint is only equal to about 14 tons per square inch of section when the plates are of a quality capable of bearing 20 tons per square inch, and as the vessel under consideration would be double rivetted, the value of each square inch of section must be allowed to be the same as that of the double rivetted joint. We have, therefore, 547 square inches, into 14 tons, into 9 feet, equal to a resistance of 68,932 tons; but showing a deficiency of 5160·5 tons, or about 369 square inches, at the same value—14 tons per square inch—and this, after the side plating and lower hold stringers have been taken into the calculation. Mr. Vernon, however, meets this by setting down 17 *tons* per square inch of section as the tensile strength.

Let it now be supposed that the strain is thrown upon the upper works of the vessel by its being suspended at the ends and resting in the middle; using the same data as Mr. Vernon, we have the load at the end of the vessel amounting to only 44 per cent. of the total load, instead of 50 per cent., or one half as much as would have been the case if the load had been uniformly distributed through the entire length. With 45 per cent. of the whole weight carried, which is 1945 tons, we have 856 tons, in addition to which there is the whole weight of the vessel, one half of which acts in conjunction with 44 per cent. of the whole load, or 856 tons, making a total of 1235 tons, one half of which, or 617·5 tons, is acting at each end by tension upon the upper works of the vessel. Let this load be supposed to act at a distance of 92½ feet from the centre on each end, by which a strain of 57,118 tons will be produced. This, as before, is obtained by the load 617·5 tons into the distance at which it acts from the centre of the vessel to be resisted by "275 square inches"—obtained as before in the bottom part into 16¼ feet—the distance from the neutral axis, which, taken as before at 14 tons per square inch for double rivetting, gives 275 × 14 × 16¼, equal to about 62,562 tons, showing 5444 tons above what is required for such an emergency; but this 275 square inches of section includes the side plates from the neutral axis, as well as the stringers, ties, and angles of both decks, and the sheer strakes. Where the centre of strain is not the centre of gravity of the material intended to resist that strain, the latter never can impart its full value to the structure of which it forms a part. Hence it will be objectionable to include the vertical plates on the side of a vessel below a given depth under the main or other deck under which the principal fastening is, and above a given height over the keel in vessels of ordinary dimensions.

Mr. Vernon has, however, made allowance for the above defect, by reducing the value or number of square inches in every strake in proportion to its relative distance from the neutral axis. When the way in which the upper works and bottoms of vessels are affected when under strain is considered with the elastic limits of wrought-iron, and that in "ship plates," this property is very limited, it may be questioned whether any of the plating under the sheer strake and that adjoining it can be said to unite with the stringers and the plates in ressiting any strain to which they may be subjected before these have been strained beyond their elastic limits, even when the strain is transmitted in an oblique direction; and in view of the limited extent of this latter property, the author does not think it admissable to estimate a number of vertical strakes on different planes, as if they were laid in horizontal layers, or of a shelved construction, the position most efficacious to resist tension, as is done by taking the centre of gravity of each strake, and considering the whole area of the same to act at their respective distances from the neutral axis. If it were not for this and the defective mode of arrangement, how is it that so many fine vessels have been torn asunder when so exposed? Is it to be wondered at, after such calculations have been made, in which the highest credit is given to the material, in the manufacturing, as well as uniting of which together, so many hidden flaws are never detected. This *practical test* should show that, instead of a sufficient or surplus strength, there has been a very great deficiency.

A structure subjected to continued applications of a load exceeding one-third of its breaking weight will ultimately fail if these are very numerous. It is not difficult therefore to see that a vessel which has been at work for some years may be impaired in strength by the strains it has undergoneduring that time; and that in its being exposed to a strain of longer duration, in the way which we have already supposed, the breaking of the vessel is but the completion of a work which for some time has been in progress. A vessel at sea is never exposed to strains produced by the same length of overhang as that at which the foregoing calculations are made, but here the strain is a gradual one, whereas that when the vessel is pitching it is greatly augmented by the velocity of each rise, to an extent which will make it very severe on the parts in tension, supposing the suspended part be very much shorter.

As the value of any tie is proportional to the sectional area of the rivets uniting it to the parts tied by it, it would appear unnecessary to tie the deck or any other part of a vessel by lengths of iron placed at any other angle than a right angle to the beams, or parallel to the length of the vessel. If the sectional area of the rivets by which the ties or bracing are united to the beams are equal, and extend over a certain part of their length, might not, therefore, the material used as diagonals be annexed to the present tie plates, and united with them in overcoming any tensional strain to which the upper works may be exposed, and at the same time overcome the zigzag action imputed to iron vessels? If this view be a correct one its adoption would give more satisfactory results, with less cost than can be obtained by the present use of diagonals.

In the former days of wood shipbuilding, a rise was given to the ends of the vessel to hide any appearance of "hogging." This sheering of the decks and bulwarks of a vessel in no way increased her strength as a whole; but, on the contrary, weakened that part which was shallowest, although it gave the appearance which was sought. In iron vessels this practice has been very considerably lessened by a few constructors; and, so far as the strength of the vessel is concerned, it is perhaps to be regretted that these are but a few; for as long as the practice of sheering the upper decks, on which the principal fastening is arranged, is followed up, this fastening will be defective in imparting its full value as longitudinal ties, and even the stringers will be similarly influenced to prevent them acting in perfect unison with the sheer strakes when these are subjected to tensional strains, as before the ties can come into tension at the lowest part of the sheer they must be in the same plane; while the sheer strakes, which are prevented the same liberty of action by the rigidity of the deck beams, are resisting the strain by which they may be stretched to destruction before the deck ties exert anything like their full power. And if the vessel be strained in the reverse way, by being suspended from each end, the deck will be subjected to compression; but instead of the area it contains being usefully employed in assisting the bottom of the vessel—now under tension—it only increases it by the strain from the middle of the deck being transmitted through the hold stanchions—the results of the downward inclination at that part of the deck given by sheering. There are certain advantages obtained from giving sheer to a vessel, such as improving her appearance when it has been properly carried out, and adding a degree of comfort when at sea; but could not this be accomplished by sheering the upper works only, excepting the deck, which might be made straight from the stem to the sterm. By this mode, not only the united action of all the material intended to resist the strains to which it is subjected would be insured, but with it a greater concentration of the weight over the most buoyant part of the vessel, by lessening the carrying capacity of the ends, and curtailing the lengths of poops and forecastles, which by the proposed mode would be more lofty and better ventilated; besides affording, in many cases, as much passenger accommodation as the present mode. It would also give greater facilities in constructing the vessels, as in laying down the same but one line and weight would be required to mark the beams firm, besides preventing mistakes, resulting in irregularities in the sheer lines of the beams, and thereby producing a superior class of work.

THE ARCHITECTURAL ASSOCIATION.

(Meeting held 16th February, 1866.)

The regular fortnightly meeting of this Association was held on the 16th ult.; R W. Edis, President, in the chair. The following were elected members of the Association:—Messrs. Charles J. Jones, Robert Stephenson, and Robert Brass. Mr. Farthing, of 9, Conduit Street, was appointed to the Registrarship, rendered vacant by the decease of Mr. Moody. Mr. Lyon then read the following paper.

ON POINTS OF ESSENTIAL DIFFERENCE BETWEEN CREATIVE AND IMITATIVE ART.

By J. T. Lyon.

Of those arts which minister to the delight of the eye, architecture is generally acknowledged to be the first, because all the other arts contribute to its development and beauty.

The arts of construction, decoration, and ornamentation, may be called the three grand divisions of architectural art. It is unnecessary to consider what is meant by Construction, but there seems to exist a confusion of ideas regarding the terms decoration and ornamentation, indeed, these words are in general used synonymously, and yet a real and important difference exists between them, the recognition of which will lead to a clearer understanding of my subject The word "Decoration" is derived from the latin *decor*, which means "anything that is seemly or becoming," and the word "Ornamentation" from *ornamentum*, meaning "that which serves to adorn," or "that with which any person is clothed in a superior manner." The first of these words then, would imply something which is beautiful in itself; the second, a beauty added on the surface, to make the thing itself more beautiful.

Suppose we take three rough stones of rectangular shape, and place two of them in an upright position, and lay the third horizontally upon the top of these, so as to form a lintel, we are simply constructing; if we cut these stones square or round, or in any way try to beautify their form, we are decorating; and if we clothe or dress these stones by cutting or painting beautiful forms upon their surface, we are ornamenting. As the art of construction can never be called a fine art, it will not be considered in this paper.

There are three ways of decorating, and three ways of ornamenting, viz., by simply creating, by creating and imitating together, and by simply imitating. When we are beautifying the column of a building, as by rounding, squaring, or fluting it, we are decorating by simply creating, because we may safely argue that such rigidly mathematical forms as these are so rarely seen in nature, that it would be affectation to say we were copying nature when making use of them; and when we beautify the column, so as to make it evident that an object in nature (as the human figure for instance) has been our type for its decoration, we are decorating by partly creating and partly imitating; and when we make an exact resemblance to such a figure, so as to lose all idea of a column, we are decorating by simply imitating.

In a similar manner, when we are beautifying a surface by cutting or painting geometrical figures upon it, we are ornamenting by simply creating; when we cut or paint forms upon the surface which have been merely suggested by natural objects, we are ornamenting by both creating and imitating; and when we carve or paint these forms exactly as we see them in nature, we are ornamenting by simply imitating.

It is perhaps necessary before proceeding further to offer some explanation of my meaning of the term "Creative Art."

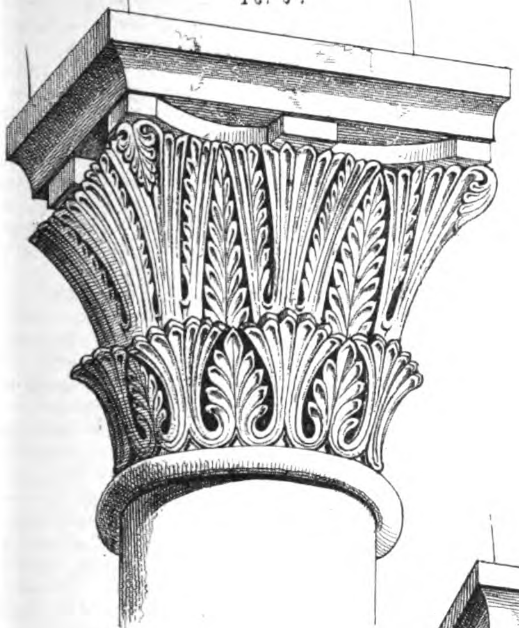
We may say, according to the abstract meaning of the word "create," that it is impossible for man to create anything, as much as it is impossible for him to destroy anything; but the word is a convenient one to express that originality of thought and formation which to the mind and eye are certainly original. The most common acceptation of the term "creative art" implies that degree of sentiment, idea, or as Shakspeare expresses it, "creation of the mind," which a pictorial artist throws into his picture. This, without doubt, is the very highest signification of the term, so high that, as Mr. Ruskin has well shown, the actual formation of the object upon the canvas is quite secondary to the idea which is conveyed by the object.

The sense in which I employ the term is of a much lower nature, because it has everything to do with the actual formation of the object, and nothing with this high ideality. I wish it to be considered in the light of Creative art as opposed to Imitative, as that art which is not a direct copy of anything in nature, or of anything which might be supposed to exist in nature.

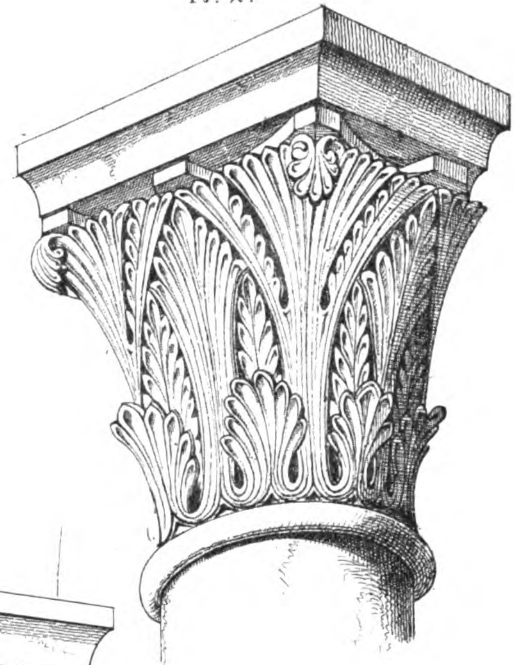
When man is about to create an object by the simple invention of his own mind, he ought to attend to the first law which we find in the works of the great Creator Himself, viz. order. It is not necessary to dwell upon the fact, that the whole of living nature is based upon an orderly system, although it would seem to be the will of the Creator that the law should be a hidden one to the superficial observer. Such an object as a large full-grown tree, for instance, never conveys to our minds an idea of perfect order, and yet all botanists will tell us that the root, trunk, and branches of a tree are but a constant repetition of the small mathematically formed plant in the seed from which it sprung, and that as this mathematical plant grows it becomes distorted and irregular, merely through accidents, as in blights, cold winds, and frosts. Man and the lower animals are made with this perfect balance of parts, but, on account of their ever-varying movements, the idea of uniformity becomes to a great degree lost. It is also remarkable, how much order has to do with our whole well-being. Success in life depends in a great measure upon orderly habits and conduct.

I will take this opportunity of quoting a passage from a book entitled 'Recreations of a Country Parson,' to show that even in the very smallest things we should pay due attention to order. The chapter is "concerning tidiness." "Order," says the writer, "is Heaven's first law, and there is a sensible pleasure attending the carrying of it out faithfully to the very smallest things. Tidiness is nothing else than the carrying into the hundreds of

No. 1.



No. 2.



No. 3.

Nos. 1. 2 & 3. From the Nave of the Cathedral at Angoulême.

Nos. 4 & 5. From the Church of S. Front Peregieux.

No. 4.

No. 5.

W. J. Wilcox, del.

J. R. Jobbins

little matters which meet us and touch us hour by hour, the same grand principle which directs the sublimest magnitudes and affairs of the universe." The writer goes on to show how a love for order is inherent in every good mind. I have said this much concerning order, because it would seem to be a law, that every art-object which man constructs or creates by the simple working of his own mind, from the most sublime architectural edifice, down to the most insignificant child's toy, ought to be made with due regard to order.

This order, then, is the first essential of pure creative art. In pure imitative art the case is reversed. We then copy nature as she naturally appears to us, and as we have seen that she naturally appears disorderly, disorder is the essence of imitative art. Even the term picturesque, as applied to the imitation of nature, means that amount of "admired disorder" which is the great charm of a picture. We have then one point of essential difference between creative and imitative art: the former is symmetrical and orderly; the latter unsymmetrical and disorderly.

Doubtless there is such a thing as a creative picture, the most common example of which is seen in what we term the Willow Pattern plate, and we may say that there is not much order in this piece of creative art; and on the other hand we may imitate in a picture a mathematically formed object, and say that there is no disorder in the composition; but I am here talking of the difference between pure creative, and pure imitative art, in the former, the simple invention of the mind without imitating the works of God; and in the latter, the simple imitation of a natural object without copying the works of man.

I have observed that a principle of order should always accompany our constructed works of art. We see this principle carried out every day in our best architectural buildings, in the fluted column, the moulded pillar, in the graceful leaves of the Corinthian capital springing from their parent trunk with mathematical accuracy, and even the naturally carved foliage of the Gothic capital, however wayward and fanciful, is bound, in good architecture, to some defined and well-ordered line of beauty, so are the bases, the arches, the buttresses, and pinnacles. This orderly outline of objects is a principle which has been carried out in the best constructive works of all ages; not only in architectural buildings, but in small household objects. A Greek artist, for instance, never allowed the carving on the side of his vase to project beyond the general form of the vase, because the carving would then have taken away from that orderly, graceful outline which was the first essential to its beauty. The large building and the small vase are alike in this particular, that they are both to be seen on all sides, and it would seem to be a law in art, that any object which is intended to be seen from all sides, should from all sides present to our view a regular, graceful outline. If we carve a member of the building, as a column, in direct imitation of a natural object, this regularity of outline from different points of view will be lost, and this imitation would seem to be specially objectionable when the object is placed on the top of a build ng so as to stand out in relief against the sky, because the irregularity of the outline is then most apparent.

I think that this leads to a question of much interest and importance at the present day, when it is so much the custom to perpetuate the memory of our great departed by imitative sculptures, viz., how far we are justified in placing these figures in some central position by themselves, where they can be seen from all sides. The idea probably is, that they are more dignified when isolated from all surrounding objects, than when set in a niche, and contributing to the beauty of a building. But if these figures had structures specially erected to their individual honour, would they not rather gain than lose in dignity; and whether in the distance, in the twilight, or under the canopy of a mist, the beautiful outline of the structure would always be maintained, instead of the figure alone, presenting under such circumstances an irregular and frequently meaningless mass.

This leads me to depart from the subject for a moment, to make a suggestion with regard to erecting small structures as memorials of the great. Would the plan not be a good one, to erect a structure containing several niches, to be specially devoted to the memory of one particular class of men, as great statesmen; another to be specially devoted to the memory of great soldiers, &c.

Besides, it seems to have been a recognised rule in what is generally allowed to be the best periods of architectural art in the world's history, that all imitative works should have a distinct enclosure or frame of their own, but that all creative works should stand by themselves. For this reason all naturally carved figures in Classic architecture are enclosed in panels, and in Gothic architecture in niches; the niche is the house to the figure, and the figure the tenant to the niche, and they are necessary to each other. All the members of the building, on the contrary, which were never rendered directly imitative, could well stand alone; and this truth is strangely manifest when we behold, as in the ruins of a Greek temple, a band of isolated columns remaining after the shell of the edifice has broken down, appearing, though sadly in want of the work they were created to do, quite capable of maintaining their own ground, and fighting their own battle with the stormy elements around.

I think then we have arrived at another point of essential difference between creative and imitative art: the former may stand alone, the latter requires protection.

Now what is true of creative and imitative art as wrought by the chisel, is equally true as they are worked out by the pencil or the brush. We may say that a column of a simple geometrical section, as a round or square, is the lowest degree of creative art; it is the case also if we draw these geometrical figures upon a flat surface. We may also say that in sculpture the mere servile imitation of natural objects is the lowest degree of imitative art; this is also the case if we imitate these objects upon a flat surface.

There can be no doubt that the reason why geometrical figures are the lowest forms of creative art, is on account of their extreme simplicity; and I think that no artist can help feeling this,—that the more the geometrically-formed column, and the geometrically-drawn pattern on the wall, lose their rigidity, and become graceful and flowing, like nature herself, always maintaining that rigidity and regularity of outline essential to pure creative art, the higher does the art rise. And is it not true that the Classic column with its plain circular section, and the Gothic pillar with its rigidly perpendicular lines, that these are beautifully relieved, the former longitudinally by its graceful bend, the latter transversely by its exquisite flow of mouldings. We may therefore say, that the more flowing or imitative of nature creative art becomes, the higher does that art rise.

The reason why the close imitation of natural objects is the lowest degree of imitative art, is not so much on account of its simplicity (for the exact imitation of a natural object may be a matter of considerable difficulty), but on account of its approaching so nearly to the work of the Creator Himself, that it is sometimes mistaken for that work, and when the mistake is discovered, the object remains more as a caricature of nature wrought by the hand of man, than as an intelligent copy of nature rendered through the mind of man.

In order to be convinced of the truth, that we sometimes mistake the close imitation of nature for a reality, we have only to enter our well-known London exhibition of waxwork, where I believe not a day passes by that persons are not painfully startled by the life-like appearance of the figures they are beholding. It is true that most of these persons think they are looking at magnificent works of art, and that the painful start occasioned by this life-like appearance is just the proof of it. It only shows how little people in general know what is meant by good and bad art, and how necessary it is for us to try by every means in our power to point out the difference. Without doubt the best reason we can give for such art being wrong is, that it is deceptive art, and nothing which deceives can possibly be right.

Perhaps another reason why the mind is not satisfied by the too close adherence in art to a living object, is that the more nearly the art approaches God's work, the more do we feel in it the want of God's life. The only life an artist can throw into his figure is the life of his own mind, and the more he does that the less directly imitative of nature will his art become.

The close or servile imitation of an object in painting is also the lowest degree of that branch of art. I had occasion to quote an observation of Mr. Ruskin, that the more idea an artist threw into his picture, the less he considered the form of the object which conveyed the idea; but Mr. Ruskin goes further than this, and shows that the too correct drawing of the object takes away from the force of the idea which it conveys; in short the artist in such a case is not so particular about his perspective and his light and shade, and draws the object in a creative manner, so that we see the creative spirit has a great deal in common with the creative manipulation.* We may therefore

* Since writing the above I happened to meet with a passage in the 'Temple Bar Magazine' for this month, in an article upon the genius of Gustave Doré, which exactly expresses my present meaning. It runs thus, "the artist's great knowledge,

say that, as imitative art ascends, it becomes more like the creative; and we saw before that as creative art ascended it became more like the imitative. These arts then are as two low extremes, which, in ascending, partially combine, but which, according to the very nature of things, never wholly combine.

It is their wise combination which leads to the highest degree of perfection, and it is their unwise confusion which tends, in decorative art, to ugliness; and in painted ornamental art to that which is much worse, deception.

Let us consider what is meant by their "unwise confusion." I have already observed, when referring to decorative art, how any irregular and disorderly outline of an object tends to ugliness, as in a naturally sculptured figure forming part of the general outline of a building. The naturally sculptured figure is essentially imitative art, and the building is essentially creative art, and yet they are made to form part and parcel of one thing, so that I think the two arts are thus unwisely confused. They would be wisely combined if the imitative were kept in its natural frame, and the creative allowed to maintain its regular and graceful outline. Happily, however, it is the rule to find this principle maintained in our buildings; but it is unhappily common to find it neglected in our articles of furniture, and still more so in our small art-objects.*

This then is my meaning of the confusion of creative and imitative art in decoration. The result is ugliness to the eye, causing dissatisfaction to the mind. In painted ornamental art, as I have said, the case becomes much worse, because such confusion actually tends to deceive. We have seen that ornamental art means the beautifying of a surface; which may be done by sculpturing a natural figure and placing it in a niche cut in the surface, or by painting a natural object and placing it in a frame.

As the natural piece of sclpture has already been considered under the head of decorative art; we will now consider what is meant by the confusion of creative and imitative art when applied to the beautifying of a surface by drawing or painting.

What do we mean by the imitation of an object upon a flat surface; in other words, what do we mean by a picture? You may think that this is reducing our subject to rather an absurd degree of simplicity, for you may very naturally imagine that every child knows, in our picture-painting age, what a picture is. However, it is necessary to our argument to have the picture briefly defined.

I have heard it said that we represent nature in a picture as if we were holding up a sheet of transparent glass before our eyes, and copying the objects upon that glass as we see them. This is quite true, but there is one thing to be observed in holding up that sheet of glass,—it must not be too large; we should be able to see the whole picture before us without moving the body, or even the head; and there is only one point of view from which we should take in the whole with ease. We must therefore be able to see the edge of the glass, or, in other words, the line by which the picture is bound; and when we have painted the picture, and placed it on a wall, this boundary line is generally made to separate it still more from surrounding objects by a margin of some breadth. This boundary line then is one essential characteristic of a picture. (It may here be observed that there are two kinds of boundary lines to a picture, one which marks it off suddenly from surrounding space, and that which marks it off gradually, as in what are called "viguette pictures.") Another characteristic of the picture is, that, on account of its perspective, and its light and shade, every needle's point of the surface painted upon becomes lost to the eye, with regard to the surface; in other words, the surface itself is never considered. This boundary line then, and this losing of the surface, are sufficient guides for our determining what is meant by an ordinary picture, or a piece of imitative art upon a surface.

The beautifying of a surface in creative art is simply the reverse of this. There is no need for such a boundary line, because the object itself may stand alone, just as we saw the creatively sculptured figures might stand alone; and, unlike the picture, every needle's point on the surface of the object is maintained to the eye, and not lost.

It is so easy to roughly imitate a piece of nature upon a flat surface, and to forget the great primary object in making the imitation, that the confusion of creative and imitative art in drawing or painting seems to be one of the great stumbling-blocks to art-progression at the present day.

If we imitate any object whatever by attending to some of the essential conditions of imitative art, and neglect others, then we are confusing creative and imitative art. If, for instance, we imitate a vase by putting it into perspective, and directly copy it in all its light and shade, and then leave it standing on the surface by itself, and neglect to fulfil that other condition of imitative art by surrounding it with some boundary line and by filling in some background, which the glass if held up to nature would show us, then we are confusing creative and imitative art.

This vase pretends to be creative art because it stands by itself, and has no boundary line; and it pretends to be imitative art, because it is drawn in perspective, and in light and shade; so that it becomes to the eye a confused art, and I am persuaded, however well the object may be drawn or painted, that the eye can never be really satisfied in beholding it. Besides, as I have observed, such art tends to deceive, because the object drawn in this fashion, if well drawn, will appear to stand out to such a degree from the surface of the wall, as to make us believe that we are looking at a real object, and not at a painting.*

It may be said that the beautifying of a letter over a street doorway is a matter of small consequence, and not worthy our attention. But the truth is, that the very commonness of the art raises it to one of great importance. I have heard it said, when speaking of its importance,—"Well, but what does it matter? People like the letters which you say are bad; and, at any rate, they can do no harm."

But I am of opinion that people do not like this false art, and that it does do harm. I believe that a very large majority of people at the present day do really not know what they like in matters of art, simply because their minds have not been educated to understand the difference between good art and bad; and surely, if people are the better for good art (which I suppose will be allowed) they must be the worse for bad. We may say (according to the words of a writer before alluded to), "though the wrong may not be grave enough to be indicated by a power so solemn as conscience; still, constant wrong-doing, in however slight a degree, cannot be without a jar of the entire moral nature."

But, unfortunately for art, our so-called people in general, together with those artists who pander to their tastes, are the rulers of art at the present day; and if what I have been saying with regard to this painted vase be true, then nine-tenths of the arts as practised around us are wrong.

Then we must condemn all our highly naturalistic wall-papers, and carpets, our illustrated books and art-papers without number, wherever any art is attempted beyond the simple picture; nearly the whole French school of ornamentation, and a large portion of the English founded upon the French model; the well-known Arabesques of Raphael, because in them we have constant repetitions of the false principle of this painted vase, &c.

I am quite willing to admit that there is a fascinating kind of beauty in such works as these, which would probably in most cases be lost if they were done rigidly true to principle; still the fact remains, that what beauty they do possess is founded on falsity, and we may be sure that the mind can never be truly satisfied where truth itself is absent.

But there would seem to be a struggle now beginning in the art-world around us, between a quiet, good, unpretentious beauty, combined with true principle, on the one hand; and a loud, staring, though fascinating beauty, combined with false principle, on the other. It is of course unnatural that truth and beauty should be at variance, and if this struggle be manfully fought, aided by the people themselves for whom the fight is carried on, the combination of true principle with perfect beauty must triumph in the end.

Again, as the imitative or round-wall painting is only intended to be seen from one point of view; so the creative or flat-wall painting may be seen to advantage from any point of view.

his many technical excellences, the bold and original methods which he has introduced into his art, the invention which characterises his work, and sets the stamp of genius upon it, as contradistinguished from the elaborate accuracy which is merely careful copyism; even his faults, his shortcomings in perspective, his disregard of geology, and his wilfully careless drawing, afford matter for criticism of the closest kind."

* Illustrations were here referred to, showing that the most costly and elaborate vases were frequently overladen with figures and ornament on the exterior, so as to hide almost entirely, the general outline of the object. These were compared with the drawing of a richly ornamented Chinese vase, the general outline of which was beautifully maintained.

* One of the ordinary block-printed vases for paper-hangings, was here referred to as an illustration; and also one of the ordinary painted block letters so common over shop fronts; other ornaments of a similar nature were also illustrated.

That which causes this flat painting to be seen from many points is because it is drawn from many points; and it never appears distorted, because it is drawn distorted.

Most persons of our day who think at all upon art-matters seem to have an idea that the correct drawing of an object in nature means the drawing in perspective from one point of view, and in light and shade; and think that they live in remarkably clever times because we are so well acquainted with such rules. But these persons forget that man is a locomotive animal, and may see an object from many different points of view; so why should he not, if possible, represent nature in his drawing in all these different views at once? He will make a much more complete work of art, than by giving us his view as seen from one point.

But it may be said, "There is always perspective, and light and shade in nature; so to have, correct drawing, we must have these." It is true that we must have this correct drawing if our object be to add beauty to a surface by imitative art, but if it be to beautify the surface itself by creative art, then we must dispense with the one point of view, with perspective, and with light and shade, and draw nature absolutely distorted.

I have often wondered why our writers on art have never made use of this word "distorted," when referring to flat painting; indeed, just where the word ought to have been employed, I have found it most carefully avoided. Yet, why should we be afraid of using this word, if it be the true word? There is nothing flat in nature, and so if we are to paint flat we must distort nature; and this distorting of nature must be a good thing if it prevent nature from being distorted to our eye.

The Japanese are perhaps the greatest creative artists of the present day, because in their creative art they approach as nearly to the directly imitative as it is possible to do.* With reference to the drawing of the Greeks we may quote the words of Mr. Ruskin, and say "It is in harmony with all true rules, and involves thousands too delicate for ear, or eye, or thought to trace;" but let us remember, that however high may be the flight of genius in either creative or imitative art, the two arts must always remain quite distinct from each other. As we have seen, any object whatever must be beautified either in its form or on its surface, and this can only be done by imitative art on the one hand, or by creative art on the other; and just as we may say that literature generally is divided into the historical and the novel, and that, however like a novel the history may be written, or to whatever extent the novel may be founded on historical incidents, the one book remains as a work of fact, the other as a work of fiction; so we may say that art generally is divided into the imitative and the creative, and to whatever degree these may approach each other, the eye should always be able to tell at a glance for which a work is intended, otherwise there is confusion.

I will now show what is meant by light and shade, as opposed to what is sometimes termed light and dark. When we draw any round object in nature by imitating, we must show high lights, half tints, deep shades, and reflected lights; but when we draw a flat object in a creative manner, this light and shade is altogether out of place, and we have as an admirable substitute, what we may call light and dark.†

Let us now enumerate the chief points of essential difference between creative and imitative art, as they are rendered by painting on a surface.

1. In imitative art a boundary line is essential. In creative art it is not essential.

2. In imitative art there is perspective, and light and shade, so that every point on the surface is lost to the eye with regard to the surface. In creative art there is no perspective, and no light and shade, so that every point on the surface is maintained to the eye.

* A drawing of a Japanese flying stork was here exhibited as an illustration. The head, neck, and breast of the animal were in a direct side view, the tail portion was as if looking directly down upon it, the nearest wing was raised high up and suddenly folded over at the top, the furthest wing was not behind this, but drawn out far beyond the head of the bird, and one leg was raised high above the other; so that the bird was drawn in a most distorted manner. The drawing was wrong as a piece of imitative art, but correct as a piece of creative, because it was drawn primarily with the object of ornamenting the flat surface, and while doing this the artist took the opportunity of exhibiting the animal to the greatest advantage, the result being that we have a more complete representation of the animal than any directly imitative drawing could give. Drawings of Egyptian and Grecian birds and figures were also exhibited, illustrating the same principles. The Egyptian drawing was so rigidly true to principle, that the beautiful grace of nature was very much lost; but the Greek drawing exhibited a most wonderful combination of those two things.

† The treatment of light and shade in creative art was illustrated by a large illuminated letter of the thirteenth century.

3. In imitative art the object being copied from one point only, admits of our seeing it only from that point. In creative art, the object being copied from different points admits of our seeing it from several points at once.

4. In imitative art we never distort nature. In creative art we must distort nature.

It is to be regretted that creative art is not more commonly studied among us, indeed, as regards the drawing of life in nature, it would seem to be an art which is now almost wholly neglected; and yet, if what I have been advancing be true, it has some striking advantages over imitative art.

There can be no doubt that if we choose to beautify the surface of our walls by imitative art instead of creative, it is quite legitimate to do so; but there is one kind of surface to which I would here refer, where the direct imitation of nature never can be legitimate. I mean the surface of glass; and as I make glass painting my occupation and study, I cannot refrain from giving my notions of the principles of that art. If it were possible to produce a picture upon glass, there could be no reason why we should not have window paintings as well as wall paintings, but I hold that true picture painting upon glass is an impossibility, and for that reason should not be attempted.

The best reason we can offer for its being wrong to attempt pictures upon glass is this. We saw before, that one essential characteristic of a picture was that every needle's point upon the surface became lost to the eye in regard to the surface. But when we are looking upon a translucent medium, as glass, where light will shine through different portions of the picture, and reveal to our senses that we are really looking upon glass, then this losing of the surface painted upon never can take place, and the absurdity of attempting the pictorial style is evident. This so-called picture-painting on glass is besides another instance of the confusion of creative and imitative art, and how such confusion leads to deception. The lead lines which separate the different pieces of glass in a window are by the pictorial artist as much as possible hidden to the eye. His endeavour is to deceive us into the idea that we are not looking upon a piece of mosaic of colours of necessity divided by black lines. The creative artist, on the contrary, is true to the nature of the material upon which he is working, and, by taking every possible advantage of these necessary lines, makes the subject tell a thousand-fold better than when they are purposely concealed. These remarks will also apply to the right mode of treatment in the mosaic inlay of glass enamels. We have certainly not a translucent medium here to reveal the surface; but we have lines of cement, which separate the different pieces of enamel, so that the idea of a flat surface is always maintained, and to attempt a picture, with its perspective, and light and shade, is for that reason absurd. But the advocate of this pictorial style might say, that the fact of our never believing that we are beholding a picture, is an argument for our painting in the pictorial style if we choose. To this we may reply, that it is true there is no chance of our being deceived into the idea of a picture, but why then make the attempt to deceive us? It is really much more absurd to attempt impossibilities like this than to attempt, as in the case of the painted vase, a piece of deception which is very likely to succeed.

But the pictorial painter upon glass, or he of the vase, may say that he does not mean to deceive. The answer to this is, that it is nothing what he may mean or may not mean, so long as his art conveys to our minds an idea that he does mean it.

Then, as a general result of such argument, comes the most fallacious of statements, "Well, but what is the use of reasoning upon principles in art: tastes will differ, and we must study to please the tastes of our customers." "So we should if we were butchers or bakers, and our customers had peculiar tastes of their own, though even then we might venture to suggest that certain of our articles of consumption were more palatable and better for digestion than others, without perhaps giving offence to anyone; and if a baker might do this with impunity in a matter concerning the well-being of the stomach, how much more should an artist in that which has so much to do with the good condition of the mind. And indeed, there is a strange affinity between the taste of the palate and that of the mind. There is nothing particularly delicious or tempting in our ordinary diet; it is the extraordinary dishes which take the fancy, and work the harm; so there is nothing particularly fascinating about simple, truthful art, it is the great gaudy things which attract the eye, and hurt the soul. But all sensible people adhere to good, simple food, because they know that that is best for them; and all wise artists practise that good truthful art which they know is best fitted for the minds of those who are to see and ponder.

Taste and knowledge, then, go hand in hand; and Burke, in his 'Essay on the Sublime and Beautiful,' has forcibly pointed this out. He writes,—"It is known that the taste (whatever it is) is improved exactly as we improve our judgment, by extending our knowledge, by a steady attention to our object, and by frequent exercise."

If taste, then, depend upon a knowledge of the subject upon which the taste is to be exercised, and if this knowledge be similar in different individuals, taste must be similar in different individuals. And this is a truth to which all our great writers upon art have pointed,—that our tastes are in reality similar, and that there is a standard of perfection, for which we should all strive.

It may be asked why it is there is so much bad taste in art at the present day, notwithstanding our advancement in general education and knowledge? But it is not the want of general knowledge, but the want of the particular art-knowledge which is at fault; and we always find that our men of greatest taste are those who have devoted most study to discover the principles which should guide their taste. The vulgar argument then, that we may do what we choose in matters of art, because tastes differ, falls to the ground. Much more might be said on the subject of this paper, but it is already extended beyond its proper limits.

We have indeed a great consolation in reasoning upon any subject, that if simple facts are laid before us as a basis for argument, and if we do argue unbiassed by prejudice, or uninfluenced by any outward circumstances we may be sure that we shall ultimately agree as to what is meant by these, to us, most important words, "Truth in Art."

Mr. Lewis said that, though he agreed with the greater part of Mr. Lyon's paper, he could not accept one principle laid down in it, viz. that bad drawing was an essential point in creative art.

Mr. Ridge observed, that it was not bad drawing that Mr. Lyon contended for, but drawing suitable to the position for which it was intended. Referring to a Japanese drawing of a stork which Mr. Lyon exhibited, Mr. Ridge allowed it was not strictly true to nature; it however was not intended for a picture, but for a decoration, and as such he considered it excellent. He allowed it was not the kind of drawing with which a work on natural history should be illustrated. The principles advocated in the paper had, in the present day, a great advantage in contending with those of an opposite character, inasmuch as these latter had ceased to produce works like Raphael's Arabesques, and were reduced to such things as shaded letters over shop-fronts. In this matter the great thing was to discriminate whether we had to produce a picture or a piece of decoration. Simple and chaste decoration, such as the principles laid down on creative art might lead the architect to adopt, was often more useful than decoration of a more ornate character; as the architect wanted that which would be most suitable for the position he desired to decorate, not that which made the greatest show. Mr. Ridge considered the statues of the Metropolis confirmed Mr. Lyon's views, as their appearance was most uncomfortable, and those of bronze were particularly objectionable; he concluded by moving a vote of thanks to Mr. Lyon.

Mr. Gilbert Redgrave thought that Mr. Lyon had, to a certain extent, been misunderstood, for he considered that his remarks only referred to the creative and imitative parts of decorative, and not of pictorial art. With respect to decoration, he considered that any ornament applied to a flat surface which, by shading or otherwise, indicated relief, was wrong. In wall-decoration the employment of forms suggesting relief might perhaps be permitted, but anything of the sort in carpets or pavements was most disagreeable. He had frequently seen encaustic tile floors so arranged as to colour and shape, that they gave one the idea of a group of pyramids. He could not agree with Mr. Lyon as to the art value of the specimens before them, of Egyptian, Greek, and Japanese creative art; he attributed the falseness of their drawing to their ignorance of perspective, and alluded to an Egyptian figure before them, as showing the full front and side view at the same time: an utter impossibility in nature, and therefore no theme either for the artist or the decorator.

Mr. Lyon, in answer to an enquiry, said he thought it was allowable in stained glass to have light and dark, but no light and shade, and no perspective.

The President said that, glad as he had been to listen to the paper, and to the debate which had followed, he had not been able to agree with all that had been advanced. He should be sorry if artists of the present day had to take Egyptian or Japanese drawings as models, and with all due deference he must beg to differ from Mr. Lyon. The beauty of all art, whether creative or imitative, lay in its being as near truth as possible. The man who designs a work of creative art must have the love of truth in his soul, and must have nature always before him, guiding him in the laws of his art. The Assyrian and Japanese drawings which Mr. Lyon had eulogised so much, although marvellous in their drawing, were false to nature, and therefore he did not think the style worthy of imitation. He remembered seeing some decorative figure drawing of the fourteenth century, upon some armoires at Noyon and Bayeux, which, although painted only in flat, was free from the falsity and distortion which characterised the Egyptian and Japanese style; there was no attempt in them to give flat and round drawing at the same time. His (the president's) own opinion was, that all art which tended to distort figures for any purpose whatever, was utterly wrong; and he thought that, although much of the distortion might be taken away by cleverness of drawing, as exemplified in the drawings referred to, yet it was always more or less apparent, but although differing with Mr. Lyon, he had derived much pleasure in listening to his erudite paper.

The vote of thanks was carried, and Mr. Lyon replied.

Christian Architecture in the East.—In our report of the discussion on the above paper, which appeared, at page 50 of the last number of this Journal, an error appears which we regret. Mr. Edis, the President, was made to say, that "He did not think that churches ought to be built, in the nineteenth century, with a grand nave, long aisles, and long façades;" whereas what was said by Mr. Edis was, that he thought in many respects, particularly as regards the plan, the Byzantine churches might be taken as a type for many of our modern ecclesiastical structures, for which the grand nave and aisles were so eminently adapted.

SIR DAVID BREWSTER ON THE PATENT LAWS.

At the commencement of the present session of the Royal Society of Edinburgh, the President, Sir David Brewster, delivered the opening address, in which he took occasion to review the working of our Patent Laws. The great experience and authority of the learned and eloquent author will render his views upon the subject especially interesting to our readers. Sir David Brewster said:—

Among the various functions which our scientific institutions are expected to discharge, not the least important is to foster the labours and protect the interests of discoverers and inventors,—of those who create new forms of matter and new processes of art,—who invent new instruments, and new machinery for controlling and rendering useful the forces of the material world.

The rights of property, in its material phase, whatever be its character, and by whatever means it has been acquired, have ever been held sacred, even in barbarous communities. The hoarded treasure, or the portion of the earth's crust which it may purchase, can be wrested from its owner but by the forfeiture of crime or the grasp of conquest. As civilisation advances, new wants are developed, and new rights established. The historian, the philosopher, the antiquary, and the poet—the pioneers of intellectual life—strive to instruct and amuse us, and claim in return our sympathy and protection. Hence has arisen the law of copyright, in virtue of which the author of any work, however frivolous in its character, however immoral in its tendency, however subversive of order, and however hostile to religion, acquires a right of property which successive acts of Parliament have enhanced in value, by lengthening its tenure and adding to its security. This just privilege, of which the humblest and the highest in the community avail themselves, is granted gratuitously by the State, and is enjoyed during the long period of forty-eight years, and by the youngest author during the whole of his life.

In the progress of civilisation, wants other than intellectual demand immediate gratification. The genius of invention, in its youngest exercise, is summoned to feed and to clothe us, to conjure from the inner earth the elements of civilisation, to strengthen the human arm and aid the failing eye, to shield us from the elements, and to open to the missionary and the merchant the rough pathway of the ocean. In its manhood, it is summoned to more transcendental functions; to supply, for the higher civilisation, the luxuries and elegancies of life; to carry us swiftly and safely over earth and ocean; to navigate the fields of ether; to converse with the world, in accents of lightning, through the air and under the deep; to bring within our research the most distant star; and to reveal the minutest life which swarms beneath and around us. With such functions to discharge, and having discharged them nobly, the inventor might have looked for a generous patronage from the State, and for a monopoly as free and secure as the copyright of the author.

The right of property in inventions has been acknowledged by almost every community in the old and the new world,* and a patent law has been passed to define its character, to fix its limit, and to secure it against infringement. In England, I grieve to say, her inventors are more cruelly taxed than in any other part of the world. Though her prosperity, more than that of any other nation, depends on the encouragement of the industrial arts, yet she levies from the poor inventor—nay, from her best benefactor, the enormous sum of £175 for a patent-right of fourteen years. In France the same privilege, for fifteen years, is given for £60, paid by instalments of £4 for each year of its tenure; and in the United States a patent continues seventeen years, and costs only £7 6*s.* 10*d.* In Sweden and Norway a patent is given for fifteen years, for the mere expense of advertising the specification. In other countries the diversities in the expense and endurance of patent rights measure the legislative wisdom which characterises the laws that pretend to encourage the useful arts; and show us how unblushingly the limited means of the poor inventor are transferred to the pockets of ignorant officials, and, in this country, accumulated in the coffers of an overflowing exchequer.

The consequence of such ungenerous legislation it is not difficult to discover. The average number of patents granted annually in England is 2000, in France 4000, and in the United States 4000; and hence we are entitled to infer that upwards of 2000 patents are annually suppressed in England, and that many valuable inventions and processes in the arts are either not perfected by their authors, or employed in secret, and for ever lost to society.

This is not the occasion to analyse the patent laws of England, and to criticise the principles which are supposed to regulate their enactments. It may be enough to have referred to the miserable tenure of fourteen years which they assign to the inventor: to the crushing tax of £175 which they levy from him; to the illusory privilege which they give him; to the endless litigation into which they lead him; and to the bankruptcy and ruin in which he is so frequently involved. There are, doubtless, cases in which patent rights have led to fortune, but it is chiefly when the wealthy capitalist has come to the rescue of the humble inventor, or when the patent has been confirmed by the decision of a court of law. The injustice of the patent law has been so fully admitted, that various acts of Parliament have been passed in favour of the patentee, aiding slightly to the protection of his right, and reducing to the sum we have mentioned the expense of its attainment; but no addition has been made to the shortness of its tenure, and no increase of security against direct piracy or partial infringement.

Whatever difficulty the statesman may experience in giving security to the rights of inventors, he can have none in giving them the same tenure as copyrights, and conferring them as gratuitously, or at no greater cost than is necessary to cover the expenses of the patent office. Between the national claims of authors and inventors there can be no comparison. Value as you may, and value highly, the treasures of ancient and of modern thought, what are they when weighed against the inventions of art and science, predominating over our household arrangements, animating our cities with the sounds of industry, and covering with mechanical life the earth and the ocean? The eloquence of the orator, the lesson of the historian, the lay of the poet, are, as it were, but the fragrance of the plant whose fruit feeds us, and by whose leaves we are healed; or as the auroral tint which gives a temporary glory to a rising or a setting sun. But grant to the favoured genius of copyright its highest claims, and appreciate loyally its most fascinating stores, their value is shared, and largely shared, with that of the type, the paper, and the press, by which these stores have been multiplied and preserved. The relative value of books and inventions may be presented under another phase. Withdraw from circulation the secular productions of the press that are hoarded in all the libraries of the world, and society will hardly suffer from the change. Withdraw the gifts with which art and science have enriched us—the substantial realities through which we live, and move, and enjoy our being—and society collapses into barbarism.

* Switzerland, China, and Japan have no patent law.

Under the influence of views like these, the friends of inventors have continued to watch over their interests, and to prosecute improvements on the patent laws. In this cause some of the leading members of the British Association, the Inventors' Institute, and the Social Science Congress, have been specially active, and through their exertions the subject was brought before the House of Commons in the last session of parliament. In the discussions which took place in the house and in the commission, the most startling opinions were advanced, and by some persons received with favour. The entire abolition of patent rights was gravely proposed, and the report of the commission was not submitted to the consideration of parliament, on the ground that that fundamental question should be previously decided.

Had this proposal to rob the citizen of the most sacred of his rights been accompanied with any suggestion that Government should give equitable rewards for successful inventions, even patentees might have welcomed the change; but no such suggestions have been made, and, judging from the past history of British science and art, we cannot indulge the hope of any such act of national liberality. It is under despotic governments alone that national benefactors are rewarded and honoured. Where mammon is in the ascendant, and the demigods of trade and commerce influence legislation, intellectual eminence must look to other lands for its recognition and its patronage. The present raid against the patent laws is the direct and acknowledged result of the ungenerous influence of trade. The shortness of the tenure of patent rights, and the heavy tax levied from inventors, are expressly maintained, in order to diminish the number of patents; and the avowed reason for thus diminishing them is, that from their number and frivolity they interfere with the operations of tradesmen and manufacturers, by exposing them to actions for infringement.

That there are many patents not remunerating, and not immediately beneficial, is painfully true, when we consider how much they have cost the sanguine inventor. That there are any patents really frivolous or useless, in the true sense of these terms, can be maintained only by ignorant or interested parties. There is no patent that does not contain a proposal to do something that is new, or to make some improvement upon what is old; and there are many examples of apparently useless patents containing the germs of future and valuable inventions. There are cases even in which the invention stigmatised as useless has proved to be an essential element in a future patent, where the new patentee has piratically used it, and dared to complain that he has been prosecuted for infringement. But there is a still more intelligible reason why no patent can be called useless. In bringing it into the market, workmen are employed, and materials purchased; and even if the process, instrument, or machine thus offered to the public has no sale and no useful application, the hapless patentee has given liberal fees to several functionaries of the State, and contributed nobly to the patent fund.

That any patent is frivolous and injurious, in the sense of interfering with the functions of honest traders, is simply untrue. If an invention which has been patented at the cost of £175, and produced nothing in return, is a necessary part of an important invention subsequently patented, it is a positive proof that patents apparently frivolous may be truly valuable. The first invention is, therefore, neither an obstacle to improvements, nor a ground for litigation. It has on the contrary, led to a greater invention; and whether the second patentee has used it ignorantly or advisedly, he ought to pay for the use of it, instead of pleading in a court of law, as he generally and dishonestly does, that the original specification is defective. But even if the cases of interfering patents were more numerous than they are, and more fertile in litigation, it is the lawgiver, and not the inventor that is to blame. If parliament, in its wisdom, cannot reconcile the interests of patentees and honest tradesman but by robbing the former, they overlook the fundamental law in social economy, that no great improvement can be made in the arts of life, and no true reform in our institutions, without interfering with a variety of interests. To abolish intellectual rights inherent in man, and long recognised and enjoyed, and this, too, on the single ground of public convenience, would be a retrograde step in legislation, of which history affords no example. As well might the surgeon propose to heal a rheumatic limb by amputation, or the philanthropist reform a criminal by his execution.

In proposing to abolish patent rights, its promoters seem to have wholly overlooked the international interests that are at stake. If we have no patent law, we deprive every foreigner of his existing right to a British patent. Foreign governments may therefore adopt a policy of retaliation, and refuse to our countrymen the patent rights which they now so freely enjoy; or, what is more probable, they may hold out additional privileges to our ingenious artizans, and thus obtain the first-fruits of their skill. Inventors will follow their inventions, and in the exodus to foreign countries—to the United States, especially, with its cheap and judicious patent laws—we shall lose, more rapidly than we have yet done, the most ingenious of our inventors, and the most useful of our citizens.

A policy like this, so Bœotian in its character, and so injurious in its results, is as politically unsafe as it is socially unwise, and personally unjust. Rights that have been firmly established and long enjoyed are not readily abandoned. Illiberal and oppressive as the patents laws are, they are still the Magna Charta of the commonwealth of inventors, and in an age tending to democracy they will not be surrendered without a struggle. Rights hitherto unquestioned, and not more sacred, may be exposed to the same scrutiny, and social interests endangered which all classes have been accustomed to respect and defend.

If these views of patent rights be just, and if, as moveable property, they are as sacred as copyrights, there can be no just reason why they should not be granted equally cheap, given to every applicant, and enjoyed during at least the life of the patentee. When a philosopher or an artizan offers an invention to the State, and receives an exclusive privilege in exchange, we might expect some equality between the gift and its reward. In perfecting his invention the inventor has already spent much of his time, and in many cases exhausted his means. When a suppliant at the Patent Office, a heavy payment is demanded, and he purchases a privilege which may ruin him. The theory of such a tax it would be difficult to discover. Its avowed object is to diminish the number of patents, for the benefit of non-inventors; but the object which it really accomplishes is to paralyse inventions; to cause valuable processes to be wrought in secret, and in many cases to be lost; to give fees to clerks and officers of state, and to create a fund, the purpose of which has not yet been revealed. A tax sufficient to defray the expenses of a patent office might be justly exacted, but to demand a sum twenty-fold that amount is a freak of finance, alien both to reason and justice. Will it be believed in an enlightened age, that the sum paid by inventors to the State during nine years and a half, from October 1852 to December 1861, was £772,778, which, at the same rate, will be £1,001,764 at the end of the present year? Of the sum of £772,778 received in 1861, L.502,000 has been expended, viz., £96,000 in fees to law officers and their clerks, who do nothing for the inventor, and £406,000 for the expenses of the Patent Office. After all this expenditure, the enormous sum of nearly a quarter of a million of money, wrenched from the inventive genius of England, slumbers, unapplied, in the Exchequer, while our schools and universities are left to starve, and the interests of science and art consigned to the munificence of our scientific institutions.

In discussing the policy of untaxing, extending, and securing patent rights, we may view them in relation to the doctrine of free trade, now developing itself in the legislation of every civilised community. In the present state of the law, patent rights may be said to be imported and exported as freely as the instruments and machines in which they are embodied; but in so far as they are more taxed in one country than another, the trade in their products and in their privileges cannot be considered free. A discovery in science, and a process or invention in art, are gifts offered to the families of mankind wherever they are made, and whatever be their character. To fetter their development in one country while they are fostered in another, is an act of international injustice, which free trade disclaims. To tax them anywhere, under any circumstances, and under any pretence, is a blot upon political wisdom, an act of cruelty to genius, and a wrong inflicted upon society at large.

In tracing the rise and progress of those great inventions and discoveries which have added to our physical enjoyments and consolidated our power over the material world, we cannot fail to recognise the grand object which, in the arrangements of Providence, they are meant to accomplish. Whatever man is fitted to understand he is destined to know. Whatever has been created for his use he is destined to enjoy. We have yet much to learn of the sidereal universe of which we form a part; of the system of planets to which our own belongs; of the physical history and construction of our terrestrial home; of the organic and inorganic substances which compose it; of the precious materials stored up for civilisation; and of those noble forms of life and beauty which everywhere appeal to the affections and intelligence of man.

But while we have thus much to learn, we have also much to do, and whatever we have power to do must eventually be done. The great inventions which, in living memories, have so mysteriously altered the social condition of our race, measure to us, however feebly, what art and science have still to accomplish. Our gigantic steam vessels—our telegraphs, aerial and submarine—our railways—our lighthouses, are still in their infancy. We have yet to pass through the sea with a surer compass, a sharper prow, and a stronger impulse. We have yet to speak more articulately through the air and beneath the ocean. We have yet to guard our coasts with brighter beacons and safer lifeboats; and our railways have yet to convey us more swiftly and safely to our home. But, what is more important still, we have yet to discover and combat those subtle poisons which are everywhere assailing the seat of life, and hurrying thousands of their victims to the grave.

In the completion of these great inventions and discoveries, we shall then learn, what statesmen have been unable or unwilling to learn, that art and science are the means by which the blessings of religion and civilisation are to be sent to the distant isles of the sea,—the several families of the earth united in one, and the reign of peace and righteousness established on the earth.

But while art and science are thus adding to our social blessings, and are pre-eminently the instruments of peace, they have in our day been busily and successfully employed in forging the weapons of violence and destruction. Nor is this a retrograde step in civilisation. By increasing the dangers, we diminish the chances of war. In perfecting the machinery of Death, we eventually add security to Life. War may become so disastrous in its consequences, so indiscriminate in its slaughter, and so appalling in its carnage, that it will cease to be the arena of the heroic virtues; and this bloody scourge of humanity—the master crime of nations—will be crushed by the genius of art, and perish by the weapons itself has used.

PETROLEUM AS A STEAM FUEL.

The following exhibits the result of a series of experiments upon the employment of petroleum as a fuel under steam boilers. The experiments were conducted by Mr. Julius W. Adams, C.E., of New York, at the request of the Petroleum Light Company of that city, and are embodied in a report to the directors:—Mr. Adams states:

The difficulty hitherto has been in attempting to burn the crude petroleum, that the imperfect combustion alone attainable by the means in use has resulted in great waste of the material, as shown by the dense smoke which invariably accompanied all attempts to burn it in a confined space. This, and the difficulty of regulating the feed, have hitherto prevented a successful application of this material as a fuel in the generation of steam in boilers. I am well aware that it has occasionally been accomplished on a small scale, but no experiments that I have knowledge of have exhibited anything like the requisite command of the material in feeding the fire, or certainty in its use as a fuel. This remark is made in full knowledge of what has been accomplished in this direction by Messrs. Linton and Shaw, as well as by Mr. Richardson in England. This difficulty has, I think, been successfully overcome in the experiments conducted for your company; and the crude petroleum, without other fuel than the chips for kindling the fires, has been burnt daily under a marine boiler, in a course of experiments extending from the month of May last, and proves more manageable, more under the control of the fireman, and developes an amount of heat greater than any fuel with which we are acquainted.

Mr. George W. Quintard, of the Morgan Iron Works, having offered the use of a marine boiler for our experiments, we applied our apparatus to it, without regard to any disproportion which might exist between the two; further experiments being needed in order to determine their precise relative dimensions. The experiments thus far have not extended beyond the determination of the fact that petroleum may be used with great facility as a fuel under steam boilers, by a single fireman of ordinary intelligence. No minute analysis has been made of its comparative economy—the results thus far being regarded as merely general; but from the results herewith shown, you will be enabled to determine how far our experiments sustain the claim we have advanced of having successfully applied this material to steam boilers.

The boiler used was an internal flue and return fire-tube boiler, the shell measuring 13 feet and 9 inches in length, by 6 feet in diameter, with a grate-surface of 35 square feet; contents about 1500 gallons of water to the level of 6 inches above the upper line of tubes. There were three flues in the boiler, the centre one of 16 inches diameter; and the other two of 12 inches diameter. The boiler was not set in the method which we recommended, but rested merely on three walls of the dimensions of the furnace walls. There were five rows of 2½-inch fire-tubes, being seventy-five tubes in all; the back connection being 15 inches by 3 ft. 5 in., and the smoke-stack 30 inches in diameter. The boiler was unclothed.

The fire bars were removed, and in their place a coil of ¾-inch wrought-iron pipe was inserted, the total length of pipe in the coil being 23 feet; at the back, directly across the furnace, a wrought-iron tube or retort, 5 inches in diameter, and closed at both ends, was placed, with a short tube of 2 inches diameter immediately in front of it. Into this latter tube (which communicates with the retort) one end of the coil is inserted, and the other end, passing out of the furnace door, communicates with the reservoir of oil, being in this case the cask in which it was brought to market. The flow of oil is regulated by a stop-cock, placed near the furnace door. Some 8 inches under the coil of pipe lie ten 1-inch wrought-iron tubes, closed at one end, the other end inserted into the retort; these tubes lie parallel to each other, and are 2 ft. 3 in. in length, and into each of them is tapped nine cast-iron burners, with one-sixteenth inch opening, making in all ninety burners. An inch above the plane of the coil, a wrought-iron pipe proceeds direct from the short tube in front of the retort into which the coil is inserted, to the furnace door, and thence to the steam space of a small auxiliary boiler; a branch, with proper valves, connects this pipe with the steam space of the main boiler—the flow of steam being also regulated by a stop-cock, placed in the vicinity of the furnace door, near the oil cock.

The water in the boiler being cold (sixty degrees), at fifteen minutes past two p.m., some billets of pine-wood and shavings, weighing about twelve pounds, being placed upon the coil, near the furnace door, were lighted, and the door partially closed; after an interval of fifteen minutes the oil cock was gradually opened, which permitted a flow of oil from the reservoir through the coil; simultaneous with which, or a little later, the steam cock was opened, which conveyed steam of about twenty pounds pressure from the auxiliary boiler, through the heated steam pipe, above the coil, to the retort or mixer, where, combining with the vapour of oil from the coil, it passes into the straight pipes, under the coil, and is fired at the burners. The flame was vivid and intense, regulated in its force by the relative flow of oil and steam, and was entirely under the control of the fireman, who, at his pleasure, could reduce the flame to the flicker of an expiring lamp, or extend it, by a single movement, to a volume filling the large flues and furnace with its flame. No smoke or unpleasant smell was perceptible, and the combustion was complete and entirely manageable. Steam, at atmospheric pressure, was raised in the boiler in twenty-nine minutes from the time of admission of oil into the coil. No measure was taken in this experiment of the amount of water evaporated; the apparatus not being considered as properly proportioned to exhibit the economical value of the fuel; and the experiment terminated in about one hour by closing the oil cock, and the fire was out.

The analysis of this experiment may be shown as follows. As this experiment only exhibited the weight of oil which, consumed under the boiler, raised a given quantity of water from a temperature of 60° to the boiling point, it is requisite, for a comparison with the known effects of anthracite coal, to show the proportionate amount of oil which would be necessary to convert this same bulk of water into steam of the atmospheric pressure, or the weight of water which a pound of this fuel will convert into steam.

According to Tredgold, the quantity of fuel which will convert a cubic foot of water, of a given temperature, into steam, at the pressure of the atmosphere, is obtained by multiplying the quantity of fuel which will heat a cubic foot of water one degree, by the sum of the latent heat of steam, and the difference between 212° and the given temperature of the water. In this case, $212° - 60° = 152°$. The latent heat of steam, according to Dr. Ure, is 967°, which, added to $152° = 1119°$, which, multiplied by the quantity of fuel which will heat a cubic foot of water one degree, will give the weight of fuel requisite to convert a cubic foot of water from the temperature of 60° into steam. This product multiplied by the number of cubic feet of water to be converted into steam, will give the total amount of fuel required in this case.

Making the proper allowance for the pine wood in lighting the fires, the weight of oil consumed in the experiment was 60 pounds; the contents of the boiler was 200 cubic feet, at a temperature of 60°, which was heated by this weight of oil to the boiling point=212°; thus the weight of oil which heated 200 cubic feet one degree was $\frac{60\text{ lb.}}{152°} = 0{\cdot}39$ pounds; and the weight of oil which was requisite to heat one cubic foot of water one degree was $\frac{\cdot 39}{200} = {\cdot}0019$ pounds. This multiplied by $1119° = 2{\cdot}126$, and this by the 200 cubic feet of water in the boiler gives 425 lb., as the weight of oil which would convert the contents of the boiler into steam at the atmospheric pressure—or $\frac{200 \times 62{\cdot}34}{425} = 29{\cdot}33$ lb., as the weight of water at a temperature of 60°, which will be converted into steam by one pound of oil. From Isherwood's valuable experiment on marine boilers,—we find this same type of boiler in use on board of the U. S. steamers—and from the mean of the experiments conducted on these boilers, we find the quantity of water evaporated from a temperature of 100° with steam at the pressure of the atmosphere by one pound of anthracite coal, to be 8·5 pounds. To compare this with the evaporation made from a lower temperature of water by means of the oil, this weight must be reduced in the following ratio, established by Isherwood; $\frac{966° + 112° = 1073}{966° + 152° = 1118} = 0{\cdot}964$, which multiplied by 8·5 gives 8·16 as the weight of water at 60°, converted into steam of atmospheric pressure by one pound of anthracite coal.

Comparing this result with that above shown for the product of the combustion of oil, we find the evaporating power of the two fuels to be in favour of the oil, in the ratio of 29·33 to 8·16, or 3·6, weight for weight; the coal and the oil occupying about the same space for a given weight. That is to say, a cubic foot of coal as stowed aboard ship, will weigh about the same, or a little less, than a cubic foot of oil, the first weighing from 43 to 52 pounds, and the latter about 54 pounds to the cubic foot.

Further experiments, with improved apparatus, will be necessary in order to determine the precise economic value of this fuel in comparison with coal; but the advantages of the oil as a fuel for marine engines may be briefly summed up as follows:—

Rapidity with which steam may be raised; reduced dimensions of boiler and furnace below that required for coal; the continuous firing effected by feeding the fuel through a pipe into the furnace, thereby preventing the great loss of heat in the furnace every time a fresh supply of coal is thrown on, and the rush of cold air upon the opening of the furnace doors; the freedom from smoke, cinder, ash, or refuse of any kind, which in coal reaches from seven to over sixteen per cent. of the whole amount; in the ability to command a forced fire almost instantly, without a forced draught, which, under some circumstances at sea, is of vital importance; in dispensing with the numerous class of coal-heavers, stokers, &c., and all the inconvenience of raising clinkers and ash from the furnace rooms; and, finally, the diminished space occupied in the storage of the fuel.

THE NOTTINGHAM SUBWAYS.

Mr. M. O. Tarbotton, C.E., Corporation Surveyor of Nottingham, remarking upon the discussion on Mr. Burnell's paper on the Gas Supply of Paris, endorses the remarks made by Mr. Godwin in reference to the question of laying gas-mains in subways; and goes on to state—

"The subways of Nottingham having been alluded to, I will give some information as to their construction, extent, and use; and as the corporation of this borough have for some time given considerable attention to the subject, their experience may have some little value.

The first subways formed were in Victoria-street and Queen-street, and have an aggregate length of about 550 feet. These new streets were made in the centre of the town, and being the first of a series of extensive town improvements, the corporation were desirous of introducing the best means of preventing the constant breaking up of the surfaces of the public streets for drainage, gas, water, and other services. The subway is 10 feet wide and 7 feet high, and was completed three years ago, and therein were laid the sewers and branch drains, and the gas and water mains and services. The subway is well ventilated, no escape of gas or water has to my knowledge taken place, though the interior has been constantly visited and worked in by the men employed by the corporation and gas and water companies for branch drains and service-pipes. I have never observed a safety-lamp used, or heard of its necessity; and I have seen gas-service connections made with an open light, even with a gas-light obtained direct from the main, immediately contiguous to the branch in course of being attached. Hitherto the workmen alluded to have had at all times free access to the subway.

The second subway was made under Lister-gate, the greatest thoroughfare in Nottingham, after the same had been widened and improved at an enormous cost to meet the increasing traffic. This subway is somewhat similar to the first, but with improved details as to ventilation, access, and internal convenience; and therein the main sewer of that part of the town is built, with service connections, and also the telegraph wires are therein fixed. For some reason the gas and water companies have declined to use it, and have, instead, deliberately ripped up the street with four trenches for two lines (each) of gas and water mains. The corporation are highly annoyed, but notwithstanding, have decided to construct a similar subway under a third street improvement, now in progress.

The advantage of subways (if safe for gas-pipes) is universally admitted, and their most earnest opponents have failed to show any case against them for water, telegraph, and similar purposes (*vide* Minutes of the Select Committee, June 1864); but in respect of gas-mains, there undoubtedly is possible danger (as in every place to which gas is conducted), unless sufficient means of ventilation are provided, and the best modes employed in making and continuing the joints of mains and service-pipes.

I entirely believe in the statement of Mr. Hawkesley, that in a well-managed company the escape from the main is very slight indeed (say from 2½ per cent. to 5 per cent.), but I venture to contend that in a well-regulated subway, escape from the mains, to become dangerous, need not take place at all, for the following reasons:—1stly. That they are not subjected to the perpetual vibration caused by street traffic (in a subway there is no vibration). 2ndly. That they are not constantly disturbed by excavations around and under them for services and drainage operations. 3rdly. That they are under regular inspection, and the joints can be recaulked when necessary, or bitumenized or varnished from time to time. 4thly. That oxidation would be less rapid. Furthermore, if an insidious escape of gas happened, an ordinary ventilation would prevent serious consequences.

The wrought-iron services are the greatest promoters of leakage; and during a daily experience of underground works for the last eleven years, I have scarcely ever found a perfect service-pipe which was not new, or nearly so. The lime of the pavement concrete and the damp of the soil destroy the pipe, and the traffic loosens the joints. Now, this may be prevented by using lead services; but in a subway the destructive influences mentioned would not operate to anything like the same extent with wrought-iron, and renewal would be readily accomplished.

It has been stated that under the present system escaped gas is absorbed by the soil, and that soil forms the best cushion on which to lay the pipes. If this be the opinion of gas companies, the subway plan offers no impediment, as on the side of the subway intended for gas mains the same may be imbedded to any required extent; in fact, this is already the case in Covent Garden subway. Leakage by endosmose action has been advanced, but if gas companies prove all their pipes, as they profess to do, the pressure employed in gas-mains will altogether be insensible. It is true, if a large pipe be accidentally broken, the same damage might arise as if the casualty occurred in a street or any other place; but if large operations were in progress in the subway, corresponding precautions would (and could most easily) be taken to meet the contingency of accident; and it is only reasonable to expect that in a large system of subways the control and management thereof would be in the hands of a single and responsible authority.

It is the interest and duty of corporations and other bodies having the charge of the highways and streets of large towns, to prevent as much as possible their constant ravishment; and if the subways now proposed will effect this object without detriment to the companies, they ought to be compelled by the Legislature to adopt them; and I think it rather exhibits a want of fairness and public spirit for the gas and water companies combinedly to oppose them (the latter company without a shadow of pretence) without giving those trials which the Metropolitan Board and the Nottingham Corporation have so generously and earnestly offered. It should be understood that the so-called subways in Paris are simply sewers above the water-level, in which the gas and water mains are fixed, and not subways proper, as those in England."

IRON ENGINE PITS FOR RAILWAYS.

(*With an Engraving.*)

THIS application of iron manufacture is certainly a step in the right direction. It is needless to remark upon the numerous improvements in the manufacture of iron, and the still more numerous uses to which it has become applicable since the Conway and Britannia Tubes were designed by Robert Stephenson—the profession know well also that there is still a rapid yet steady increase in the uses of this metal. Even where timber, stone and brick were considered indispensable, from their peculiar natures, for purposes to which they were applied, iron has by improved processes been so wrought and shaped as to enable it to supersede them. We live in an age of iron, and welcome any new application of that valuable material, when we find efficiency and economy are the results.

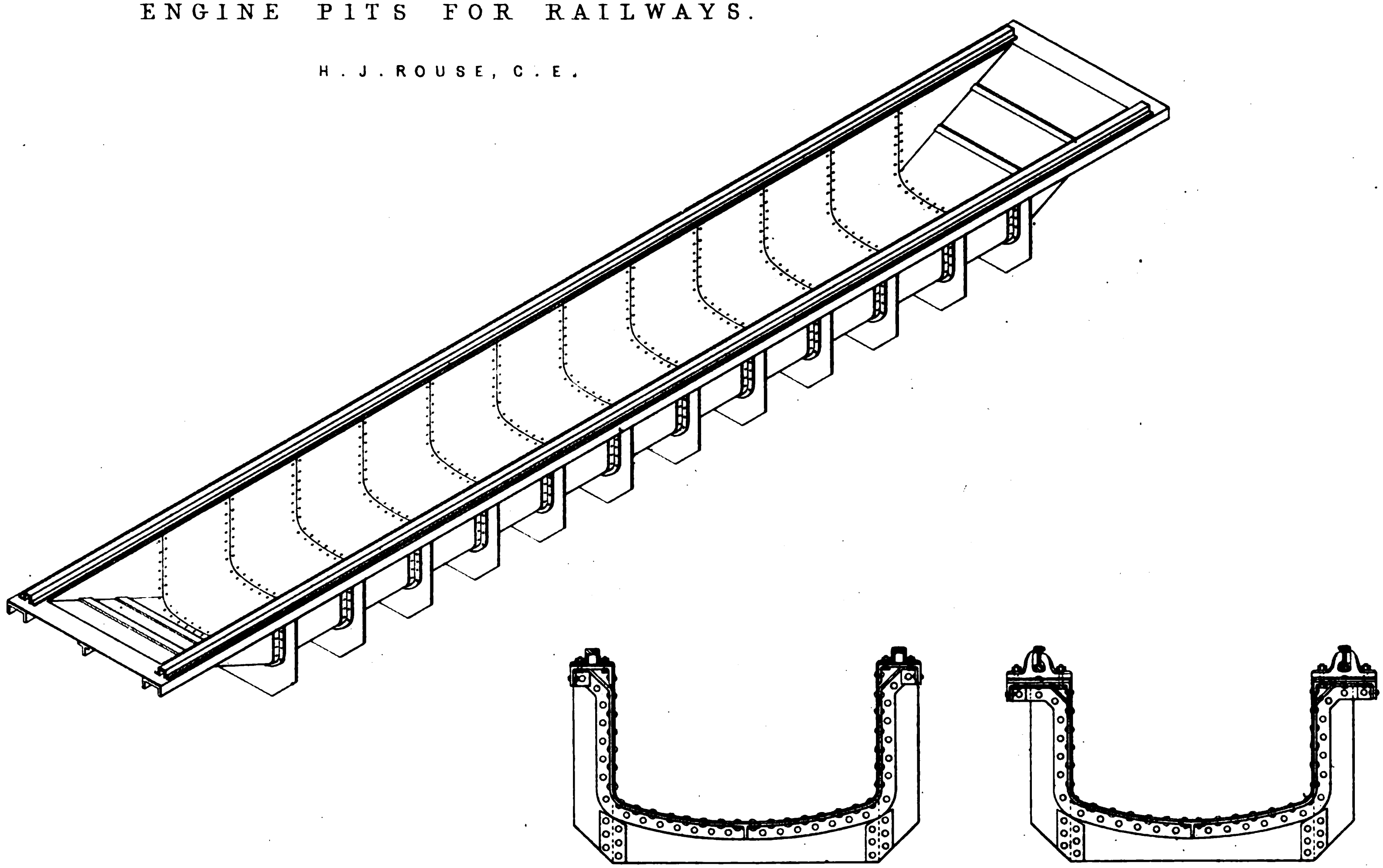
For the invention under notice the public are indebted to Mr. Henry James Rouse, Civil Engineer, of Abingdon-street, Westminster, formerly Engineer of the Egyptian Railways. Mr. Rouse's patent promises a safe and durable engine pit, self-sustaining as a girder spanning the entire length, yet light in weight, sufficiently portable, and easily constructed. When fixed, it is amply rigid to sustain the weight of the heaviest rolling stock running over it at high speeds; and while its use obviates the difficulties that sometimes unavoidably occur in such situations when formed of masonry, due to bad foundations or bad-setting mortar—its price does not exceed that of a masonry pit. We cannot do better than give Mr. Rouse's own description, as contained in his specification, remarking perhaps beforehand that the check rail described in the specification may invariably be dispensed with in practice as unnecessary.

This invention consists in the construction and employment of "engine pits" or "pits" of metal, by preference wrought-iron, the form proposed being that of a rectangular or square-sided box or pan let into the ground, and carrying the rails upon its upper rim; and in certain cases there may be, in addition to the ordinary main rails, check or guard rails, extending the whole length of the pits, and placed on the inner side of the main rails, and curved or elbowed at the ends, in a similar way to the check rails in "crossings" at stations. The check rails are for the purpose of preventing engine or other wheels from leaving the line at or on the pits.

The following is the mode in which the metal engine pits or metal pits are constructed:—They are, by preference, made of wrought-iron, rivetted together with angle irons and tee irons, having flanges on their top rims, for the purposes of carrying the rails and stiffening the edges of the pits. These flanges are to be either of plain boiler plate or bar iron, connected to the sides and ends of the pits by angle iron or tee iron, or they are to be of chequered or stamped plate, the chequered or uneven surface being undermost, so as to secure a good hold in the ground; or the flanges are of an entire rolled section, to be attached at once to the sides and ends of the pits. The bottom plates of the pits are of rough fluted, chequered, or other stamped or rolled plate, for the purpose of giving foothold for the workmen who may be engaged in attending to the engines or other rolling stock over

ENGINE PITS FOR RAILWAYS.

H. J. ROUSE, C. E.



J R Jobbins

the pits. The transverse and longitudinal ribs of tee iron or angle iron forming the framing or stiffening of the pits are placed on the outer side of the pits, leaving a clear uninterrupted surface inside, and forming a good hold in the ground surrounding them outside. Gussets and stiffening pieces are used also where it is found necessary, for the purpose of ensuring the rigidity of the whole system. The form of the metal pits may vary according to the space that may be allotted to them, or other circumstances; and one or both ends may be made sloping, in the form of inclined planes, with transverse pieces of angle, tee, or other iron, to give foothold to the workmen in descending or ascending; or steps are provided either of wrought or cast iron, bolted or otherwise, fastened to the sloping end or ends; or the means of access to the pits may be by portable iron or other ladders or gangways, in which case the ends of the pits may be vertical. The metal pits may be provided with a box or locker for tools and a place to keep a lamp, such box or locker being attached to the inside of the pits in some convenient place. As regards dimensions, the metal pits are made for railways of any gauge, and their length may vary from a length only sufficient for a portion of or for a single engine, tender, carriage, or waggon, to a length capable of taking any number of the same combined.

The various kinds of iron used in manufacturing the wrought-iron pits are either of the usual kind of rolled or stamped form, or of specially rolled or stamped iron, to suit the form of the pits in as near their entire section as possible. The main rails and check rails, whether of iron or steel, or any combination of metals bearing upon the upper rim of the pits, are either the usual double-headed rails, flanged rails, bridge rails, or any other known section of rails, or some specially rolled section of rail which may form part of the rim of the pits; the main and check rails may be rolled together in one section or separately. The bearings or seatings of the rails are either to be on or with cast-iron chairs, or on or with wrought-iron chairs, brackets, lugs, or steps bolted, rivetted, or otherwise secured to the flanges of the pits, or continuous bearings, bolted, rivetted, or otherwise fastened, as the case may require, and for the purpose of uniting the main rails on the pits with the adjoining main rails of the line, either the ordinary fishing plates are to be used, or in the event of the sections of rails on the pits being different to those of the line, fishing plates or seatings so formed as to unite any two dissimilar sections may be used.

The above description refers principally to wrought-iron pits, but this invention includes pits formed wholly or partly of steel; it also includes pits made of buckled plates or other stamped plates wholly or partly; also pits of corrugated iron wholly or partly. The mode of forming these pits is somewhat similar to that described for the wrought-iron pits, varying in detail according to the nature of the plates used, and the mode of framing necessary. Sometimes these pits are formed wholly or partly of cast-iron; the cast-iron pits are cast in sections or entire; where they are cast in sections the joints are made with flanges or laps, bolted together with bolts and nuts, and caulked with iron cement, or other suitable cement or caulking, or otherwise fastened. The cast-iron pits may have the chairs for the rails cast with the pits or separately; and they may have cast-iron rails in lieu of rolled rails cast with the pits in cases where cast-iron rails will be sufficiently strong and durable, otherwisk the rails are of the kinds already described. The description of the sloping ends, steps, or ladders for the wrought-iron pits apply also to the cast-iron pits.

The following details are common to every description of metal pit applicable to railways, namely:—There is a slight inclination or fall of the bottom inside towards one or more points for the purpose of drainage. In all the top rims or flanges of the pits, holes are provided for the purpose of ramming or punning the ballast, earth, or whatever the ground may be, so as to form a solid bearing or bed for the pits. There are also holes, handles, eyes, or lugs, provided for the purpose of lifting or lowering the pits in place or removing them by means of tackle, and the rails and check rails being attached to the pits will be raised or lowered with them as part of them. To render an alteration in the length of a pit an easy operation, the pit already in place to be lengthened or shortened need not be entirely taken away to be replaced by another of different length, but the end portions may be so constructed, if necessary, that they can be taken away, leaving the middle portion in the ground, to which can be attached new end pieces. The metal pits of every description when made for xportation, and when of too great length to be shipped entire, may be prepared in detached plates, bars, tee, or angle irons, or in pieces or sections for the convenience of shipment, to be united when arriving at the place for which they are intended. The metal pits may be coated by either of the processes called galvanizing, glazing, or enamelling, or by any other process for the prevention of oxidation, the coating being applied to the material before being put together, or to the pits when complete. The check rails, as well as main rails, are or may be attached to all metal engine pits where trains or engines pass over them at high speeds, as, for example, on main lines of railways; but for those pits that are used for sidings, station yards, engine and tender shops, or carriage and waggon shops or sheds, where the speed over the pits would be slow, or where engines are never taken, check rails would or need not be used; and in such cases the flanges of the pits carrying the main rails would be narrower than those where check rails are used, and there would be no holes for punning or ramming the ballast or ground, the narrowness of the flange obviating the necessity for the holes, and the punning or ramming would be done from the outside edge. The metal pits may be placed on a curved line of rails or railway, the main and check rails may be curved on the pits to suit the curve of the line, either by the marginal flange of the pits being made sufficiently broad to include the curvature of its length of rails, or in a very sharp curve by the pits being curved or polygonal, so as to present a uniform support under the curved rails, and the tilting of the outer rail may be effected either by packing or by special chairs, or rails for the purpose. In all the situations where the ordinary engine pits may now be placed, and also in situations where they cannot be used without additional cost and danger, namely, in embankment or made ground, and where the heaviest express trains may run over them at high speeds, the metal engine pits are applicable from their self-supporting form and materials, and they will be perfectly fire-proof. These can be shifted from one place to another when required, and their construction allows of the greatest working space within them; the space between the sides can be as wide as the gauge of the line, by having the rails of a section projecting only outwards from the pit.

Our engraving shows (Fig. 1) an isometrical view of an engine pit formed of boiler plate, being the kind of pit to which preference is given by the inventor. Figs. 2 and 3 show cross sections, the former where a bridge rail is used, and the latter where a double T rail and chair is employed.

PARIS UNIVERSAL EXHIBITION, 1867.

Memorandum on the arrangements for the Machinery Gallery of the Paris Exhibition.

By Captain Festing, R.E.

I.—By the General Regulations for the Universal Exhibition, approved by Imperial Decree of the 12th July, 1865, instruments and processes of the common arts are placed in Group VI., which is divided into 20 classes. A gallery 115 feet wide, and 82 feet high, is to be provided in the building for this group. In breadth this gallery is to be subdivided into a central block 75½ feet wide, and two side passages each 16½ feet wide, leaving a space of little over three feet at each side for counters and glass cases, placed against the partition walls. In the middle of this central block, and running throughout the machine gallery, there is to be a platform 13 feet wide, supported on columns about 14½ feet high. From this platform visitors will be able to see at a glance the machines exhibited. The columns of the platform will also carry two parallel main shafts for transmitting motion to the various machines, and under the platform will be workshops for skilled mechanics, whose work is to be exhibited as examples of the processes of the common arts. In the words of the supplementary instructions issued by the Imperial Commission relative to the arrangement of this group—

"It is not enough, in fact, to show to the visitors of an Exhibition the mechanical powers characterised by power and speed. In juxtaposition with it must be placed the work of man, showing perfection of taste, manual dexterity, and intelligent precision. In adopting this scheme the Imperial Commission believe that they will remedy an undesirable omission, and at the same time add a perfectly new attraction to the Exhibition of 1867. By this means the Commission hope to suggest comparisons both useful and productive, to bring to light the share of the workmen in the productions of industry, and at the moment when machinery seems on the eve of absorbing every manufacture, to show that for certain works the hand of man can defy all mechanical competition. A special Class of Group X. (Class 95) comprises the most attractive and ingenious processes carried on by hand-labour, and particularly those suitable to skilled workmen. But some of the Classes of Group VI. are also open not only to the apparatus enumerated in the system of classification appended to the General Regulations (Appendix A.), but also to the workmen achieving, either with or without simple tools, results which these apparatus produce mechanically. The following may be quoted as examples: in Classes 55 and 56, weaving, rope-making, spinning, embroidering, knitting; and in Class 59, paper-making, bookbinding, &c.

"This Exhibition of manual labour will not excite so much interest unless it be placed in juxta-position with the machinery with which it contends with more or less success, according to the particular industry. The workmen who are to use manual labour will find under the central platform mentioned above, a workshop, separate from the collection of machines, but sufficiently near to them to render comparisons easy. The portions of this covered ground space thus converted into workshops will be flanked on each side by a passage 5 feet wide, which will allow visitors to approach and observe in detail the performance of the workmen.

"In order to give greater prominence to the collection of objects comprised in a Class, it is desirable that the public circulating in the lateral passages of 5 metres, which extend along the whole length of the gallery, should be able to see the central block displayed as a whole, without being obliged to make their way into it. To effect this object, the Committees should as much as possible place the machines upon stages rising from the border of these passages up to the central platform. If necessary, steps with proper foundations rising one above the other would produce this amphitheatrical effect.

"On the other side of the 16¼ feet passage laid out on each side of the central block, tables and glass cases will be placed against the wall for the reception of a multitude of objects, machines or apparatus of small size, which would be lost amidst the large engines placed in the central block. Lastly, the partition walls of the great gallery which has just been described will be available for the exhibition of drawings, trophies, and objects which are of no great thickness. This additional space, which it will be expedient to turn to account, will give a desirable depth to the space where the objects are exhibited. Each Committee should make every effort to obtain for exhibition those ittle known and attractive processes, each successive stage of which can be followed, showing how the raw material is transformed into the finished product. Under this head may be mentioned the manufacture of paper, completed by the process of printing; spinning, weaving, &c. It will also be desirable, where in any Class the manual labour can be brought into proximity with the mechanical, to find a place for the workmen under the central platform, provided the general arrangements do not suggest a more suitable spot."

II.—The cost of all foundations, &c., and all erections and fittings necessary for the proper display of the objects in this group, is to be borne by the exhibitors. The motive power for the machines exhibited will of course be procured principally by steam, but other means will not be excluded. Instead of the supply of the motive power being carried out, as hitherto, by the administration, it has been decided to employ the system of private enterprise, and to distribute the generators of force at various points round the Exhibition Building, instead of concentrating them in one spot.

III.—The whole machinery gallery is to be divided into a number of sections, each of which will have its own system for supply of motive force.

IV.—The Imperial Commission will enter into agreements with contractors for the supply of motive power for the various sections.

V.—The British Executive has arranged to contract for the supply of motive power to the British portion, which consists of two and a half of these sections.

VI.—All prime movers are to be inside the building; accumulators for the supply of water under pressure to hydraulic engines should also be inside, as well as reservoirs for gas, compressed air; &c., for working any part of the machinery, if they are free from danger and inconvenience. The boilers or other generators of force which require fire are to be outside the building, at the distance of 98½ feet from its exterior, or about 197 feet from the centre of the machine gallery,

VII.—Each section of the building will have its set of boilers. From thence the steam is to be conveyed by pipes to the prime movers in the galleries. The prime movers will not be collected in one group, but will be distributed wherever there may be need of motive power, from one horse, or half one horse power, as supplied by gas engines, to that required for the largest machines. It is requested that those exhibitors who may wish to assign their prime movers to the use of the Exhibition will notify their wishes as soon as possible. They will have to fix them on solid foundations and fit them up for work.

VIII.—The only conditions made by the Imperial Commission with regard to the generators of motive force, is that those for each section should be in a certain position, on one or both sides of, but close to, a road in the Park which leads to the entrance door of the section. For each section there may be any number of boilers of the same or different kinds.

IX.—The boilers, shafting, and prime movers will all be considered as objects exhibited, and must be accessible to the public. It will, therefore, be desirable to have as great variety as possible, in order to show the various ways of turning to account the force derived from the combustion of the fuel employed.

X.—All machines which work with their own boilers, and which the exhibitors may wish to show in motion, must be placed in the Park. The Imperial Commission will make special arrangements about such machines.

XI.—Processes which require the use of fire, such as the working of metals, glass making &c., must be shown in the Park, and the works will be arranged round the boiler houses of each section. The exhibitors will have to construct all the necessary buildings for these works. and to plant, turf, and keep in good order the approaches to their establishment.

XII.—It is suggested by the Imperial Commission that those who wish to exhibit agricultural machines at work which cannot with safety or convenience be placed within the building, should club together to erect in the Park, at their common cost, some inexpensive structure for their machines.

XIII.—Those who may wish to exibit machines for raising water, &c., may in the same way unite to make a pond in the Park. This pond can be supplied from a well in the French portion of the Park.

The Metropolitan Tramway Company and Patent Crescent Rails.—Notwithstanding the want of success of Mr. G. F. Train's project for tramways in the Metropolis, a number of gentlemen have combined together for the purpose of repeating a similar experiment, and have prepared a bill, which will be brought before Parliament upon an early day. Recently Messrs. John Noble and Co., engineers, of Bridge-street, Westminster, exhibited at the Westminster Palace Hotel, a model of the proposed tramway, and described the advantages of the patent crescent rail. The rail is laid below the level, and is such a mere split or chink in the roadway, that the promoters assert that "the most tender vehicle cannot experience any shock." Four routes are proposed, viz., 1. From the Archway Tavern, Holloway, to the south side of Finsbury-square; 2. From the Seven Sisters'-road through the Camden-road to Tottenham-court-road; 3. From Lower Edmonton to the southern end of Kingsland-green; and the 4th from Stratford-grove to High-street.

Sewerage of Perth.—The magistrates of Perth have resolved to adopt a scheme for a general system of drainage for the burgh, keeping in view the practicability of utilising the sewage, and avoiding the pollution of the river Tay. They have engaged Messrs. Stevenson, of Edinburgh, to report on the subject.

Sanitary and City Improvement of Edinburgh.—A very comprehensive scheme for opening up the truly close districts on the flanks of the ridge down which the High-street and the Canongate extend from the Castle to Holyrood Palace, has been prepared by Mr. Roderick A. F. Coyne, C.E., and submitted to the city authorities. Mr. Coyne's plan includes three great lines of street, the longest and intermediate one extending from the Grassmarket down the (widened) Cowgate, whence it nears more and more to the ridge of High-street as it crosses South Bridge-street, Niddry-street, and St. Mary's-wynd, running on into the Canongate at the head of St. John's-street, where other two new streets are proposed to be joined with it, one affording an opening to Queen's-park, and the other running back along the other or northern flank of the High-street ridge to Cockburn-street, westward of the North Bridge-street, which it crosses on its way, as it also does the other block of Mr. Chambers's twofold project. The third line of street runs from Grey Friars Church also eastward, passing the College to the Pleasance. The estimated cost of the two first, and most important, of these plans, including Queen's-park approach, is £168,031.

ART IN RELATION TO ARCHITECTURE.

By John P. Seddon, F.R.I.B.A.

The object of this paper is to direct attention to what is the nature and object of Art.

Art may be defined as the skilled labor of man, the object of which is to superadd to what is practical or utilitarian, the pleasurable and the instructive.

In the early days of civilization Art was the simplest, readiest, and most effective means of conveying instruction. At the present time this particular office has been almost superseded by the invention of printing. We know, however, how welcome an aid the pictorial is in the tuition of children, and we have none of us so far outgrown this propensity, childish, if you will (and it is to be hoped we never may) as to be willing, if able, to dispense with its attractions. Instruction is still the highest and noblest office of art, and we all owe much, and we hardly know how much, to its influence. Of all the arts, that which has been most serviceable in one of its most valuable offices, that of handing down historical records, architecture has been the most so, and little should we know of many eras in the history of the world but for the fragments of the buildings which modern research has exhumed. Christianity also from its earliest days made use of art, as an able assistant and disseminator of its doctrines. Its Cathedrals were but vast storied books in stone; and their carved portals and painted walls and windows preached to the people sermons, the necessity of which, in those days, when such were the only books they had access to, we can now hardly appreciate, and it is this superaddition of instruction to the practical purpose, of providing a mere covering for the worshipping multitudes, which forms in those structures the one grand distinguishing characteristic between architecture and mere building.

I am, however, disposed to claim no greatly diminished importance for the other characteristic of art which I have named, that of providing the pleasurable element to the handywork of man, and I believe its importance to be now-a-days greatly overlooked. This is eminently a scientific age, and science has made, and is making, such vast strides, that the comparative progress of art is little noticed or cared for—and yet science merely provides the means of life, or curing its ills, while it is art which embellishes it.

Art and Science are the *translators*, as it were, of the beauty and the construction of God's book of nature. In nature, which of these is the more freely offered to our admiration? We are not taken behind the scenes to see the subtle method of her construction, but beauty is showered upon the surface of all her works. We need have no close acquaintance with the hidden machinery of bones, of muscles, and ligaments, to perceive the grace of outline, the glory of colour, or the power of expression which lie on the surface. Inasmuch then as health is prior to disease, and therefore to surgery, which would cure it—so is Art the elder sister of Science.

It cannot be denied, however, that at the present day there is a wide-spread feeling that art is a luxury, or at any rate anything but a necessity. The world is so absorbed in making money, that it seems to have no time to stop to consider, what alone can make the possession of money desirable. My present object is to shew that this should not be so—that it never has been so, until the last three centuries: to prove that those centuries have been none the better or happier for its absence, and that a splendid future lies before us, if we would only accept the doctrine that art should go hand in hand with science, the one assisting, the other adorning, their mutual progress.

I must, firstly, then, shew what art has been at different periods in the history of the world.

Its power over the minds of men was early recognized by those who have ruled the religious aspirations of the various nations, and in their hands there has been no more effective engine of priestcraft. It was thus wielded by the Assyrians and Egyptians, and to realize the manner in which it could bind, as in fetters of iron, the spirit of multitudes, I would ask the reader to accompany me in thought to the ancient city of Thebes, on the banks of the Nile, and to approach the far-famed Temple of Carnac, through its wondrous avenue of sphinxes, more than a mile in length, from the river's brink, each of vast size, of hewn and polished granite, appearing sternly, but calmly, to be gazing into futurity. Between these we pass up to the stupendous Pronaos or Portal of the Temple Courts, flanked on either side by its obelisks, emblems of light, wrought all over, as indeed was almost every stone, appearing by very multitude of design to realize infinity, with significant hieroglyphics. Enter beneath its frowning brows into the spacious outer court with colonnades all round it, and through successive pronavi and courts, until the Temple itself is reached, and we are lost amid the vistas of colossal columns, with spreading lotus capitals, dimly through which may be seen the shrine of the sacred ox or embalmed Ibis, which the deluded crowds have come to worship. And now in imagination strip the caged beast, or potted mummy, from all this external paraphernalia of architecture and art, and what remains in the bellowing or shrivelled carcase of the god, that myriads of human souls should bow down themselves to it in abject reverence.

Let us pass from this rude, yet indisputably effective style of art, calculated to impress, to bewilder, and to crush into subjection the ignorant masses, to the other side of the shores of the Mediterranean, to the Acropolis and city of Athens, and scan there the art which addressed itself to the polished and sceptical Greeks—votaries of "the unknown god," in search ever for something new, and gaze upon their Parthenon, the shrine built to contain the precious chrys-elephantine statue of Minerva, begirt with fluted columns, forming a grateful shady promenade for those who thronged to do honour to that favourite goddess. There is no mystery, no redundance here, no aid sought by means of mere magnitude or multiplicity of parts, but instead, by the utmost delicacy and refinement, such as our uneducated eyes could hardly appreciate, optical irregularities are corrected with scrupulous and scientific care, even its pavement was said for this purpose to have been laid with an exquisitively delicate curvature; the snowy marble to have been tinted in order to soften its glare; the aid of sculpture—and such sculpture as the world neve saw before nor since—was invoked to heighten and complete the effect of the architecture, and to speak intelligibly to intelligent men. Take away this casket, with all its lovely setting, from the goddess' statue, which was the gem it was framed to guard, and the crowd of her worshippers would without doubt have been most woefully thinned.

Now let us follow the stream of time, and proceed to the confines of imperial Rome, and see the wondrous array of arches which traversed the wide Campagna, to bring the tributary waters from the provinces within the walls: to this day the stupendous wrecks of these remain to attest to the magnificence and wealth of the city. Let us enter the vast circumference of the guilty arena of the Coliseum, with its arcaded tiers of building, in which the fashion of Rome congregated to gloat over the death throes of the victims of the State, and we can read there, in many clumsy expedients to marry the architecture they had stolen from more inventive nations to the science and scale their wealth could command, that their endeavour to keep art harnessed as a captive to their triumphant car was a futile one. Still what is there that Rome has left to tell future generations of the sway she once held over the world but the ruins of those her architectural works.

And if we would know something more of the inner life of those days, we may turn to where the ashes and lava from Vesuvius buried for us, and the antiquarian research of the present age has since exposed, the provincial towns of Herculaneum and Pompeii, and there is preserved for us through all those ages even the ordinary decorations and paintings upon the walls of their dwelling-houses, and numerous minutiæ, which historians would have thought it beneath them to have chronicled in their pages, but which are nevertheless of the greatest interest to us, consecrated as they seem to be by their antiquity. Art, however, in the hands of the Romans, sunk at length to such a depth of degradation, that it was no loss to the world when it was all swept away, in company with the empire of Rome itself, by the successive floods of invading barbarians, since it slowly but gradually revived again with renewed energy and under better auspices as Christianity completed its triumph over Paganism.

The period of this revival is one fraught with intense interest in an historical point of view, and from its associations, and yet comparatively little is known respecting it. Modern complacency has given to it the term of "The dark ages," mainly, one would think, because we ourselves are unable to see clearly into them; I have grave doubts, however, as to whether our own time has good cause to look down upon them, at any rate, when questions of art are under discussion.

Here again the remains of the architecture and its associated arts of the period appear likely to afford valuable assistance towards filling up the hiatus in our knowledge of its history, and the character and degree of its civilization. For although hitherto but a few remnants had come into our possession of those of a character which led us to believe that art, if not dead, was but in a stagnant and undeveloped condition, this has been altered within a very recent period in a most remarkable manner. It would appear to many almost as if the age of miracles was not extinct, to be told that but the other day, not a few isolated monuments of this very era had come to light, but that a discovery had been made, in a region but little removed from the beaten track of tourists, of a whole country studded with deserted towns, entirely composed of buildings erected from the 4th to the 7th centuries, of stately and sumptuous character, evidencing a higher and more refined state of society than we had dreamed could have existed then.

In Syria, in the district known as The Hauran, near Damascus, and in the country around Aleppo, which has been recently explored by the Comte de Vogüé, who has just published the results of his travels, there are now existing in an area of about 30 or 40 leagues, more than 150 towns, uninhabited, save occasionally by a few wandering Arabs, and which are in a wonderful state of preservation, due to the character of the climate, through the empty streets of which the traveller may pass and examine at his leisure monuments of the era under notice, and enter noble courts, spacious and stately houses, the very staircases of which remain, elegant baths, colonnades, and fine churches, in the details of which may be found the missing links between Classic and Mediæval art, very different from what had been imagined from that we had previously been acquainted with as the work of the contemporary early Christians, who in Rome had passed a hidden and struggling existence in the gloom of the catacombs beneath that city.

Mr. Cyril Graham, who rapidly explored this country in 1857, speaking of the enormous city of "Um-el-Gemel," to the South of Bozrah, and probably the "Beth-gamul" of scripture, says, "I wandered quite alone in the old streets of the town, entering one by one the old houses, went up stairs, looked into the rooms, and, in short, made a careful survey of the whole place; but so perfect was every street, every house, every room, that I could have almost fancied, as I was wandering alone in this city of the dead—seeing all perfect, and yet not hearing a sound—that I had come upon one of those enchanted places described in the Arabian Nights, where the population of a whole city had been petrified for a century."

Venice, which was founded in the 5th century, might fitly be called the battle ground of the styles, and there more easily than in any other locality may the history of architecture and its associated arts from this period, until the complete establishment of the Mediæval Gothic of Western Europe be studied.

The classic art of antiquity was at the time of the foundation of the Queen of the Adriatic, dragging out a languid existence at Rome, under one phase, which was founded upon the type of the Basilicæ, the old Courts of Justice of the Roman empire, and in Constantinople, and the Eastern Provinces under its sway, under another phase, known as the Byzantine. In Venice these met and contended for the mastery. There the various nations of the east and the west met and built for themselves, under its tolerant and paternal government, according to their own traditions, and as might be expected, we soon see their work united in various proportions in the same buildings.

But the northern Teutonic energy was the most vigorous, and before long asserted its supremacy, taking however from each of its competitors some element which it blended with its own, and thence sprung and spread over Europe the Gothic Architecture and Art.

However, the brilliant story of its rise and progress, as written in the stones of Venice, is it not well chronicled in the glowing pages of Mr. Ruskin? I will not therefore follow it further, as my purpose is now to trace the same progress from this point, as it may be seen in the noble church of St. Nicholas, Great Yarmouth.

The whole series of the styles of English ecclesiastical architecture are represented in this structure—the first in order being *The Norman*, this is the English development of the Romanesque, which is the Teutonic version of the decayed old Roman architecture and spread from Italy along the banks of Rhine and through France and thence into this country, receiving in each a distinct local character. This style is to be seen in the lower stages of the Tower of St. Nicholas' Church, immediately above the roofs, being a remnant of the original church built by Bishop Herbert, (surnamed Lozinga), to whom this diocese is so greatly indebted for the foundation of the noble Cathedral at Norwich as well. The semicircular arch is the principal feature which distinguishes Norman from the succeeding ecclesiastical styles of architecture. In this instance its details are very simple and plain, and devoid of many of the enrichments which usually are its characteristics; probably from the position of the church upon the sea-coast, its character was half-military, and such simplicity was a necessity enforced by circumstances.

The next period the work of which we find represented in this building is that known by the term "*Early English*," which is the earliest of the Gothic styles. Without entering into the discussion as to how and whence this style arose; whether it was due to the Crusades, which brought the eastern and western nations into close if not friendly contact, or to other causes; certain it is that in Gothic architecture, which became indigenous in all the western countries of Europe in the mediæval ages are to be found the best elements of both the Romanesque and Byzantine styles, but with the pointed arch as henceforward the ruling form of every opening.

In England alone was the earliest phase of Gothic developed so as to form a style of itself, which is termed the Early English, in which the windows are simply narrow, lancet shaped openings, used singly or grouped in couplets or triplets, as in the west end of the nave of St. Nicholas' Church, whereas in other countries tracery appears in the windows almost as soon as Gothic architecture may be said to have been established at all.

Another point which should always be borne in mind, is that although for our own convenience we have classified Mediæval architecture into distinct styles, these were not abruptly divided, in point of fact, but passed gently, almost insensibly, the one into the other, and indeed its whole history was but one course of transition or growth.

The architecture of the na[illegible]e of St. Nicholas' Church may therefore be described as of t[illegible]e period of the transition from Norman to Early English Gothi[illegible], and is remarkable for its fine arcades with their admirably [illegible]aried piers, being circular, octagonal, and shafted in succession.

The great feature of St. Nicholas' [illegible]hurch is its unequalled and splendid aisles, those adjoining the [illegible] nave are of the more completely advanced Early English or Tra[illegible]sitional style, between the Early English and Decorated. Their [illegible]oble west windows shew the rudiments of tracery, and doubtle[illegible]s the original side windows did so also. I have prepared a drawi[illegible]ng to shew what I believe to have been the southern side of the [illegible] church before it was spoiled by later alterations. The side wind[illegible]ows still retain the beautiful original internal dressings, it being [illegible]only the outer framework which was replaced later by perpendic[illegible]ular tracery to their great detriment.

The south porch has been a sumptuous work, of [illegible] date somewhat later than that of the *aisles*. It is of the earl[illegible] Decorated period, with rather curious and unusual tracery, sup[illegible]ported upon detached Purbeck marble shafts, and is an excellent [illegible]example of the style.

Then we have the chancel and its aisles, and the casi[illegible]ngs of the tower piers, of fully developed Decorated work, and the [illegible]ransepts of still later date, or flowing Decorated; and of the last [illegible] style of Gothic architecture, known as the Perpendicular, w[illegible]e have numerous inserted windows and other alterations, wh[illegible]ich unfortunately do not improve the architectural and [illegible]artistic character of the fabric, although they increase in some [illegible]degree its antiquarian interest, as a monument embodying in itse[illegible]f the work of all the periods of ecclesiastical architecture.

Recently the interior of this unique and magnificent struc[illegible]ture has been restored to its full magnitude, and its just proporti[illegible]ons. It is, however, far from being in a condition to convey an ide[illegible] of the splendour which in olden days it undoubtedly posses[illegible]ed.

It is well known that few of our churches, none of suc[illegible] as St. Nicholas, were left in unsophisticated stone and plaster, [illegible]hey were all sumptuously enriched with works of high art, ca[illegible]ved and decorated screens, such as Norfolk, beyond any count[illegible] is still famed for; and from encaustic flooring to painted and gilded ceilings, the whole glowed with rich and beautiful colouring.

The present generation has made a vast advance beyond the limited appreciation of art which has obtained during the last three centuries, if they can be said to have appreciated art at all.

It is useless to speculate why it was that simultaneously with the Reformation (which we all believe to have been a great boon to the world, as clearing away the mists of superstition that at length had obscured the Christianity of the middle ages) art at the same time fell into so lamentable a state of decay and neglect.

It is the nature of mankind to run into extremes, and the feeling that art had been made the instrument to foster such superstition doubtless helped to lead to a reaction, through which it became altogether ignored and set aside.

Next succeeded a period of stupor, of entire indifference to art, when men could see naught but the merest utilitarianism in such buildings at all.

From this deplorable condition the present generation has awoke. It does at last admit, not only that it has no right to destroy its ancient churches, but that it is a duty incumbent upon it to maintain them, nay even if they can accomplish it, to restore them, and to wipe away the shame of the neglect of their forefathers. All this is well. It is well that this appreciation of art and architecture has commenced with our churches, but I am anxious that it should not stop there.

I wish to plead for the importance of art in our homes, throughout our towns, so that our improved churches should not be so utterly out of harmony with their surroundings as at present, and in the country, so that our villas and cottages should not be such marplots in a fair landscape as they are at present.

This was the case formerly. Those who have seen such cities as Rome and Nuremburg will attest that their noble churches are but the best buildings where all are good and of harmonious and picturesque character.

People took then a pride in their houses, and some thought for those outside; their work was solid and substantial, and truly expressed the character and feelings of their builders and inhabitants.

But what does modern building express? Does it express anything? At any rate it is to be hoped it does not express our character. For if so, how could we claim truth to be a part of it? seeing that one material is commonly made to mimic another, as cement to imitate stone, and the whole decoration is in general one system of sham.

For this state of things who is to blame; the art producers, or the public? As is generally the case, there are faults on both sides, which act and re-act upon each other. Primarily it is the fault of the art producers, who have acted the part of unnatural parents, by giving stones in answer to the cry of the people for bread; that is to say, giving them nothing that could interest and please them, but instead, only dry scientific architecture, not composed as our own indigenous Gothic was, of fair arches and traceried openings, that everybody could love and understand, but the dreary exhumed dry bones of classic architecture, what they have been pleased to call Italian, and which, however scientific and convenient (though I am prepared to contend it is less so than Gothic), never touches the feelings with the slightest pleasure.

Then architecture, in modern times, has lost the able assistance of painting and sculpture, by which in olden days she pierced to the hearts of men, our buildings are thus left devoid of colour, and their carving is done by men hardly raised above the rank of masons, and thus cold and cheerless they have no charms for ordinary spectators, since it requires some education of the eye and a considerable intellectual effort to appreciate the merits of proportion, which is all that is aimed at. Our painters are entirely occupied in the production of easel pictures, for which alone they are commissioned, and our sculptors give us little but the annual ghastly array of busts in the dungeon of the Royal Academy, with an occasional galvanic revival of some long-forgotten mythological personage.

Thus the public, accustomed to be treated as if it had neither part nor lot in artistic matters, and finding no pleasure in architecture and in the other arts only in a dilettanti manner, has withdrawn its sympathy from them, and makes no demand for a higher description of supply.

Must we then despair of better things? Mr. Ruskin, the eloquent author on these subjects, says he is weary of writing about them, seeing so little result. But I think we may look forward much more hopefully. The progress made by artists of late years is undoubtedly great, and as the demand increases the supply will keep pace.

All should love architecture and art, and not believe there is any difficulty about them; I want all who can enjoy beautiful things in nature to equally well admire them translated into the language of art; and they should believe that architecture, painting, and sculpture, are each and all necessary to complete and render intelligible that language. Separately they are imperfect; their strength consists in their unity, which combines the efforts of each, and gives purpose to their power and direction to their aim. Thus architecture embodies but the abstract principles of nature; recreating, by means of her laws of construction and geometry, she gains sublimity by size, by symmetry, and contrast—beauty, by proportion and harmony. She builds up the polished stones of the earth into a music of visible matter, which yet is, and must remain ever but a "frozen music" as it has been called; out of tune with the natural melodies around, which concentrate all kinds of attraction, if she avail not herself of the graces of her sister arts. Apart from these, her means of expression are very limited, and extend not beyond the simplest emotions of the mind, addressing but few of the sympathies of men; with no more power than the lispings of a babe, or the gestures of the dumb. But still, that which she has to say is told from one generation to another, is told so clearly, that men may not but hear; and while she shields within her arms the more fragile works of Painting and Sculpture, their voice, whose compass is greater, blends with and becomes one with her own. History lends its associations, and the wild legends there are; and when records have perished and the voice of tradition is still, so long as one stone will stand upon another, time will but add a charm and bedeck the mouldering walls with the golden hues of the lichen and the moss; till, beautiful, even in death, the last relic is ploughed into dust.

THE ARCHITECTURAL ASSOCIATION.

The ordinary fortnightly meeting of this Association was held on the 16th ultimo, Mr. R. W. Edis, President, in the chair. Mr. Benjamin Lee, Mr. Edward Haselhurst, Mr. Charles Darby, and Mr. Ormond Stanley Brown, were elected members of the Association. The President reported that he had received a letter from Mr. Phipps, of Bristol, the honorary secretary of the Bristol Archæological Society, bringing before the Association the intended demolition of an old house at Bristol named Colsboro House. It was proposed and carried that the Association should memorialise the Town Council of Bristol, in the hope that they might be induced to save this ancient relic.

Mr. Mathews observed, at one of the earlier meetings of the present session a question had been raised relative to whether armorial bearings used in building were liable to pay government duty. Mr. Potter, who had communicated with the Government on the subject, had received an answer from the Chancellor of the Exchequer stating armorial bearings used in buildings were not liable to duty.

Mr. Tarver called attention to a letter from Mr. Burgess, addressed to the "Building News," having reference to the Figure Drawing Class, and explained that the statements relative to poor attendance were too true; and that it was consequently found necessary to raise the subscription somewhat above the seven shillings monthly, which it had been hoped would be sufficient to cover the outlay caused by increasing the number of weekly meetings from two to three. He had heard that the expense of joining this class, as compared with that of the Government schools, had deterred some gentlemen from becoming members; but he had learned from enquiry, that those who drew from the life in the Government schools, were only admitted after a much longer course of study than architects have time for. He disclaimed the notion that architects should devote to figure drawing so much of their valuable time as to make them perfect masters of the art, but hoped that many new members, from among the pupils especially, would seize this opportunity of acquiring most useful information by attending the class.

Professor Kerr, F.R.I.B.A., then delivered an address upon

DOMESTIC ARCHITECTURE.

The Professor stated that his lecture would be upon the design for an ordinary country house for a gentleman. The plan he proposed to follow in his address was to show practically the way in which he had been accustomed to design the plan of a country house. There might be some gentlemen present who knew as much as he, but he was aware that there were younger men who did not, and it was to the latter that he addressed himself. He assumed a house, containing rooms of the following dimensions, for the purpose of showing the principle in which it should be planned:—Dining room, 24 feet by 18; drawing room, 24 feet by 18; library, 24 feet by 18; billiard room, 24 feet by 18; gentleman's room, 18 feet by 18; morning or breakfast room, 18 feet by 18; entrance hall, staircase, cloak room, of each dimensions such as may be convenient; kitchen, 20 feet by 16; scullery, 16 feet by 16; 3 small larders; servants' hall, 20 feet by 16; butler's pantry, 16 feet by 12; housekeeper's room, 16 feet by 16; a store room; side entrances; back entrances, and so on.

He ventured to distinguish three types of plan, not so much theoretically as for practical purposes. These were what he would call, 1st, the regular type; 2nd, the irregular type; 3rd, the quadrangular type.

The *first* of these he sub-divided again into the square house, the gallery plan and the *Cortili* plan.

The *second* he subdivided into the hall plan, the gallery plan, and the Scotch plan.

The *third* he would shew in two different manners, the first with side offices, and the second with rear offices.

Professor Kerr then proceeded to draw in crayon a number of interesting ground plans, illustrating the various styles of which he spoke, pointing out their merits and defects, and giving a number of practical hints as to placing of doors, fire places, &c., which, however, could only be understood by seeing the drawings which the Professor exhibited. Having finished his description of the various styles of ground plans he proceeded to deal with a few questions of interest connected with the subject. He considered it a self-evident proposition that internal convenience should be the first consideration in designing a house. He was not stating a mere truism, which was to enter in at one ear and go out at the other. Whatever reverence an architect may have for art, whatever desire to shine, or to produce a grand effect, all must be made subsidiary to convenience. Looking at the works of nature we find this rule to be universally dominant. There is no attempt to make a shew on the outside so as to compromise any organic property within. Speaking with reverence we saw that nature never sacrificed the interior to the exterior. The exterior was ever designed with reference to the interior. And in art the same principle ought to be adopted, whether for a warehouse or a church. He could find 500 men who can design a good outside, but he would not like to say how many of them could design a good inside.

He then made some observations on the question of aspect. He would remind them that the sun shone on the east side of a house at six in the morning; on the south side at noon; on the west at six in the evening. Also he would remind them that winds from the north-west and south-west were boisterous; from the north-east keen; from the south-east mild; and therefore the rooms in which the family mostly resided ought to have a south-easterly aspect.

A window to the west will never do for a dining room, because the sun would shine in at such window at the usual dinner hour. North was therefore the proper aspect for a dining room.

The drawing room must be towards the south-east; it has the benefit of the early morning sun, but the glare is off the windows betimes. The south-east was also best for the dining room, if it could be managed, and in cases where the dining room was also the sitting room, it should have windows to the south-east.

With regard to the question of architectural effect, he pointed out the fact that English gentlemen do not like anything that is obtrusive or conspicuous, or which will provoke remark; they want what is ordinary, not extraordinary; the colloquial sense of the word elegance expressed that which the better class of this and other countries appreciate.

As regards Archaism, he observed, there were many men in the present day who seemed to desire to make their buildings as ugly as possible. He did not want too much ornament, but a paucity of decoration or rudeness of execution were not desirable. On the point of style he remarked, that architects were very much divided between the Gothic and the Classic. He would not go into any controversy on the subject, because he considered the controversy a most healthy stimulant. That which is called Italian architecture ought rather to be termed modern European, because it belonged to that reorganization of intellect which took place in the sixteenth century, and spread over Europe, and which was only called Italian because Italy was its cradle. He thought, however, Italian architecture was perhaps less suitable for domestic design than the Elizabethan style; the latter did no violence to our ideas, it preserved a certain picturesqueness which had nothing repulsive in it, and also coincided with our habits and historical feelings, which made it peculiarly applicable to England. Therefore he considered there was something pleasant in the competitive rivalry between the Italian and the Elizabethan styles. Neither style was likely to throw aside the other. The Elizabethan tended to add picturesqueness to the Italian; the Italian was fitted to add elegance to the Elizabethan, and the styles offered a pleasant alternative. Architects often found a client with a peculiar structure of mind, which led him to prefer whatever was delicate and classical; while another man, perhaps his neighbour or his brother, with different tastes, would have leanings in a different but not in a contrary direction, and would prefer something more picturesque, more *piquant*, more stimulating. According to the tone of mind which a man possesses, so in a great measure would be his preferences. He (Professor Kerr) considered that no architect need have any hesitation in offering a gentleman his choice between the two styles. An architect should feel himself quite at liberty to say to a gentleman consulting him, "You may have either style you please, and I will do my best for you."

Professor Kerr next proceeded to speak of some of the rooms which were essential to a gentleman's house, and instanced "the service room." He said it was the small chamber connecting the offices with the dining room, in which dinner was placed, and then served through a private entrance. The object of having such a room was to prevent the inconvenience of the dinner being carried through the house. He (Professor Kerr) was acquainted with a wealthy gentleman who had not such a room in his house, and the dinner had to pass through the staircase. The consequence was that the dinner odours penetrated through the entire dwelling. This showed the necessity of considering the dinner route in planning a house, and of planning the kitchen in such a position with respect to the dining room that all such unpleasant results might be avoided.

A cloak room was another apartment which the lecturer considered essential to a gentleman's house, and on the importance of which he laid great stress. It was necessary to have a room fitted up with lavatory, &c., and it ought to be as near the outside door as possible.

Strangers visiting often lost their way in a large house, they could always, however, find thair way to the entrance door, and it was always of great convenience to know there was such a room at the entrance.

The gentleman's room he considered deserved a few words of notice; it was the business room of the master of the house, and into which no one was allowed to enter, except of course the servants who cleaned it. No one had a right to come in and sit down without leave; it was like an architect's private office, in which after visitors had transacted their business they were not at liberty to remain. The gentleman's room ought to be so placed as to be easily accessible from the private entrance, and also for the attendants. It ought, however, to be somewhat removed from the ordinary traffic of the house, so that the ladies should have no excuse for opening the door if passing by.

The Professor then proceeded to deal with the question of suites of rooms. He said he did not refer to the system of having communication between several rooms by means of folding doors, but rather to the method of having two or three rooms separated from the other apartments by having an outer door, which, when closed, completely excluded the dwellers within from all the other people in the house. The suite to which he first adverted was the bed room suite. In most houses people were accustomed to find bed rooms "pitchforked" together any how. Sometimes they were so constructed that people could not find room for a washstand. A bed room ought to be designed so as to hold the furniture. The object in having rooms in suites was to give guests, and especially married guests, a set of rooms as their own. This was a particular point in the designs of Mr. Burn, the well-known architect, and gave great satisfaction. There might be a suite consisting of bed room and dressing room only for guests, there might also be what was called the family suite. In a large house in which the master and mistress were quite alone, it is very uncomfortable to inhabit the whole house, and even if the house were filled with guests there were times when the host and hostess desired to retire from the bustle and enjoy a period of quiet. The family suite would consist of a bed room, dressing room and sitting room. The lady's boudoir should be adjoining the dressing room. There were various erroneous ideas extant regarding the lady's boudoir. It was not a fanciful apartment, it was the lady's business room.

Another suite which was to be recommended was the nursery suite, to which a bath room, scullery, and other conveniences ought to be attached.

The lecturer then proceeded to make some observations relative to the distinction between the Classical and the Mediæval hall. The classical was distinguished by great loftiness. The mediæval was more homely in character. In olden times it was the room in which everybody ate and drank and slept. The hall should be the first apartment after passing through the porch. It was more domestic than the nobler and more refined Classical hall.

On the kitchen group of a gentleman's house, he observed, that in simple form they consisted simply of kitchen, scullery, and larders. They ought to be as far as possible from the house, so that the dinner smells might not be perceptible in the rooms.

The lecturer recommended that in planning a house, the architect should place the furniture on his plan, it might be a little extra trouble, but it would save much inconvenience afterwards.

The gentleman's desk was a piece of furniture which was most particular in its requirements. It must have light from the left side; it must be near the fire, and the door must be at the right hand, and the bookcase must be conveniently placed.

The lecturer concluded by saying he would impress one further remark upon the younger members of the profession, namely, the necessity of considering the function of an architect in its purely practical light. Great allowances were to be made for the enthusiasm of youth, but still, in the present day, he believed there was a necessity to impress on the younger members of the profession to devote more attention to the practical matters.

Mr. Tarver observed that Professor Kerr's condemnation of "*gothic*" domestic architecture at the present day was, to a great extent, deserved. He considered that one secret of this failure was to be found in the neglect of the details, and especially the joinery, which ought to be made the object of individual study; and he also pointed out that in many cases architects applied "church gothic" to domestic purposes, for which of course it was unsuited.

Mr. Webber expressed his approbation of many of the remarks made in the course of the paper, and supported the vote of thanks. The President said, that though Professor Kerr and he might differ on some points, it was with very great pleasure he had listened to the lecturer, as no man was more able to deal with the subject. Although Professor Kerr might not like Mediæval houses or Mediæval architecture, yet he (the President) believed in its practical applicability with modifications to existing circumstances. It was for the architects of the present day not to copy in a servile manner the architecture of the past, but to avail themselves of all the appliances of modern science, and so to modify the antique as to suit it to existing demands; he agreed with all that Professor Kerr had said on the subject of planning, and felt that the suggestions contained in the lecture were of great value.

The vote was carried.

The International Exhibition of the products, arts, and manufactures of New South Wales, Queensland, South Australia, Western Australia, Tasmania, New Zealand, and Victoria, to be held during the present year in Melbourne, promises to assume proportions somewhat beyond the calculations of its authors. It is estimated that from the growth of manufactures and the general progress of the colonists since 1861, the space required by Victorian exhibitors alone would need an edifice at least double the size of the present exhibition building, so that if the six adjoining colonies only contribute in moderation, the aggregate collection of objects will be very large indeed, and will necessarily involve the erection of a new and very capacious building.

THE MAINTENANCE AND RENEWAL OF PERMANENT WAY.

By R. Price Williams, M. Inst. C.E.

The Author thought it must be confessed, that the condition of the permanent way, so far as regarded its durability, had in no way kept pace with the demands upon it, and that in this respect it compared unfavourably with other branches of railway engineering. Thus, for instance, whilst the weight and power of locomotive engines had been more than quadrupled in thirty years, the increased efficiency resulting from more perfect workmanship and a better description of material was such, that, on the Great Northern Railway, the per centage on the gross traffic receipts for locomotive expenses had even slightly decreased during the last fourteen years, whereas, on the other hand, that of maintenance of way had increased more than 200 per cent. in a similar period.

With a view of showing that the durability of the permanent way, and more especially what was termed the "life of a rail," had been considerably over-estimated, and further with the object of supplying more reliable means for comparing the cost of maintenance and renewals on different railways, the Author had been engaged for some years in preparing from reliable sources, tables and diagrams relating to the following lines of railway, arranged according to their mileage:—1. London and North Western; 2. North Eastern; 3. Midland; 4. London and South Western; 5. Great Northern; 6. Lancashire and Yorkshire; 7. South Eastern; 8. London, Brighton, and South Coast; and 9. Manchester, Sheffield, and Lincolnshire. These tables and diagrams showed, for a period of nineteen years, 1st, the detailed charges of *a*, maintenance of way; *b*, staff and other charges; *c*, works of line; *d*, stations and station works; and *e*, renewals of way, all of which were usually comprehended under the head of maintenance and renewal of permanent way and works; 2nd, the number of miles maintained; 3rd, the train mileage; 4th, the gross tonnage, together with other information bearing upon the subject.

The diagram relating to the London and North Western Railway was then explained in detail, and it was remarked, that the cost of maintenance of way had reached £270 per mile per annum, that of staff and other charges had been regular and uniform throughout down to the present time, that the item works of line showed considerable variation, due probably to the heavy expenditure at times in replacing timber viaducts and repairing slips, and that stations and station works also exhibited the same variable character. It was, however, in the last item, renewals of way, that the principal disturbance of outline was noticeable. This was alluded to in periods in the Paper and the gross result arrived at was, that in the nineteen years £1,906,858 had been expended on renewals of way alone, representing something like 1,362 miles of single line, or almost one-half of the whole mileage maintained in the year 1865. This gave an annual average, since 1847, of £103,000, which was equivalent to nearly 73 miles of single way of the main line broken up and entirely replaced annually during the period referred to; chiefly in situations where the traffic was heaviest, and where consequently, owing to the short intervals between the trains, the facilities for doing the work were the least and the danger of accident the greatest.

The average cost of renewals per mile per annum during a period of years, on the nine railways to which the statistics related was shown in the following table:—

No.	Name of Railway.	Average of years.	Cost per mile per Annum.
1.	London and North Western	18½	£145
2.	North Eastern	14	83
3.	Midland	17½	84
4.	London and South Western	11	72
5.	Great Northern	9½	110
6.	Lancashire and Yorkshire	16½	156
7.	South Eastern	15½	102
8.	London, Brighton and South Coast	12½	94
9.	Manchester, Sheffield and Lincolnshire	9	49

As the Diagrams and Tables already described were too general in their character to enable a reliable estimate to be formed of the "life of a rail," the Author, with the assistance of Mr. R. Johnson (M. Inst. C.E.), had supplemented those relating to the Great Northern railway, by longitudinal sections of the two principal divisions of the main line, from King's Cross to Peterborough (75⅓ miles), and from Peterborough to Askerne junction (84¾ miles), showing the places where the renewals had occurred, the periods of renewal, and the nature of the different geological formations. Here it was that the destructive effects upon the permanent way of a large and concentrated traffic, more especially of a heavy and rapid coal traffic, were most significantly evident. Various modifications had been rendered necessary in the way as originally laid, and the rails and chairs now used in renewing the road were of a heavier character, and the sleepers were of a larger scantling and were placed closer together. The cost of renewing a single mile of this road, exclusive of ballast, credit being allowed for old materials, was now estimated at £1372. It appeared that during the last twelve years 315 miles had been entirely renewed on the main line between King's Cross and Askerne junction, at an expenditure of £423,820, being at the rate of £35,273 per annum, which was equivalent to upwards of 1 per cent on the ordinary stock of the Company. In other words, the renewals on the 160¼ miles during the period mentioned had amounted to an average cost of £200 per mile per annum. It was explained that the up traffic, including as it did all the heavy coal trains, exceeded that on the down line nearly in the ratio of 2 to 1; and, as might naturally be expected, the cost of maintenance and renewals was found to be much in the same relative proportions, 203 miles on the up line having been re-laid, and 112 miles on the down line. Where the different streams of traffic converged, as, for instance at Hitchen and Hatfield, the frequency of the periods at which renewals had occurred became very apparent; for the greater part of the up line, on the descending gradients between Potter's Bar and Hornsey, had already undergone a third renewal during the short period of thirteen years, giving an average of only three and a-half years as the life of a rail under these exceptional circumstances. From a return, furnished by Mr. Grinling, it appeared that, on the up line near Barnet, 57,536 trains and 11,760,926 tons had sufficed to destroy in three years the rails laid in 1857, and that 65,529 trains and 13,484,661 tons those laid in 1860 and taken up in 1863.

The results of an investigation made by Mr. Meek, extending over a period of seven and a quarter years, showed that on the Lancashire and Yorkshire, where the traffic was of a heavy character, but conveyed at a slow speed as compared with the Great Northern, on the falling gradient of 1 in 130 at Ramsbottom Viaduct, between Bury and Accrington, 62,399 trains and 12,451,784 tons wore out the best sample of rails in seven and a quarter years. At Bolton, on the level, where all trains drew up, the same description of rails had required 203,122 trains and 38,803,128 tons to wear them out in a similar period.

The Author considered these facts clearly proved, that the rapid deterioration of the permanent way was in a great measure attributable to the increased weight and speed of the traffic; and that the concurrence of the tonnage outlines with the cost of renewals was collateral evidence of the truth of these deductions. It was contended that the chief material, the rails, was wanting in the essential element of durability, and that the experiments on the Lancashire and Yorkshire showed that both the best Yorkshire iron and the coarser and harder descriptions of Welsh manufacture, were alike incapable of withstanding for any length of time the excessive wear and tear to which they were exposed. The mode of manufacturing iron rails, and the various methods of forming the pile adopted at the principal iron works in South Wales, were, then described. It was stated that very few makers were now disposed to give even a seven years' guarantee for iron rails, which was tantamount to an admission, that when exposed to the excessive wear and tear of main line traffic, their employment must no longer be looked for.

The introduction of steel rails, manufactured chiefly by what was known as the Bessemer process, and the satisfactory nature of the results obtained, encouraged the belief that in this material had at length been obtained, what was alone wanting to give something like real permanency to that which in name alone had hitherto deserved the title of permanent way. Two steel rails laid in May, 1862, at the Chalk Farm Bridge on the London and North Western Railway, side by side with two ordinary iron rails, after outlasting sixteen faces of the iron rails, were taken up in August last, and the one face only which had been exposed, during more than three years, to the traffic of 9,550,000 engines, trucks, &c., and 95,577,240 tons, although evenly worn to the extent of a little more than a quarter of an inch, still appeared to be capable of enduring much more work. A piece of one of these rails was exhibited, and another piece had been tested by Mr. Kirkaldy's machine, the results being recorded in tables and diagrams, showing the comparative strength of steel, steel-topped, and iron rails of different sections.

The general adoption of steel rails on main lines, where the traffic was of the heavy description referred to, would, in the opinion of the Author, not only prove cheaper in the end, but, what was of infinitely greater importance, would through the less frequent breaking up of the road, materially, add to the safety of the travelling public. A tabular statement, which had been prepared by Mr. R. Johnson (M. Inst. C.E.), of the cost of using guaranteed iron rails at £7 18s. per ton and estimated to last three years, and of steel rails at £15 per ton, supposed to last twenty years, showed a balance of fifty per cent. in favour of steel rails.

CHRIST'S COLLEGE, BRECKNOCK.

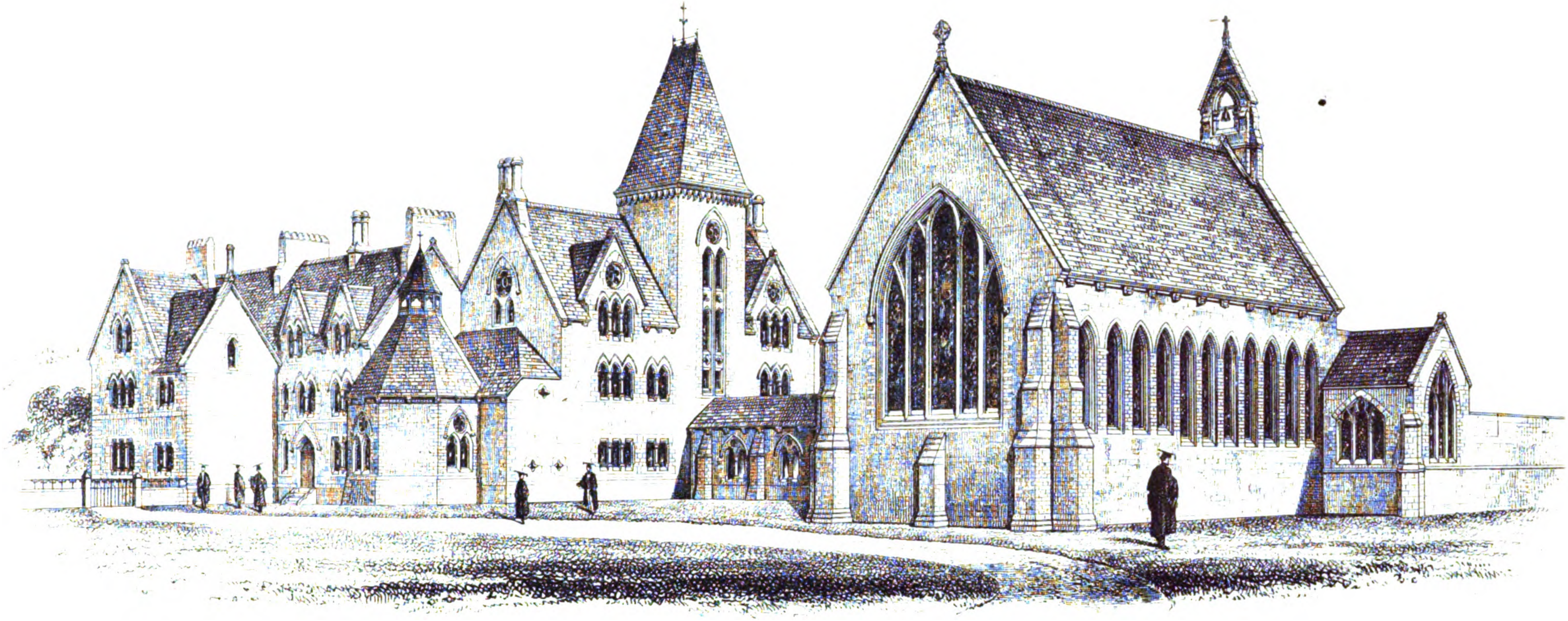
(With an Engraving.)

The group of buildings of which we give a view and plan in the accompanying illustration have lately been completed, and are now opened as a public grammar school, of which the Rev. John D. Williams, M.A., is the head master. It comprises accommodation for forty borders, with masters' residence, and school and class rooms on a scale sufficient to receive a considerable number of scholars resident in the town of Brecon and its neighbourhood, besides those who are boarders in the establishment. The site of the buildings is just outside the town, on the Merthyr-road, among the fertile meadows on the banks of the Usk, and beneath the majestic and towering range of the Brecon Beacons. This position was fixed by the ancient buildings belonging to the College, which have been restored, utilised, and added to, to render them fit for their present purpose. These old buildings were the remains of a monastery suppressed in the reign of Henry the VIIIth, and consisted of the chapel seen in the foreground of our illustration, and parts of an old Decanal house, now converted into the schoolroom and library. The chapel was originally the chancel of the monastic church, the extent of which may be seen on the plan by the enclosure walls of the yard to the west of the chapel, and which are, in fact, portions of the very walls of the old church itself. The nave and chancel seem to have been one parallelogram, without structural division, or even chancel arch, as is not unfrequent in the locality, and there was a north aisle extending only as far as the nave, the treatment of which was very unique, as there are unmistakeable proofs that it was lighted by a series of five large dormer gables, of which one gable (seen in the view) exists nearly in its original condition. Between the gables the aisle wall received the lean-to roof continuous with that of the nave.

The walls which now form the western wall of the chancel, and enclose westwards the eastern portion of the aisle, as may be seen by the plan, date less than a century back, and the bell-turret upon the west wall of the chancel, the copings and cross of the eastern gable, and the side eavescourses and corbels, and the roof, are part of the recent works, all traces of original work having been previously destroyed. The interior of the chapel contains a founder's monument, a beautiful range of sedilia and piscinæ, and rich arcades to the side windows, all of the finest thirteenth century work, executed in hard grey sandstone. The school room and library, which formed the principal apartments of the old Decanal house, still retain their noble oak roofs and stone chimney-pieces of fourteenth century work, and a few other old details.

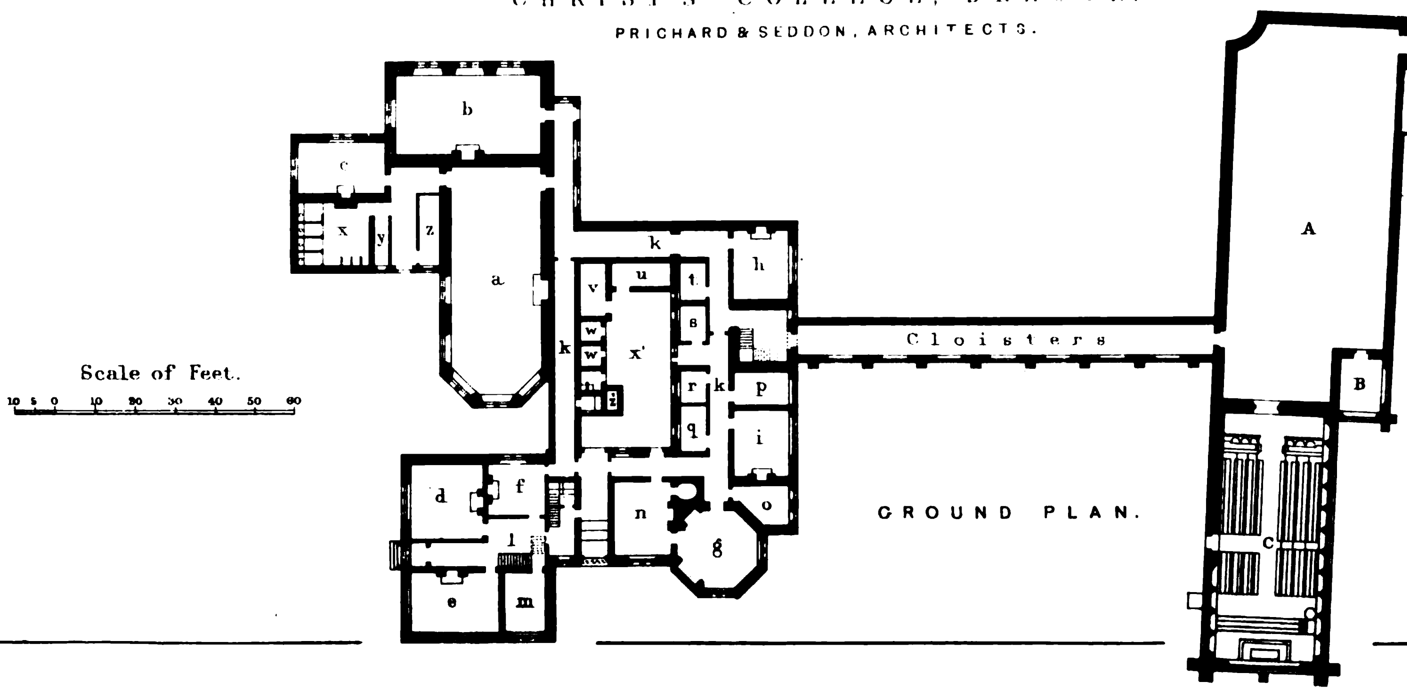
The building in the centre of the group contains the boys' dormitories, with a proposed tower over the general staircase. This tower has been omitted for the present, from the insufficiency of the funds. An octagonal kitchen projects from this building, and forms a prominent feature, as may be seen by the view. The masters' house is the furthest portion of the group.

The expenditure up to the present time has been about



CHRIST'S COLLEGE, BRECON.

PRICHARD & SEDDON, ARCHITECTS.



GROUND PLAN.

J.R.Jobbins.

£10,000. The buildings were erected from the design of Mr. John Prichard, then of the firm of Prichard and Seddon of Llandaff. The chapel contains some striking stained glass by Messrs. Clayton and Bell, and rich tile decoration by Mr. Godwin of Lugwardine, from designs by Mr. Seddon.

References to Plan.

a. School room.	*r*. Boots.
b. Library.	*s*. Hall pantry.
c. Class room.	*t*. Matron's store.
d. Dining room.	*u*. Beer cellar.
e. Drawing room.	*v*. Root house.
f. Study.	*ww*. Wood and coal.
g. Kitchen.	*x*. Yard.
h. Matron's room.	*x*¹. Back yard.
i. Servants' hall.	*y*. Lavatory.
k. Corridor.	*z*. Hats and cloaks.
l. Staircase hall.	*z*¹. Ash pit.
m. House pantry.	*A*. Site of nave and aisle of the old church.
n. Scullery.	*B*. One bay of aisle now enclosed.
o. Larder.	*C*. Chapel, originally chancel, of the old church.
p. Cleaning room.	
q. Cook's pantry.	

THE CATHEDRAL OF ST. CANICE, AND OTHER ARCHITECTURAL ANTIQUITIES, KILKENNY, IRELAND.*

By T. Newenham Deane, F.R.I.B.A.

The Cathedral of Kilkenny being now in process of restoration many things have been brought to light connected with its original design, which may make a short paper on the subject interesting to the Institute. In connexion with the description of the Cathedral, I purpose touching briefly on the other buildings of interest which still exist in Kilkenny—ecclesiastical, military and secular.

Under the first of these heads I would enumerate the Cathedral; the Augustinian Abbey of St. John the Evangelist, whose charter, in the "Monasticon," is dated 1220, founded by William Marshall, the elder, Earl of Pembroke; The Dominican Abbey, founded by William Marshall, the younger, 1225, dedicated to the blessed Trinity, commonly called the Black Abbey; the Franciscan Abbey, founded 1230; St. Mary's Church, probably finished 1328; the Vicar's Hall, near the Cathedral, and other buildings forming part of the Cathedral establishment. Under the second head, the Castle forms the most interesting object of attention. Under the third head, I would mention the Hospital founded by Sir Richard Shee, 1581, and several houses dating from the Sixteenth Century and onwards.

The Cathedral.—A full description of this beautiful and interesting structure has been given by the Rev. James Graves, in his book on the "History and Antiquities of Kilkenny," from which, and other authorities, I have made a few notes. St. Canice, to whom this church was dedicated, was a man of distinguished piety, the intimate friend of St. Columbkill, on the model of whose foundation at Iona he founded a monastery at Aghaboe, in Upper Ossory, which existed in 577. The earliest allusion to Kilkenny, in "The Four Masters," A.D. 1085, mentions that Cael Cainnagh, or the Church of Canice, was partly burnt—probably a wooden structure, which was shortly after rebuilt, and destroyed by fire 1114. After this second destruction, it appears to have been raised again, of more costly materials. Numerous carved stones, of twelfth-century work, have been found built into the walls, and under the paving of the present church; and extensive foundations at the eastern end of the Cathedral indicate that a church of that period existed. In 1189, William, Earl Marshall the elder, through a marriage with Isabella, only child of Richard FitzGilbert, Lord of Ossory, became Earl of Pembroke and Lord of Leinster. With this nobleman commences the authentic history of Kilkenny. He was appointed Governor of the Kingdom of Ossory, by Prince John, 1191—Richard I. being then in exile. He erected the castle 1192, returned to England 1194, came back to Ireland 1207, *rebuilt* the Castle of Kilkenny, and gave a charter to the town, under which it still enjoys certain privileges. In 1202, we find the see of Ossory at Aghaboe, St. Canice's original foundation, under the prelacy of Felix O. Dullany, who was succeeded by Hugh Rufus, or De Rous, an English Augustinian canon, and the first English Bishop of Ossory. This prelate exchanged the see lands of Aghaboe for others at Kilkenny, belonging to the Lord of Leinster, and probably used the church which he found on the site of the present cathedral, as it is stated "he did nothing further for his episcopal see." From manuscripts in the Ormonde Collection, we find that a cathedral existed in 1229. This may have been the ancient church of Dullany's time, or the choir of the present church, used as a cathedral prior to the completion of the structure. Bishop Hugh de Mapleton carried on the work with great vigour from 1251 to 1256, and nearly brought it to a finish. Geoffry St. Leger, 1260, completed the cathedral, at great cost. From the foregoing remarks, it will be seen that the present structure in its main features, was built between the years 1251 and 1260, and possibly may have been commenced before 1229. In 1332, we find that the belfrey fell, breaking the side chapels. For twenty years the cathedral remained in a ruinous condition, when, in 1354, the tower was restored, the vaulting of which was put in by Bishop Hackett, 1460 (this prelate was architect of the Convent of Bathalla in Portugal). In 1338, Bishop Ledred filled the windows with beautiful stained glass, particularly the eastern ones, which represented the whole life of Our Lord. So beautiful were they that Rennuccini, the Pope's Nuncio, who saw them in 1645, offered £700 for the stained glass, which was declined by the then prelate David Roth. In 1650, those windows were demolished by Cromwell, who broke the monuments and "took away the great and goodly bells, and threw down the roof thereof." On the 12th of August, 1658, the Commonwealth passed "An Act for the Reparation of Churches," which does not appear to have taken effect on the Cathedral. In 1660, Bishop Williams, finding the church in this ruinous condition, commenced to repair it, expending on the choir alone £400. From this date until 1675, the Cathedral underwent sundry repairs, and was supplied with a ring of four bells at a cost of £246 13s. 10d. In 1677, Bishop Parry supplied plate, value £100; and, 1756, Bishop Pocock, finding his cathedral almost totally neglected, its roof tumbling down, and its monuments broken, commenced the work of renovation, and with the assistance of his chapter placed the Cathedral in the condition in which it has been handed down to us when the present restoration was commenced. The fittings of the choir put up by Bishop Pocock, being of a Grecian character, were quite at variance with the architecture of the cathedral, as were also the stucco ornaments which covered the ceiling. In 1863, the roofs were found to be much decayed, and it was then determined to restore the church, as far as possible, to its original condition.

The accompanying plan gives the general arrangement and principal dimensions of the Cathedral, which is the second in point of magnitude in Ireland. The total length is 226 feet, breadth at trensept 128 feet. The chapels on either side of the choir, marked upon the plan H and K, have given rise to various discussions as to their use; until the present alterations were commenced, the only access to these was through small doors, one opening from the north transept, the other from the Lady chapel. The removal of the old plaster on walls, disclosed the fact that these chapels were divided from the choir by large arches, with beautiful mouldings and corbels. Similar arches opened into the transepts. The fall of the tower, in 1360, carried in its ruin part of the adjoining arches and walls of choir and transepts: when the tower was rebuilt, the injured walls were carried up in solid masonry, and thus the arches alluded to were blocked up. One of the principal features in the present restoration is the rebuilding of these arches, completing their mouldings and corbels. The clerestory windows of choir, five at either side, which were also built up, are likewise being restored.

The church appears to have undergone several changes, shortly after its erection in the thirteenth century: for instance, the Lady chapel, although a beautiful specimen of early English work, has clearly been an addition, as the wall of side chapel, shows indications of a continuous arcade of arches, proving it to have been an outer wall. Almost all the windows in the Cathedral have detached and filleted shafts. The east end of choir is very beautiful, having nine lights, with detached and

* Abstract of a Paper read before the Royal Institute of British Architects.

filleted shafts, heads cusped on interior, and semicircular on exterior. The windows (were originally filled with the stained glass, so much admired by the Papal Nuncio, and for which he offered so large a sum in 1660. Funds for the restoration are too limited to allow of those large windows being restored. It is, however, hoped that persons interested in the work may be induced to lend their aid to the accomplishment of this part of the restoration.

The Lady Chapel, owing to defective foundations, has had to be rebuilt, the stones being numbered and used in the work. A complete arcade of arches runs round the two external walls, south and east. On the former there are nine lights, in groups of three, with three drop arches to the interior, with marble filleted pillars and carved capitals. To the east, six lights, grouped in pairs, with drop arches and pillars. This portion of the building will be used as chapter-house.

A small chapel used as the parish church and the two side chapels have each their aumbry and piscina. On the south side of choir has been discovered the site of the sedilia; sufficient indications of the designs remain to enable it to be correctly restored. Higher up, beneath the side windows, are two recesses—the one an aumbry, the other a piscina.

The carved capitals to windows of the side chapels are interesting, as giving a certain weight to the theory put forward by Mr. Skidmore, that early English foliage takes its type from metal work. Each capital has its foliage bound round, as it were, with a hoop. These windows are being carefully restored, no stone being cast aside which can possibly be re-used in the work. On the walls of side chapels the original decoration has been discovered—scrollwork of excellent design in black, orange, and green, running under the wall-plate, the walls covered with what may be called an ashlar pattern. It is proposed to carry out the same mode of decoration in the new work. The roofs of the side chapels owe their design to the only remains of an early English roof I have seen in Ireland, that of Callan Church, removed some years ago.

The roofs of the whole church are new, stone gutters having been used throughout, behind the parapets, which are embattled —the most usual finish for ecclesiastical buildings in Ireland; still, I am of opinion that such was not the original design, but probably dates from the fourteenth or fifteenth century, portions of tombstones of an early date forming part of their structure. Still, they are of sufficient antiquity, and nationality in their character, to make it desirable to maintain them.

The porch is interesting as having been, in 1478, the scene of the murder of Richard, the son of Edmond Mac Richard Butler, in revenge for a similar outrage enacted thirty-five years before under his direction. The mouldings of the entrance archway are very beautiful, and busts, which are introduced in the carving, exhibit as a fastening to the cloak what is now known in Ireland as the Tara Brooch.

On removing the pavement, several patterns of ancient tiles have been discovered, some of which have been forwarded to Messrs. Minton, with a view to their reproduction. The device is generally incised, four tiles forming the complete pattern, two glazed with a black glaze and two with red. A scale pattern has also been discovered, all red. Several stone coffins have been brought to light; and an effigy, face downwards, forming part of the modern paving, has been revealed. On opening an ancient vault, which is supposed to have belonged to the Ormonde family, a leaden coffin was discovered. The profile of the body, having been copied in lead, formed the upper portion of the coffin; the under portion is shaped in such a manner as would have fitted into the hollow of one of the stone coffins which have been dug up. In this same vault a leaden urn, supposed to contain the heart of Viscount Mountgarret, was discovered.

In examining the ruins of Ireland, it is interesting to trace the influence of a particular architect, or band of workmen, in various districts. In Kilkenny I trace the workmen who were employed at Christ Church, Dublin, and probably at Boyle Abbey—the filleted shaft and writhed angle shaft, as in north transept doorway, are to be found in all three. In Co. Galway, the tracery of altar tombs and windows evinces that the same mind was there at work, if it was not executed by the same workmen. In Waterford, again, I see the handiwork of the Kilkenny craftsmen. In mentioning this, I do not wish to infer that one thing is a servile copy of another, but that there is sufficient to lead the enquirer to the conclusion that certain men carried their art from place to place, and were esteemed for their talent in architectural construction.

The general details of Kilkenny Cathedral are much simpler than is usual in English churches, owing to the hardness of the materials employed, and limited means; but the proportions, as in most Irish churches, are very good, and the simplicity and massiveness of the work give an idea of size which elaborate tracery and multiplicity of mouldings, would not have produced.

The work of restoration has been pressed on with vigour. The roofs are finished, the arches between the choir and side chapels opened, the prebend's stalls in hand; still, much remains to be done. The tower must rest in its present unfinished state until funds are collected for its completion. Considerable portions of the common hall still exist, particularly the gable end, which has a very interesting window.

At the north-west angle of the Cathedral Close is the library, founded by Bishop Otway, 1676. In mentioning the mode in which his bequest was to be expended, he enumerates "claims for every particular book." At the eastern corner of the south transept stands one of the round towers almost peculiar to Ireland, and so ably written on by the celebrated antiquarian. Dr. Petrie, whose theory that they are of a Christian origin is, in my opinion, thoroughly borne out by the following facts. The tower, which is one hundred feet in height, was filled to a considerable depth with accumulated rubbish, principally the deposit of birds. This was removed, and on digging two feet below the outside level, human remains were discovered, contained in wooden coffins, placed partly under the foundations. The tower must have been erected on, or nearly on, the surface of the ground, which ground must have been a place of burial previous to its erection; and the position of the remains, with reference to the points of the compass, indicates that they were those of Christians. It is curious that a structure of such height and small base, should have stood so well, resting on such a foundation.

Priory of St. John—The oldest monastic foundation in Kilkenny is the Priory of St. John, founded by William Marshall, the elder, earl of Pembroke. In 1645, when the abbeys of Ireland were everywhere being restored, the Augustinians claimed their abbey; but the Jesuits, being the more powerful body, opposed the claim, and were confirmed in their occupation by Rinnuccini, the Pope's Nuncio. Dr. Ledwick states that a portion of the abbey was pulled down to make room for an infantry barrack. Sufficient however, remains to show much of its original extent and beauty. Fifty-four feet of south side of choir is a continuous arcade of lancet windows, the largest pier being only nine inches wide. It is to be regretted that, in converting this ruin into a modern church, the windows have been cut down, especially the eastern one, and every second light stopped up. These ruins contain several monuments and effigies of great interest. The design of the chapter house at the Cathedral was taken, evidently, from the choir of St. John's.

The Franciscan Abbey, situated among orchards near the river, exhibits some interesting details. The east end is lighted by five lancets. The choir and tower of this abbey alone remain.

The Dominican or Black Abbey, founded by William Marshall, the younger, 1225, has lately been restored by J. J. MacCarthy, Esq., Architect, to whom I am indebted for the plan which accompanies this paper. It is interesting as showing how the simple form of the Dominican or Franciscan churches were added to, the most usual shape being two parallelograms, nave, and choir, sometimes with a narrow tower between. Frequently this tower is an addition. In the present instance the usual addition of the two chantries has been extended to aisled transept and nave. The top of the tower is a particularly good specimen of crenellated battlement and truncated roof.

St. Mary's has little of its original architecture worth describing; the church has been completely modernized. Surrounding the church are several tombs of great interest, principally of the fifteenth and sixteeth century, belonging to the families of Archer and Shee.

(*To be continued.*)

CELESTIAL PHOTOGRAPHY.

By A. Brothers, F.R.A.S.

The credit of having produced the first photograph of a celestial object is generally given to the late Mr. Bond, of Cambridge, U.S.; but it appears from a paper by Professor H. Draper, of New York, published in April, 1864, that in the year 1840 his father, Dr. J. W. Draper, was the first who succeeded in photographing the moon. Dr. Draper states that at the time named (1840) it was generally supposed the moon's light contained no actinic rays, and was entirely without effect on the sensitive silver compounds used in daguerreotyping. With a telescope of 5-inch aperture Dr. Draper obtained pictures on silver plates, and presented them to the Lyceum of Natural History of New York. Daguerre is stated to have made an unsuccessful attempt to photograph the moon, but I have been unable to ascertain when this experiment was made. Mr. Bond's photographs of the moon were made in 1850. The telescope used by him was the Cambridge (U.S.) refractor of 15 inches aperture, which gave an image of the moon at the focus of the object glass 2 inches in diameter. Daguerreotypes and pictures on glass mounted for the stereoscope were thus obtained, and some of them were shown at the Great Exhibition of 1851, in London. Mr. Bond also proved the advantage to be derived from photographs of double stars, and found that their distances could be measured on the plate with results agreeing well with those obtained by direct measurement with the micrometer Between the years 1850 and 1857 we find the names of Father Secchi in Rome, and MM. Berch and Arnauld in France; and in England Professor Phillips, Mr. Hartnup, Mr. Crookes, Mr. De la Rue, Mr. Fry, and Mr. Huggins. To these may be added the name of Mr. Dancer, of Manchester, who, in February 1852, made some negatives of the moon with a 4½-inch object glass. They were small, but of such excellence that they would bear examination under the microscope with a 3-inch objective, and they are believed to be the first ever taken in this country. Mr. Baxendell and Mr. Williamson, also of Manchester, were engaged about the same time in producing photographs of the moon.

The first detailed account of experiments in celestial photography which I have met with is by Professor Phillips, who read a paper on the subject at the meeting of the British Association at Hull, in 1853. Professor Phillips does not enter very minutely into the photographic part of the subject, but he gives some very useful details of calculations as to what may be expected to be seen in photographs taken with such a splendid instrument as that of Lord Rosse. It is assumed that an image of the moon may be obtained direct of 12 inches diameter, and this when again magnified sufficiently would show black bands 12 yards across. What may be done remains to be seen, but up to the present time the Professor's anticipations have not been realized. We have next, from the pen of Mr. Crookes, a paper communicated to the Royal Society of London, in December 1856. Mr. Crookes appears to have obtained good results as early as 1855, and, assisted by a grant from the Donation Fund of the Royal Society, he was enabled to give attention to the subject during the greater part of the year following. The details of the process employed are given in the paper with much minuteness. The telescope used was the equatorial refractor at the Liverpool Observatory, of 8 inches aperture and 12½ feet focal length, producing an image of the moon 1·35 inch in diameter. The body of a small camera was fixed in the place of the eyepiece, so that the image of the moon was received in the usual way on the ground glass. The chemical focus of the object glass was found to be 8-10ths of an inch beyond the optical focus, being over corrected for the actinic rays. Although a good clock movement driven by water power is applied to the telescope, it was found necessary to follow the moon's motions by means of the slow motion handles attached to the right ascension and declination circles, and this was effected by using an eyepiece, with a power of 200 on the finder, keeping the cross wires steadily on one spot. With this instrument Mr. Hartnup had taken a large number of negatives, but owing to the long exposure required he was not successful; but with more suitable collodion and chemical solutions, and although the temperature of the observatory was below the freezing point, Mr. Crookes obtained dense negatives in about four seconds. Mr. Crookes afterwards enlarged his negatives twenty diameters, and he expresses his opinion that the magnifying should be conducted simultaneously with the photography, by having a proper arrangement of lenses, so as throw an enlarged image of the moon at once on the collodion plate; and he states that the want of light could be no objection, as an exposure of from two to ten minutes would not be too severe a tax upon a steady and skilful hand and eye.

Mr. Grubb read a paper on this subject before the Dublin Photographic Society on May 6th, 1857. After referring to the fact that he found the actinic focus of his object glass to be longer than the visual (thus agreeing with Mr. Crookes) he states it to be generally understood that, in a compound object glass made as nearly achromatic as possible, the actinic focus is shorter than the visual. The most valuable portion of Mr. Grubb's paper is the suggestion for a piece of apparatus to be attached to the part connected with the telescope for holding the dark frame, which he proposes may be so arranged as to follow the moon's motion in declination; and he gives the following description of a contrivance used by Lord Rosse, and which is suitable for telescopes not equatorially mounted:—"On a flat surface attached to the telescope, and parallel to the plane of the image, is attached a sliding plate, the slide being capable of adjustment to the direction of the moon's path at the time of operating. The slide is actuated by a screw moved by clockwork, and having a governor or regulator of peculiar construction, which acts equally well in all positions. The clockwork being once adjusted requires no change; but the inclination of the slide must be effected by trial for the moon's path at the time of taking the photograph." This idea originated with Mr. De la Rue, Lord Rosse's share in it arose from his having applied a clock motion to the apparatus. The telescope used by Mr. Grubb is $12\frac{1}{10}$ inches aperture and 20 feet focus, giving an image $2\frac{1}{16}$ inches diameter in from ten to forty seconds. Mr. Fry, in 1857, commenced his experiments on the moon with an equatorial telescope, the property of Mr. Howell, of Brighton. The object glass of this instrument is 8½ inches diameter and 11 feet focus, and gave an image of the full moon in about three seconds; but under very favourable circumstances a negative was made in a single second. Mr. Fry appears to have removed the eyepiece of the telescope, and in its place a board was fixed having a screw adjustment, so that a plate holder could be moved backwards and forwards on the board (graduated to tenths of an inch) for the purpose of finding the actinic focus, which was ¾ inch beyond the visual. He found that this position of the chemical focus was variable, owing, as he thought, to the varying distance of the moon from the earth, but, as suggested by Mr. De la Rue, it might arise from the length of the telescope tube having altered through change of temperature.

In 1858 Mr. De la Rue read an important paper before the Royal Astronomical Society, from which it appears that the light of the moon is from two to three times brighter than Jupiter, while its actinic power is only as 6 to 5, or 6 to 4. On December 7th, 1857, Jupiter was photographed in five seconds and Saturn in one minute, and on another occasion the moon and Saturn were photographed just after an occultation of the planet in fifteen seconds. The report of the council of the Royal Astronomical Society for 1858 contains the following remarks:—"A very curious result, since to some extent confirmed by Professor Secchi, has been pointed out by Mr. De la Rue, namely, that those portions of the moon's surface which are illuminated by a very oblique ray from the sun possess so little photogenic power that, although to the eye they appear as bright as other portions of the moon illuminated by a more direct ray, the latter will produce the effect called by photographers 'solarisation,' before the former (the obliquely-illuminated portions) can produce the faintest image." And the report also suggests that the moon may have a comparitively dense atmosphere, and that there may be vegetation on those parts called seas.

At the meeting of the British Association at Aberdeen, in 1859, Mr. De la Rue read a very valuable paper on celestial photography. Mr. De la Rue commenced his experiments about the end of 1852, and he used a reflecting telescope of his own manufacture of 13 inches aperture and 10 feet focal length, which gives a negative of the moon averaging about $\frac{1}{10}$ of an inch in diameter. The photographs were at first taken at the side of the tube after the image had been twice reflected. This was afterwards altered so as to allow the image to pass direct to the collodion plate, but the advantage gained by this method was not so satisfactory as was expected. In taking pictures at the side of the tube, a small camera box was fixed in the place of the eye-piece, and at the back a small compound microscope was attached, so that the edge of a broad wire was always kept in contact with one of the craters on the moon's surface, the image being seen through the collodion film at the same time with the wire in the focus of the microscope. This ingenious contrivance in the absence of a driving clock was found to be very effectual, and some very sharp and beautiful negatives were thus obtained. Mr. De la Rue afterwards applied a clockwork motion to the telescope, and his negatives taken with the same instrument are as yet the best ever obtained in this country. The advantage of the reflecting over the refracting telescope is very great, owing to the coincidence of the visual and actinic foci, but it will presently appear that the refractor can be made to equal if not excel the work of the reflector. In this brief history of the subject of celestial photography, I have not referred to anything which has been done in making photographs of the solar spots, but the matter must not be altogether passed over. The first step in this direction appears to have been taken in France, in 1845, by MM. Fizeau and Foucault, but it is chiefly due to the efforts of Mr. De la Rue that so much useful work has been done in heliography. In 1860 Mr. De la Rue and his staff of assistants performed one of the greatest feats yet recorded in this branch of the art of photography, having succeeded in obtaining several beautiful negatives of the various phenomena seen only during total eclipses of the sun, and two negatives were obtained during the totality. One question of much interest to astronomers was determined by this great experiment. The red prominences or flames generally seen as issuing from the edge of the moon were proved to belong to the sun. Photographs of the sun are taken daily, when the weather is favourable, at the Kew observatory, and also by Professor Selwyn, at Ely. With the Kew photoheliograph, pictures of the sun's spots have been made on the scale of 3 feet to the sun's diameter. Much, however, remains to be done. The light of the sun is much in excess of what is required to obtain a collodion picture, so that the loss of light consequent on the necessary interposition of lenses, and the distance of the plate from the instrument, can be no objection; and for these reasons I have very little doubt that, with apparatus suitably arranged, photographs of spots and groups of spots will be obtained of very much larger diameter than any yet taken.

The 'Quarterly Journal of Science,' for April 1864, contains the next important paper on celestial photography. It is by Dr. Henry Draper, one of the Professors at the New York University. On his return to America, after paying a visit to Parsonstown, where he had the advantage not only of making some observations with Lord Rosse's large reflector, but also of seeing the method there pursued in grinding and polishing mirrors, stimulated by what he had seen, it was determined to build an observatory, and to construct an instrument to be devoted solely to celestial photography. The speculum used by Dr. Draper is 15½ inches in diameter, and 12½ feet focal length; but this was afterwards superseded by one of glass on Foucault's principle. The great labour involved in a work of this character may be judged of by the fact that Dr. Draper ground and polished more than 100 mirrors, varying in diameter from 19 inches to ¼ inch; but he appears at last to have secured a good instrument. The chief points to be noticed in this article are, that instead of driving the telescope in the usual way by means of a clock, the frame carrying the glass plate was made to move on the plan previously referred to. Instead of clockwork to effect this motion, an instrument called a "clepsydra" was used. It has a weight and a piston rod, which fits into the cylinder filled with water, which is allowed to escape by means of a stopcock, and can be regulated with great exactness, so as to follow the object. The large number of 1500 negatives are stated to have been taken at this observatory, some of which would bear magnifying twenty-five diameters (the paper says, times, but I assume this to be an error, as a negative must be very bad if it will not bear more than five diameters, or twenty-five times). As the average size of the negatives was $1\frac{1}{10}$ inch, an increase of twenty-five diameters would give an image of the moon nearly 3 feet in diameter. I have not seen the prints from these negatives, and have never heard anything of the quality of the work produced by this telescope; but it may be stated that Dr. Draper writes as if the negatives were of the best quality, and encourages others to follow his example. Nearly a quarter of a century has elapsed since the moon was first photographed in America, and our friends on that side of the Atlantic have not been idle in the interval. To an American gentleman we are indebted for the best pictures of our satellite yet produced, and it is difficult to conceive that anything superior can ever be obtained; and yet with the fact before us that Mr. De la Rue's are better than any others taken in this country, so it may prove that even the marvellous pictures by Mr. Rutherford may be surpassed.

Mr Rutherford appears, from a paper in the 'American Journal of Science,' for May of the present year, to have begun his work in lunar photography in 1858, with an equatorial of 11¼ inches aperture, and 14 feet focal length, and corrected in the usual way for the visual focus only. The actinic focus was found to be $\frac{1}{10}$ inch longer than the visual. The instrument gave pictures of the moon, and of the stars down to the fifth magnitude, satisfactory when compared with what had previously been done, but did not satisfy Mr Rutherford, who, after trying to correct for the photographic ray by working with combinations of lenses inserted in the tube between the object glass and sensitive plate, commenced some experiments in 1861 with a silvered mirror of 13 inches diameter, which was mounted in a frame and strapped to the tube of the refractor. Mr. Rutherford enumerates several objections to the reflector for this kind of work, but admits the advantage of the coincidence of foci. The reflector was abandoned, and a refractor specially constructed of the same size as the first one, and nearly of the same focal length, but corrected only for the chemical ray. This glass was completed in December last, but it was not until March 6th, 1865, that a sufficiently clear atmosphere occurred, and on that night the negative was taken from which some prints were made, which were exhibited at the meeting.

Every writer on this subject speaks of the difficulties encountered from optical, instrumental, and atmospheric causes; and to this may be attributed the fact that we have so few of our amateur astronomers giving their attention to the subject. Another reason may be that comparatively few of those who possess telescopes may have the necessary photographic knowledge; but surely some friend having this knowledge might be found who would be willing to spare a few hours occasionally to assist in taking negatives of the stars, planets, or of the moon. The reason, then, why this subject is brought before your notice in this paper is, that it is believed that the apparatus I use is—in some particulars—more simple than any heretofore described, and as it can be used with any kind of telescope, a greater number of amateurs than are now engaged in it may be induced to follow this fascinating branch of photography. It will have been noticed that when particulars of the apparatus have been given, the writer has spoken of a *small camera*, which has been fixed at the eyepiece end of the telescope. As to how this was effected I have seen no description, and as no camera box is required I need not enter into any supposition as to the mode in which it may be done. Before deciding what was necessary to be done, it occurred to me that the telescope tube itself is the camera, and all that was required was the means of fixing the dark frame or plate holder. If the telescope is pointed to the moon, the eyepiece removed, and a piece of ground glass held between the eye and the aperture, the image will be seen on the glass, and we require then the means of holding the sensitive plate steadily near the same place. All that is needed is a brass tube about four or five inches long, of the size exactly fitting the tube of the telescope in the place of the eyepiece. In some cases the sliding tube of the eyepiece may be unscrewed and used for this purpose. At one end of this tube a thread is cut, and is made to screw into a piece of metal plate (in the centre of which is a circular aperture of the same size as the tube), of the same dimensions as the dark frame. Attached to the plate holder are clips accurately fitting the brass plate, but so that the frame will easily slide off and on without disturbing the telescope. This is all the additional apparatus required to enable photographs of the moon or any other celestial object to be made. A separate frame for the ground glass is not necessary; it must be cut to fit the dark frame, and while in use can be held by slight springs fixed inside the frame at the sides.

The method for ascertaining the actinic focus may be stated in a few words. With the rack motion adjust the focus for distinct vision on the ground glass, and then mark the tube and also the sliding part of the telescope. Although very unlikely to be of the slightest use, unless taken with a reflecting telescope, a picture may now be taken; it will at least serve to give some idea of the proper exposure. If the chemical and visual foci are not coincident the image will have a blurred appearance. Before exposing the next plate turn the adjusting screw so as to lengthen the tube about the sixteenth of an inch, and so proceed until, by the greater distinctness of the image, it is seen that the chemical focus is found. At every change of the focus a slight mark should be made on the tube, and when the true focus is satisfactorily determined the marks should be made distinctly visible; and in all future experiments with the same instrument the focus will be always at or very near the same place. Should it be found that the indistinctness increases, it will of course be found necessary to try in the other direction. The appearances arising from atmospheric disturbances are very much the same as when the object is out of focus; experience alone will enable the operator to determine from which cause the defect proceeds. It is assumed that the telescope is provided with a driving clock; when such is the case every care should be taken that all the parts are clean, and, when necessary, oiled or greased, so that the motions may be as smooth as possible.

In photographs of the moon in the phases prior to and after the full, the side opposite to the sun is always too light or "burnt up," while those parts near the terminator are often so dark that only the tops of the craters and peaks are visible, although in the telescope a clear and bright image can be seen. The cause of this must be that the exposure, if continued long enough to bring out all the eye can see on the darker side, would entirely obliterate the details on the brightly illuminated portions of the moon's surface. Mr. De la Rue's suggestion as to why the dark side of the moon has so little actinic effect, has been already referred to. I would suggest that, as the light of the full moon is 100,000 times weaker than that of the sun, the twilight* on the moon's surface must be very much less, and consequently the actinic effect of the light is lessened in the same way as at a corresponding time on the earth. The question, then, of photographing the terminator is only one of time, and in order to remedy the defect spoken of to some extent, I have used diaphragms such as are shown in the engraving. In the tube E, openings are made on opposite sides, and wide enough to admit the diaphragms to be used without touching the tube. The diaphragm must be of the proper length and width to shut off the moon's light until the plate is ready for exposure. The shape of the diaphragm will suggest which form should be used according to the moon's age. The exposure should be made with the full aperture for as many seconds as previous experiments have proved to be necessary for the bright side, and the diaphragm then gently moved and kept in motion, gradually approaching the darkened side. By this means the exposure may be regulated, and the great differences in the light and dark sides of the moon may be modified.

As to the processes employed, each experimenter must adopt the one he finds in his hands gives the best result. It seldom happens that two operators can produce the same effects with apparently the same chemicals. Experience has shown me that the ordinary patent plate glass (carefully selected, so as to be free from scratches and other defects) is preferable to the white patent plate, having found that after a time the surface becomes covered with a kind of dew, or "sweat," as it is termed, owing to the decomposition of some of the salts used in the manufacture. The collodion used was made for me by Messrs. Huggon and Co., of Leeds; it is very quick, free from structure, and suitable for iron development. I prefer to develop with an iron solution, using only sufficient to cover the plate; and with this developer and collodion, when the plate has been properly exposed, a negative can be obtained which will not require intensifying afterwards. Not having had sufficient experience with pyrogallic acid, I cannot speak with confidence as to any advantage it may possess in giving fine texture to the negative. With the bath and collodion exactly in the proper state, there is no doubt that with this acid negatives may be had as quickly as with iron; but it is extremely difficult to have everything constantly in the best working order. Unless the greatest attention be given to this matter, the time of exposure is so much increased, that iron, for this reason, must have the preference. Upon the character of the image after development entirely depends the value of the enlargement to be made from it, and in this direction there is much room for improvement. Even in the best negatives yet made defects from this cause are very apparent. The microscopic photographs by Mr. Dancer have the finest texture, and will consequently bear greater magnifying than any other photographs I have ever seen, but the process by which they are made is not published.

The weather in this country is so very uncertain, and success in this branch of photography is so entirely dependent on the state of the atmosphere, that it is necessary to be always prepared to take advantage of a favourable night. I have a small cupboard placed in a convenient part of my house, where there is a supply of water, and the temperature is always much above the air outside. This cupboard is just large enough to hold a small glass bath fixed at the proper angle ready for use, also the bottles for collodion, bath, developing and fixing solutions, and other little requisites. This arrangement is so convenient, that when there is a prospect of getting a negative I can set the telescope, prepare the plate, and take a negative in less than ten minutes. But when there is a chance of two or three hours' work an assistant is desirable, as the best results can only be obtained when one's attention is chiefly devoted to the careful adjustment of the apparatus connected with the telescope. The convenience of the plan adopted may be judged of by the fact that, on the evening of the partial eclipse of the moon, the 4th October last, in four hours I succeeded with the help of two assistants in taking no less than twenty negatives, and the telescope was several times disturbed to oblige friends who desired to see the progress of the eclipse through the instrument, but the apparatus was quickly readjusted, although possibly in some cases with slight loss of definition in the negative, through haste. At a previous meeting I described how these negatives were made, but it may be interesting to refer to the fact that, while the fifteenth of the series was taken the telescope was at rest. The clock had been disconnected for readjustment, and it was forgotten when the plate was ready for exposure, consequently the moon had moved partly off the plate, and the negative shows a portion only; but the exposure was so short that the eye fails to detect any difference in the sharpness of this and the others, which were all taken when the clock had been watched and carefully regulated for the moon's motion. This fact is, I think, of some interest, as it shows that about the time of full moon, when the light is of the greatest intensity, pictures may be made with telescopes not equatorially mounted. My telescope is a refractor of 5 inches aperture and 6 feet focal length, giving an image of the moon, averaging about $\frac{11}{16}$ of an inch in diameter. The actinic focus is one-tenth of an inch longer than the visual. The object glass is of Munich manufacture, and is mounted by Mr. Dancer on the Sissons, or English plan, with double polar axis. The hour circle is 26 inches in diameter, and is used also as the driving wheel, having teeth cut in the edge, in which a screw works, connected with the driving clock by a rod, and which can be instantly disconnected by means of a cam. The object glass is an excellent one, and the mounting is everything that can be desired.

The negative taken direct in the telescope is but one step towards what we require, that is, the enlarged copy on paper. From the small negative a positive on glass must be made, say of twice or three times the diameter of the original. It will be quite unnecessary here to explain how the enlargement is to be made; but I may remark that the negative should be placed with the film side towards the copying lens, and the resulting positive copy must also be placed in the same way. The enlarged copy or negative will then give the true telescopic appearance of the moon. In the print of the full moon by Mr Rutherford a mistake has been made, arising from the negative or positive copy having been placed the wrong way, and consequently the moon looks as if it had been photographed from the opposite side. The print is a very beautiful one in other particulars, but entirely worthless as a picture of the moon, as the eye can never see it as there represented. I have sometimes taken two negatives on the same plate. It will be seen in the engraving that the dark slide is not quite central with the telescope, so that by reversing the plate after one exposure a second picture can be taken. In photographing the planets Mr. De la Rue has allowed the object to move on for a few seconds, the telescope meanwhile being at rest, and thus four or five

* In the absence of an atmosphere on the moon there can be no twilight such as we see on the earth. The meaning, therefore, of this sentence may be misunderstood. It is intended to say that on those parts of the moon, enlightened only by the oblique rays of the sun, the light is so diminished that the actinic effect, is lessened as it is on the earth shortly before sunset and during twilight, when it is well known that a much longer time is required to obtain a photograph.

negatives can be taken in a very short time on the same plate. It has occurred to me that by having a frame made "landscape" way, instead of upright, and in place of having four clips such as K, there might be a kind of groove at top and bottom, so that after taking the first negative, and the light shut off, by moving the plate about an inch, at least three negatives might be taken on the same plate—or a "shifting back" might be adapted. The advantages of this plan are that different exposures might be tried, and the development continued for the one or two which promised the best results. This method would effect a great saving of time, which on a fine night is of great importance. With a Barlow lens I have made some negatives, which have shown that when the same care has been taken to find the actinic focus negatives of a much larger size may be made, and in a very short time. The image is increased from 11-16ths to 1½ inch, and the time of exposure at full moon was two seconds. The fittings of the lens are so arranged that three different sized negatives may be taken.

UNSINKABLE OR RAFT SHIPPING.*

By Charles Atherton.

The aggressive powers of ordnance *versus* the defensive powers of iron armour plating still constitutes, after years of experience and millions of expenditure, an inquiry, the solution of which fluctuates with every alternate test of their relative capabilities. The introduction of armour plating induced improvements in ordnance; the ironsided floating batteries, which successfully withstood the fire from the Kilburn Fort in 1855, originated and succumbed to the more effective gunnery of 1859. The resisting power of armour plating was consequently increased, and the 4½-inch armour of the "Warrior" was for a time regarded as invulnerable, until the gunnery of 1862 sent both shot and shell through the then most approved model of the "Warrior" target. Attention was then directed to improving the quality of the iron which constitutes the armour plating of ships. The relative efficiency of hammered plates, as compared with rolled plates, was duly investigated, and in the lately launched ship ("Bellerophon") the thickness of the armour plating has been increased to 6 inches, with an inner plate of 1½, making 7½ inches; but now, again, guns throwing shot or shell of 320 lb. weight are found to prevail, and consequently the "Hercules," now being laid down at Chatham, is said to have been designed to carry armour plating of the aggregate thickness of 9 inches, but guns to carry shot of 600 lb. weight are also being prepared, and 1200-pounders are said to be in contemplation, and with little doubt of their being successfully introduced, for the whole matter of practical gunnery, as respects the required quality of materials and the relative proportion of parts to produce any desired effect, is now prosecuted on principles based on the ascertained laws of progressive increase, whereby it is confidently expected that guns may henceforth be constructed of the required capabilities for penetrating any armour plating of which the thickness may have been determined upon. In short, practical gunnery seems now to have become one of the exact sciences in the prosecution of which, with a view to the attainment of any given result, there is no limit but cost. But this is not all. We have hitherto aimed at rendering only the sides of ships invulnerable, and granting that we may attain that end, what of it? What is there to prevent mortar practice being revolutionised, as has been the case with gunnery? Ships may thus be assailed by a new era in mortar practice, hurling down thunderbolts from above, smashing the deck, carrying all before them, and passing through the bottom of the assailed ship. No construction of vessel has yet been devised to meet this mode of attack, so manifestly possible, and therefore so probable, and which, whenever adopted, will again necessitate the reconstruction of our ships of war. Whilst thus threatened from above, we are also threatened with being assailed from below. Ships are now being constructed with submerged peaks for bursting through the sides of vessels below the level of the armour belt—a foul blow insidiously applied, yet lawful by the code of relentless naval honour. Then again, the possible introduction of the steam ram, with monstrous powers of collision, combined with explosion, is not to be ignored. Now, how are the effects of these aggressive forces to be met or averted? and in reply I propound the question—may not the principle of raft-like unsinkability be combined with the partial protection afforded by armour plating, by which combination the guns, mortars, and rams of our opponent may do their worst, but still our vessel shall not sink? By this device there may still be some chance of hostile ships being lashed alongside each other, and victory determined not by the fire of guns, or the bullying of the ram, but by the arbitrament of hand-to-hand personal prowess.

My purpose, therefore, now is, to bring forward for review those elemental bases, a knowledge of which is necessary, in a practical point of view, to a due consideration of the question, whether resistance by armour plating being supplemented with the introduction of the principle of "unsinkability," does not afford the most available means as applied to ships of war for mitigating the horrors that may otherwise result from the destructive powers of modern ordnance and modern device, consequently whereon it has already been publicly avowed, that hostile ships of war will scarcely be able to approach each other without one or the other being sent to the bottom. In pursuance of these views I proceed—

1. To explain the theoretical principle of procedure by which, as distinguished from other plans, I propose to effect the object of preserving ships afloat, notwithstanding the penetration of shot or shell through the sides, deck, and bottom of the ship.

2. To give the theoretical elements, data, and calculations on which the efficacy of the proposed system is based, and show the general mode of practical construction by which the principle may be applied to mercantile shipping and to ships of war.

Various devices have from time to time been adopted for mitigating the danger of sinking to which ships, and especially steam ships, are liable from the occurrence of leakage, rupture from striking on rocks, collisions with other vessels, derangements of machinery, and other accidental causes. These devices have hitherto consisted in dividing the ship into compartments and cellular divisions by means of water-tight bulkheads. Also, in constructing the ship with a double skin or shell, and dividing the space between the two shells into water-tight cells. These devices afford great protection against ordinary casualties, which usually occur singly, and affect the ship only at one spot; but such cases are not analogous to the dangers resulting from the repeated and continuous damages from shot and shell to which ships of war are exposed in action, and whereby all parts of the ship may be penetrated, lengthways, crossways, and vertically, through and through, in a single hour. Several such compartments or cells may be penetrated by a single shot and become immediately filled with water, and this being repeated, the buoyancy of the ship becomes gradually reduced, till she ultimately sinks. This system of cellular air spaces may greatly mitigate the danger of sinking, and prolong the floating of the vessel, but it cannot be said that such ships are unsinkable by shot.

The system which I propose may be denominated the solid raft system, to distinguish it from the hollow cellular system above referred to, and it consists in combining with the structure of the ship such a quantity of solid and non-absorbent materials, lighter than water, as shall support the whole weight of the ship and its load, whereby the vessel shall not sink, though perforated in all directions by shot and shell, or cut down by the stroke of a hostile ram.

Theoretical E ements.—The practical construction of raft shipping with a view to carrying out the principle of "unsinkability," must evidently be based on calculations involving the weight or specific gravity of the materials of which the floating body is to be composed, with reference to the weight or specific gravity of the fluid on which it is intended that the vessel shall float, and which in this case we will assume to be fresh water, which will give about 2·4 per cent. of the displacement in favour of the buoyancy of the vessel when floating in ordinary sea-water. That is, a ship which would carry, say 1000 tons weight, on a fresh-water river, will, at the same draft, carry a load of 1024 tons at sea; and the materials used for ship-building being, as respects their specific gravity, of a fluctuating character, dependent on their quality and condition, it follows that different authorities have not always assigned the same specific gravity to timber of the same denomination. The following table is therefore annexed, as the basis on which the results put forward in this paper have been calculated:—

* Paper read at the Royal United Service Institution.

Materials.	Weight of a cubic foot. Ounces.	Pounds.	Relative sp. gr.
Fresh water at 60°	1000	62½	1000
Sea water	1024	64	1024
Wrought-iron	7760	485	7760
Seasoned oak	800	50	800
Teak	704		
Honduras mahogany	704	44	704
English elm	704		
Seasoned red pine	656	41	656
„ larch, and „ yellow pine	560	35	560
„ white pine	448	28	448
„ poplar	400	25	400
„ cork	192	12	192

Now, as the weight of any floating body is equivalent to the weight of the quantity of fluid displaced by the floating mass, it follows that the load which will be supported by a cubic foot of any material of less specific gravity than water, when floating on water, will be equal to the weight of a cubic foot of water less the weight of a cubic foot of the floating material; consequently, from the foregoing table, we at once deduce the weight that would be supported by each cubic foot of the different materials referred to in the table, when immersed in fresh water, weighing 62¼ lb. per cubic foot. For example:—

			lb.
Each cubic foot of	oak	will carry a load of	62½ − 50 = 12½
„ „	teak, mahogany, elm	„	62½ − 44 = 18½
„ „	red pine	„	62½ − 41 = 21½
„ „	yellow pine	„	62½ − 35 = 27½
„ „	white pine	„	62½ − 28 = 34½
„ „	poplar	„	62½ − 25 = 37½
„ „	cork	„	62½ − 12 = 50½

Hence we deduce the following table, showing the number of cubic feet of each of these materials which, if used as the buoyant material of raft shipping, must be employed to support each ton weight of load with which it will be burdened.

For each ton weight of load there will be required as follows:—

	Cubic feet.
If oak be used as the buoying material	179
„ teak, „ mahogany, „ elm	121
„ red pine	108
„ yellow pine	82
„ white pine	65
„ poplar	60
„ cork	44·36

Thus it appears that the advantages of cork as compared with oak for the floating material is as 179 to 44·36, or about 4 to 1, as respects quantity to be employed for supporting any given load, and as 80 to 4·8, or about 16 to 1, as respects the weight of material for any given load. But cork, or any other material of the same specific gravity as cork, may require the support of some bonding material to give it the solidity which is desirable for its constituting the buoyant material of raft shipping. It is probable that cork and timber may be advantageously built into the ship in alternate layers, whereby a light compound mass, well bonded together, may be formed. The results shown in the following table will therefore be useful:—

Table showing the proportions of cork and different kinds of materials which will form a compound mass of one-fourth the specific gravity of water, the specific gravity of the various materials being taken as shown in Table A:—

Compound materials.	Proportional quantities.		
Cork and wrought-iron	1	to	·0077
„ oak	1	„	·105
„ teak	1	„	·128
„ mahogany	1	„	·128
„ elm	1	„	·128
„ red pine	1	„	·143
„ larch	1	„	·187
„ yellow pine	1	„	·187
„ white pine	1	„	·293
„ poplar	1	„	·386

It thus appears that a compound mass one-fourth the specific gravity of fresh water may be formed by combining

			Cubic feet.	
	10 Cubic feet of cork	with	·077 or 37 lb.	of iron
or	„	„	1·05 cubic feet	of oak
„	„	„	1·28 „	teak
„	„	„	1·28 „	mahogany
„	„	„	1·28 „	elm
„	„	„	1·43 „	red pine
„	„	„	1·87 „	larch
„	„	„	1·87 „	yellow pine
„	„	„	2·93 „	white pine
„	„	„	3·83 „	poplar

Hence we see in what proportions of thickness alternate layers of cork and other materials may be used to form the buoyant material of raft shipping, such that the average specific gravity of the mass shall be only one-fourth of the specific gravity of water. For example, a layer 10 inches thick of cork, or other material of the same specific gravity, may be alternated with ·08 inch of iron, or 1·05 of oak, or 1·28 of teak, mahogany, or elm, or 1·43 of red pine, or 1·87 of larch or yellow pine, or 2·93 of white pine, or 3·83 of poplar.

Whence it appears that if cork at 12 lb. per cubic foot, or other material of the same specific gravity as cork, be used for our buoyant material, every cubic yard of such material may, when built into the ship, be bonded together with 100 lb. of hoop-iron, producing a well-bonded mass of buoyant material, of which the specific gravity will be one-fourth that of water, and of which each cubic foot weighing 15·625 will carry a load of 46·875 lb.

Seeing now, from the foregoing tables, the great advantage of employing substances of light specific gravity as the buoyant material, it will become important to ascertain what substances or preparations of material will be available for the purpose referred to. There are many vegetable productions of tropical growth of a specific gravity nearly the same as that of cork, which productions may, like cork, be so prepared and manufactured as to form masses or blocks, of any definite size, convenient for being built in layers of definite thickness, into the hold of a vessel, and so chemically treated as to be uninflammable; such masses, manufactured by the aid of machinery, may be produced at probably a cheaper rate than cork, and be equally serviceable.

Moreover, as an example of manufacture, small boxes of suitable dimensions for being laid by hand, like bricks, may be formed of white pine, poplar, or other light wood, which would constitute a cellular mass of extremely light specific gravity, and which, if used in those parts of the ship least exposed to shot and shell, would be available for forming the buoyant medium of raft shipping. It is therefore, suggested that if premiums be awarded for the discovery and production of buoyant materials, whether in their natural condition, or manufactured suitable for the purpose referred to, a choice of such material would be produced whereby dependence on any one kind would be obviated, and various materials fit for the purpose would be supplied at their fair market value, based on the cost of production. The specimen of buoyant material submitted herewith, six inches square and three inches thick, weighs 10 ounces, being at the rate of 10 lb. per cubic foot, or about one-sixth the specific gravity of water; consequently, we may calculate on the buoyant material for raft shipping being prepared and cemented in place at the average weight of 15·625 lb. per cubic foot, being one-fourth of the specific gravity of water. The buoyant power of such material will be 46·875 lb. per cubic foot, exclusively of its own weight, and each ton weight of burden will require 47·8 cubic feet of such material, and the weight of the material itself will be at the rate of 143·36 cubic feet per ton weight.

Practical Construction.—We now proceed to explain the practical construction of raft shipping with reference to its buoyant properties, such being necessary to enable us to arrive at some definite conclusion as to the mercantile effectiveness of such vessels for carrying weight of cargo with reference to their size as expressed by displacement, and also to determine, in the case of gunboats and ships of war, the definite weight that can be allowed for armour plating, with reference to the size or load displacement of the ship, whence the extent of armament and ammunition which the ship can carry may be deduced, for it is presumed that the guns and crew of such vessels should be fenced in by armour plating equally with their opponents. Protection from sinking is the object which we seek, and we require to know at what sacrifice of capability for carrying weight of cargo, in the case of mercantile ships, or of aggressive armament in the case of ships of war, that protection is to be obtained.

Having predetermined that the length of our ship shall be six times the breadth, and the depth one-third the breadth, and that the lines of the vessel shall be such that the displacement expressed in cubic feet shall be one-half the product of the length, breadth, and depth, we know from these data that, to obtain a displacement of about 2500 tons, the breadth must be about 45 feet, the length 270, and the depth 15 feet. These dimensions, under the above-mentioned conditions of construction, give the immersed hull a cubical content of 91,125 cubic feet, which, divided by 36, the number of cubic feet in a ton weight of fresh water, gives 2531 as the displacement of our ship in tons weight, and consequently the total aggregate weight of our hull, buoyant packing, packing for surplus buoyancy, engines, coals, ship's stores, armour plating, armament and ammunition, such being the entire weight of the ship and its burden, and we propose to treat of each of these items separately.

1. *The Hull.*—For the sake of strength combined with lightness, we may suppose the shell and frame of the hull to be of steel, lined or planked inside with timber, and as the buoyant material with which the vessel is to be packed will greatly strengthen the shell of the vessel, we may assume the weight of the hull (including rig and equipment, but not including armour plating, armament, ammunition, or other stores) to be 25 per cent. of the load displacement, amounting in this case to 633 tons weight.

2. *The Buoyant Packing.*—This packing, on which the buoyancy of the ship is intended to depend, must be in such bulk, with reference to its specific gravity, that when floating in water, it will uphold from sinking the entire weight of the ship and its burden, consequently the bulk of the packing must be at least equal to the load displacement of the ship, being in this case 91,125 cubic feet, which quantity is represented as tinted pink on the drawing; and the specific gravity of this packing being one-fourth that of water, its weight will be one-fourth of the load displacement of the ship, or 633 tons weight.

3. *Surplus Buoyancy.*—We have hitherto made provision only for such quantity of buoyant packing as would merely float the ship, but in the case of ships of war portions of this packing may be blown away by the explosion of shells, which may have lodged in the body of the mass; it is, therefore, proposed to allow 20 per cent. surplus buoyancy, coloured light pink on the drawing, amounting to 18,225 cubic feet, the weight of which is 126 tons, the same being 5 per cent. of the displacement.

The centre of gravity of the hull and packing, amounting to 1392 tons weight, is shown on drawing.

4. *Machinery.*—It is proposed that this vessel of 2617 tons, builders' measurement, or 2531 tons displacement, be supplied with engines suitable for propelling the ship at the speed of about 12 knots per hour, requiring 316 horse-power, working up to 1580 ind. horse power; the weight of the machinery complete and in working condition will be 316 tons weight, being 12½ per cent. of the total displacement.

5. *Coals.*—One ton of coals per nominal H.P. will give about six days' supply at full steaming power, amounting to 316 tons, being 12½ per cent. of the total displacement, and as the weight of the machinery and coals is necessary to the stability of the ship, it is desirable that the coals be stowed in the lower hold, and the coal-bunkers be fitted water-tight for the reception of water-ballast.

6, 7, and 8. *Stores—Armour-Plating—Armament and Ammunition.*—Having already appropriated, as above shown, no less than 80 per cent. of the load displacement, we have now left only 20 per cent., amounting to 507 tons weight, to meet the requirements of ship's stores, armour-plating, armament and ammunition. The proportion in which these three items are to be distributed entirely depends on the intended armament for the ship, and the thickness of armour-plating which may be considered sufficient for the intended service. We may, however, assume the distribution as follows:—

Ship's stores 2 per cent., amounting to 51 tons.

Armour-plating 12 per cent., amounting to 304 tons.

Armament and ammunition 6 per cent., 152 tons, of which the centre of gravity is shown on drawing, 507 tons. Hence the foregoing scale of appropriation of displacement gives as follows, viz.:—

Hull	25 per cent.,	weighing 633 tons.		1392
Packing	25 ,,	,, 633 ,,		
Surplus packing	5 ,,	,, 126 ,,		
Machinery	12½ ,,	,, 316 ,,		632
Coals........................	12½ ,,	,, 316 ,,		
Ship's stores................	2 ,,	,, 51 ,,		507
Armour-plating	12 ,,	,, 304 ,,		
Armament & Ammunition	6 ,,	,, 152 ,,		
	100	Dispt. 2531		

From the above scale of appropriation of displacement the following table has been deduced, showing the weights available for armour-plating, armanent and ammunition, the vessels varying from 257 tons displacement, to ships of 10,368 tons displacement, the largest size now built, whence we may see approximately what amount of armour-plating is available for ships of different sizes, and thence determine whether such vessels will carry out the object we may have in view. The weights shown as armour-plating, armanent and ammunition in the following table, constitute the tons weight of cargo which would be carried by the ship if fitted for merchant service. (See p. 103).

From the foregoing table we arrive at the following deductions:

1st. With reference to armour-plating, it is manifest that in a ship of given size, as determined by displacement, the weight available for armour-plating is to a considerable extent a compromise with the weights required for machinery, coals and armanent, as we increase the one we must reduce the other; but assuming the appropriations of displacement taken in the table, the rates allotted to armour-plating would give the following results:—

	Thickness, if plated all round, 12 feet deep.	Thickness, if plated all round, 16 feet deep.	Thickness, if plated all round, 20 feet deep.
No. 9	2·42 inches	1·82 inches	1·45 inches
,, 10	2·75 ,,	2·06 ,,	1·65 ,,
,, 11	3·10 ,,	2·33 ,,	1·86 ,,
,, 12	3·50 ,,	2·62 ,,	2·09 ,,
,, 13	3·93 ,,	2·95 ,,	2·36 ,,
,, 14	4·31 ,,	3·23 ,,	2·58 ,,
,, 15	4·73 ,,	3·55 ,,	2·84 ,,
,, 16	5·21 ,,	3·91 ,,	3·13 ,,
,, 17	5·69 ,,	4·27 ,,	3·42 ,,
,, 18	6·20 ,,	4·65 ,,	3·72 ,,

It is also to be observed that if the length of the vessels be four times the breadth instead of three times, the thickness of the armour-plating in each case would be increased 50 per cent. on the above dimensions; and, moreover, if instead of plating the ships all around the armour-plating be confined to protecting the limited space of the battery, the thickness of the plating will be proportionately increased, the application of the weight available for armour-plating, armament, and ammunition is thus entirely a matter of arrangement dependent on the class of ship to be constructed.

It also appears that the ratio of power to displacement being given, and the vessels of similar type, the speed becomes greater as we increase the size of the ship. The extra cost that would be incurred in the construction of raft shipping may be approximately estimated as follows, supposing the material to be cork of the lowest quality, which is generally the lightest, and therefore the most suitable, for the purpose of raft ship packing. Take for example ship No. 9, of 2531 tons displacement:—

Cork for packing, 760 tons at £10	£7,600
Preparation for rendering the packing uninflammable, 760 tons at £2 10*s.*	1,900
Workmanship and labour, preparing material, cementing, and setting in place, 760 tons at £2 10*s.*	1,900
	£11,400
Casualties 5 per cent.	570
Total for ship of 2531 tons displacement	£11,970

Being at the rate of about £5 per ton on the displacement tonnage of the ship.

Rear-Admiral E. P. HALSTED.—Mr. Atherton has so clearly and completely given his details and definitions, that the question is scarcely to be discussed, except upon its general principle. From

No.	Dimensions.			Tonnage. O. M.	Cubical Contents.	Displacement.	Appropriation of Displacement.								Power.		Speed.
	Length.	Breadth.	Draught.				Hull 25 per cent.	Packing 25 per cent.	Surplus Packing 5 per cent.	Engines 12½ per cent.	Coals 12½ per cent.	Stores 2 per cent.	Armour 12 per cent.	Armament and Ammunition 6 per cent.			
	Feet.	Feet	Feet	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Nom. h.p.	Ind. h.p.	Knots.
1	126	21	7	266	9261	257	64	64	13	32	32	5	31	16	32	160	9·28
2	144	24	8	397	13,824	384	96	96	19	48	48	8	46	23	48	240	9·68
3	162	27	9	565	19,683	547	137	137	27	68	68	11	66	33	68	340	10·05
4	180	30	10	775	27,000	750	187	187	38	94	94	15	90	45	94	470	10·50
5	198	33	11	1032	35,937	998	249	249	50	125	125	20	120	60	125	625	10·77
6	216	36	12	1340	46,656	1296	324	324	64	162	162	26	156	78	162	810	11·08
7	234	39	13	1702	59,319	1648	412	412	82	206	206	33	198	99	206	1030	11·39
8	252	42	14	2128	74,088	2058	515	515	103	257	257	41	247	123	257	1285	11·68
9	270	45	15	2617	91,125	2531	633	633	126	316	316	51	304	152	316	1580	11·98
10	288	48	16	3175	110,592	3072	768	768	154	384	384	62	368	184	384	1920	12·20
11	306	51	17	3810	132,651	3684	921	921	184	460	460	73	442	221	460	2300	12·45
12	324	54	18	4523	157.464	4374	1094	1094	218	547	547	87	525	262	547	2735	12·70
13	342	57	19	5213	185,193	5144	1286	1286	257*	643	643	102	618	309	643	3215	12·92
14	360	60	20	6204	216,000	6000	1500	1500	300	750	750	120	720	360	750	3750	13·15
15	378	63	21	7182	250,047	6946	1736	1736	348	868	868	139	834	417	868	4340	13·36
16	396	66	22	8258	287,496	7986	1997	1997	399	998	998	160	958	479	998	4990	13·57
17	414	69	23	9436	328,509	9125	2282	2282	456	1140	1140	182	1095	548	1140	5700	13·79
18	432	72	24	10,721	373,248	10,368	2592	2592	518	1296	1296	208	1244	622	1296	6480	14·00

the paper just read it is clear that Mr. Atherton looks upon it as a question of absolute solidity. (Mr. Atherton: Yes.) This, of course, then becomes, with naval people, a question of accommodation, which does not seem to have been very comfortably provided for. However, there may be circumstances wherein vessels of that sort may be constructed for special purposes, perhaps with great benefit. Far greater changes have actually introduced themselves within the last ten or fifteen years even than the one now described.

Mr. Alexander Gordon.—With regard to the question of inflammability, I am satisfied that Mr. Atherton is entirely correct. I have had great experience in the preparation of timber for lighthouse and other works, where the danger of fire was considerable, and I found that by Mr. Maugham's process, which was patented many years ago, timber was rendered uninflammable. You may put a piece of wood so prepared into a furnace, and you may bring it out red hot, but it will not carry fire—it is uninflammable. I mention this after having had great experience with timber prepared by Maugham's process, and I regret that this process is not more generally known. In a conversation with Sir George Cockburn, when he was at the Admiralty, I proposed the subject of so preparing the ceiling and internal fittings of H.M.S. "Simoom." It was also proposed to line that ship with kamptulicon so prepared, of which I produced some specimens perfectly uninflammable.

Captain Julius Roberts, Royal Marine Artillery.—I believe Mr. Atherton has in his mind the idea of connecting the sides of the ship together by bulkheads, forming cellular compartments, right through, so that each of these compartments, separately formed with thin sheet-iron, adds very little to the weight of the cork. This would form a great protection against the penetration of shot, and those cellular spaces filled with packing would give the ship a vast amount of strength in every way.

Captain Selwyn, R.N.—We must recollect that the use of rams is dependent entirely upon their possession of extreme speed, or superior speed, I may say, and the most perfect power of manœuvring. Unless these two conditions be attained, the use of rams is one which may possibly sometimes be brought into play against other vessels which are at anchor, but which can never be brought into play in those great naval actions which should take place, as they have always done, at least with the English, on the open ocean, where the question is, how to chase your enemy, how to catch him, and when caught, how to dispose of him. The ram will play its part indubitably; but we must not rely any more exclusively on that than we must on guns, or on the peculiarities of ships, which may be attained, as Mr. Atherton has very properly remarked, by a compromise which sacrifices in a certain degree each one to all the others, that is to say, the speed may be attained by a certain sacrifice of capacity and of seaworthy qualities. The enormous power of carrying fuel may be attained by other sacrifices; and so we may go through the whole list of compromises, never being able to attain in absolute perfection the whole of the objects which we seek. With regard to penetration, and how it is to be resisted, Mr. Atherton, I think, does not intend that the cork or other buoyant material which he employs as packing should be viewed in any measure as a resistant material. He relies for that on the armour-plate outside, and which must remain very much as it is at present, a question between the power of the gun and the power of the armour-plate. If we build our ships of a lighter material, such as steel, we may then afford to devote increased thickness to the armour-plate, and, therefore, be able to resist heavier guns than those which are now brought against us. If, on the other hand, our enemies find that we are so disposing our weights, it is reasonable to expect that they will increase the size of their ordnance up to the power of which they may be effective against the increased resistance. The cheapest buoyant material we have, and that hitherto has been resorted to, is air, —cellular spaces filled with air; and the only objection which I understand Mr. Atherton entertains to that, is the possibility of penetration in every line by shot or by shell. Now, I think if we were to enter into a calculation of the thickness of the transverse partitions required to stop shot after they have penetrated a portion of the water (because they are not dangerous above the water-line), but passing through a portion of the water, the armour-plate, and then a certain number of the cells, if that thickness of armour-plate and of armour-partition were calculated, we should find it rather inferior to the weight of the packing which would be required to prevent the ship becoming water-logged from these transverse perforations. There is another circumstance to which we may turn our attention usefully—that having engines on board, we can use them to pump air into the air-cells to keep out the water; and that, then, although perforated, the cells remain air-cells by the continued power exerted against the water. You can do that in this condition that the outer cells be kept free from water, and only if air be pumped into the interior ones can you keep out a head of water. It is possible to do that, and it is worthy of consideration how far we may do it in opposition to the system of filling up with a material which, after all, if perforated, does not keep out water. In proportion as the cells, whether the packing material be cork or light porous wood, are destroyed by the impact of shot, so will the water penetrate those cells, and enter among the splinters or the powder into which the material would then be reduced, thus not giving us the full value which we should obtain, if we considered it only as cork having certain buoyant qualities. When by penetration in whatever direction the ship has been reduced to the water-logged line, it is very clear, he says, that the engines might be drowned out, and the ship would certainly be drowned down to such a line of flotation that her manœuvring power would be gone, and then she would be at the mercy of any ship that ran against her having superior manœuvring power. I do not urge this as an objection, but I merely urge it as a remark as to what would be the result in such a case of water-log. When you have also a large quantity of buoyant material, if there be an alteration in the centre of gravity, you find, if you consider this ship as not alone carrying a hull, but carrying masts and yards, you will so seriously compromise the centre of gravity, that you are liable to have your ship capsized, although she floats, particularly if she is in a sea. If it be possible, as Mr. Atherton seems to show, that we may have ships that will not sink, then it becomes a very grave question whether the cupolas may not be more efficiently introduced than they have hitherto been, for the whole secret of the want of success of the cupola system in large ships seems to be, that it is necessary to defend the ship as well as the gun. Not alone must you put armour round the cupola, but you must put iron round the ship, not solely to prevent her crew being hit, but to prevent her offensive powers being injured, and to prevent the ship being sunk. If it is possible to make a raft like that, we shall return to that ingenious invention, for which Captain Cowper Coles deserves the greatest credit, of putting heavy guns on an unsinkable raft. I hope, by the devotion of such talent as that of Captain Coles as a Naval Officer, and as that of Mr. Atherton as an Engineer, to the subject, we shall yet arrive at a more clear conclusion than we have hitherto been able to do.

Mr. Atherton.—The stores and amunition will be stored in water-tight cells formed in the packing, so that in the case of the ship being sunk down to the water-logged line all the stores and ammunition will be accessible. The arrangements for the accommodation of the crew would be dependent on the number of the crew and position of the batteries. I do not pretend to know how a ship's batteries ought to be arranged, whether broadside, cupola, or fore and aft, but I have assumed that in this case the batteries would be fore and aft, thereby affording the usual amount of accommodation for the crew amidships between decks. The lower hold I mean to be exclusively appropriated to machinery and coals. The coal will be put into water-tight compartments, and as the coal is consumed the bunkers may, if necessary, be filled up with water, to preserve the stability of the ship. As regards present mortar practice, the mortar practice of the present system is not at all comparable to what I anticipate being resorted to as the agent for sinking iron-clad ships, viz., masses of eight or ten tons weight being thrown nearly vertically to a considerable height, and falling into a ship through the deck at a range of say 200 yards only. As you shorten your range you arrive at greater precision, and doubtless mortar practice may be so modified that at short range, say 200 or 300 yards, you would not fail to drop a shot or shell through the deck of such a vessel as the "Warrior." With regard to the efficiency or otherwise of rams, it is not for me to discuss that question. I am of opinion they may become formidable rivals to ships of war as now constructed, and, therefore, I suggest this mode of rendering ships unsinkable, though assailed by the ram. With regard to penetration, the theory I go upon is that nothing will stop the penetration by shot. I anticipate that the penetration will be absolute, but whilst the packing remains an integral part of the ship it will float the ship. You must entirely get rid overboard of that 127 tons of surplus packing before the ship of 2531 tons displacement will sink. As regards air-tight cells, if of iron, they would probably be of equal weight, and occupy the same space as the packing. I believe it would be very difficult to make the cellular system absolutely air-tight, and if perforated by shot they would become non-effective. By the proposed system when the vessel becomes perforated and water-logged, we still have the lower deck some two or three feet above the water-logged line of flotation; therefore, I do not see why that ship, though water-logged, should not be perfectly manageable and seaworthy. Many a ship goes to sea with a water-line as low as that. The stability increases as she gets down, because the centre of gravity becomes lower with reference to the centre of displacement.

THE ARCHITECTURAL MUSEUM.

Prizes to Art Workmen.

Mr. Beresford Hope said they met that night in a new home, and for the very simple reason that the tabernacle—he supposed he must call it—in which they used to meet, at South Kensington, had been pulled down to give way to a permanent South Kensington Museum. Whether they should meet again at South Kensington permanently, or not, was a matter in regard to which he wished to make a short explanation. The meeting was very well aware that for many years past South Kensington had been their home. He had talked of the tabernacle in the wilderness. Some people said that when they went down to South Kensington, they went to Egypt. But he must say that, having gone down to Brompton, they were most hospitably entertained there. With the authorities there they sometimes had had a few friendly "tiffs;" but altogether they worked very well together, and owed a deep debt of gratitude for the kindness that had at all times been shown by the authorities at South Kensington. But as time went on, and as the distinguishing features of the South Kensington Museum shaped themselves more and more clearly, the more it became apparent that there was a divergence of intention between them and that body. He would tell the meeting what that divergence was. All of them who had considered the museum question must be aware that there were two kinds of museums. One was what was called a technical, or study museum, which contained things that were rather dry and uninteresting to the general visitor. There was no popular museum in anatomy, nor ought there to be, inasmuch as it would consist of a number of specimens in bottles. A technical museum in chemistry also consisted of a lot of specimens in bottles; and so in their line of science, a technical museum in architecture consisted of a number of mouldings, carvings, and details, many of them rough and mutilated plaster casts, and, therefore, very uninteresting and ugly to the general public; but of inestimable value to the man who had to manufacture works of art, in which light and shade produced by mouldings, and the art beauty produced by foliage, were his requisites. Such was their idea of the collection that was essential for the study of architectural art. The other sort of museum, which he did not deny was equally valuable and necessary, was what was called the Exhibition Museum, but it did not go into the detail necessary to enable the art-student to work out either originals or models of monuments, like the tomb of Archbishop Grey, at York, or the Pisa pulpit, which raised its head so proudly at South Kensington. He thought their Government,—he did not mean the authorities at Kensington, who were not to blame,—but the Government, were to blame for not having realised the great importance of a study collection; and, when they had the unique opportunity of plenty of acres at Kensington, they were to blame for not giving to England what, he believed, no other Government had given to any other country in the world, a Study Museum of Architectural Art. There was plenty of room at Kensington for carrying out such a project, and it was a sort of museum which it would not be very expensive to create. The authorities, however, thought otherwise; and it was impressed upon those connected with the Architectural Museum that they were to clear out a very large amount of their collection, and leave only so much behind as would form part of an exhibition collection, and not part of a study collection.

Now, they had been looking forward, as he had stated, to a great national study collection for the benefit of the art-workmen of England. They did not pretend to say that, with their limited means, their collection could be either a very large one or a very perfect one; but they did say that it was the first thing of the sort that had ever been started. It was a matter of honourable ambition with them; and they thought that it might have been taken up by the Government as the foundation of a more important collection of the same kind. That matter was now past and gone. The study collection was no longer to be an element of the South Kensington Museum. It was only to be an exhibition collection. It would, no doubt, be an interesting, a beautiful, and an important one, but it would not be that special kind of technical collection which was required. Accordingly, they felt there was nothing to do but to give an amicable notice to quit. That notice was taken amicably, and he was able to say that they were leaving on the best and most affectionate of terms with the authorities at Kensington, who had not withdrawn from them the privilege of using their collections. Now, at this time of final divorce, nothing could be more friendly than the terms upon which they stood towards each other. Speaking ministerially, the question as to where they should go was under consideration. Talking confidentially, they had very little idea where they would go. But they were working hard for a place, and he might say, without breaking confidence, that their condition was under mature consideration by a very important body, of a cognate character to their own, though somewhat older, and more dignified—he meant the Royal Institute of British Architects.

He now passed to the special work which they had to perform that evening, namely, the distribution of prizes. The meeting were aware that last year was a year of disappointment. They offered valuable prizes, but it was not considered that the competitors came up to the mark, and they went down to South Kensington with rueful faces and blank cheques. This year they adopted the course, not of sulking or despairing, but of revising their list of prize objects, and offering prizes even more valuable in a monetary view. He was glad to say that the exhibition of one class of works of art had met with signal success. They had had an unusual good tender of objects, and they felt that they might conscientiously award the large prizes which they offered to the competitors. He was exceedingly glad to have to say that the art-workmen of the country had awoke to the movement of the times—he did not allude to the Reform movement. He was glad to say that they felt in all things the growth of education and of refinement: that growth of refinement which had substituted the present cheap press for the scurrilous press of forty or fifty years ago—a cheap press which had placed the study of literature and the discussion of political questions, whether they agreed with the conclusions they were come to or not, on the high level which they now occupied. He was glad to see the realization of the growth of education and the improvement that had taken place in those means of locomotion which made the word "provincial" almost a word belonging to the dead languages. The growth of science had extended itself to the wants of private life, and people felt that the furniture they lived amongst, the carpets they trod upon, the arm-chairs they slept in, the plates from which they ate their mutton, and the basins in which they washed their faces, might be, need be, should be, and could be, specimens of art, without being too expensive to those persons who might become their purchasers. He was glad our workmen realized that fact; and this brought him to another point. The other day a capitalist; who was a producer of art-workmanship, had asked him whether he (Mr. Beresford Hope) knew what he was about; whether he knew the necessity of capital to produce these large works, and was he not putting the art-workman out of his place? He (Mr. Hope) said distinctly he was not putting the art-workman out of his place; and he would tell them why. Everybody's duty was to be moving on. It was like the theory of the astronomer, that the sun and all the fixed stars were in reality revolving round some very distant central sun. He did not put the art-workman out of his place, because the capitalist who employed that workman, and the purchaser who went to the capitalist, had themselves marched on, and he only asked that the art-workmen should march on by their side. Of course, there were many branches of art-workmanship that required capital to put them in the market, and he should be a very bad friend to the art-workmen if he were to come forward to bring down that necessary law of political economy which made the capitalist necessary to put his work in the market,—ay, and necessary to give him the materials with which he could work. All he maintained was, that the development of art education on all sides did not destroy the relations between the employer and the workman. It only placed them in a more satisfactory position towards each other. It showed the workman that artistic work was wanted from him; and it told the employer that it was right and generous that with his name the name of the man who produced the work should be connected. Of course, many art-workmen would only be art-workmen all their lives. It was an honourable thing to be an art-workman all one's life if one stamped his name on the work. But it was possible that, like Chantrey, a man from being an art-workman might become a great master and teacher of art, and he was for throwing open the door to such a man, that he might come forward and prove himself a Chantrey. He would give an illustration in point. It might be thought a trivial consideration, but it would show his meaning. For many years past it had been the habit in this country to hold flower-shows, at which they saw that Mr. Smith, gardener to Lord Brown, took prizes. Lord Brown was the capitalist, but Mr. Smith's knowledge of botany produced the grapes, the melons, or the roses which won the prizes. Now, he wanted the art-capitalist to be the squire, and the art-workman the gardener. He would now pass to the special prizes for the present year. He was going to speak plainly. In former years they had had many pleasures and many disappointments. He dared to say that, in the allotment of the prizes it might have been supposed by some that they did not take sufficient account of the small number of hours, comparatively speaking, that might have been at the competitors' own disposal; that they did not take sufficient account of the wear and tear of mind which must have taken place in the pursuit of their calling, before they could apply that wear and tear for their own advantage. They felt, for the present, at least, that they were asking for two things that it was hardly right to ask for; at the same time one was a pure and absolutely original composition; the other that knowledge of manipulation or practice in art-handling which made the good rendering of the composition manifest its superiority to the bad rendering of the same. Accordingly, except in one case, in which they included composition, they had determined this year to absolve their competitors from much of the original composition, and only looked to them to give them the best rendering of an idea for which the institution was responsible, and they were justified in that determination by the results. He asked pardon from those of whom in former years, in their over-enthusiasm, they might have exacted too much.

Mr. Hope then procedeeded to distribute the various prizes to the successful competitors, as thus:

Stone Carving.—Prize 1, £20.—Arthur N. Harris, Ryde, Isle of Wight; prize 2, £5.—John Seymour, Tower-lane, Taunton; prize 3, £2.—Henry Harrison, 82, Upper Ebury-street, London; extra prize, £1 1s.—T. Sharp, 50, Connaught-terrace, Edgware-road.

Wood Carving.—Supplementary prize, £10.—W. Wormleighton, at Mr. Roddis's, 19, St. James's-street, Birmingham.

Silver Work.—Prize 1, £15.—W. Holliday, 14, Nailour-st., Islington; prize 2, £5.—A. G. Frantzen, 20, King-square, Clerkenwell.

Transparent Enamels.—Prize 1, £10.—Frederick Lowe, 13, Wilderness-row, London; extra prize, £1 1s.—H. De Koningh, 69, Dean-street, Soho.

Opaque Enamels.—Prize, £10.—Frederick Lowe, 13, Wilderness-row, London.

Marble Mosaic.—Prize, £10.—George Rooke, 27, Bywater-street, King's-road, Chelsea.

Modelling in Clay (Architectural Union Company).—Prize 1, £5.—R. W. Martin, 5, John's-terrace, Olney-street Walworth-road; prize 2, £2.—J. W. Gould, 33, Bayham-place, Camden Town.

ON ARCHED ROOFS.*

By C. R. Von Wessely.

The present paper does not aspire to exhaust the very interesting subject of arched roofs as it stands at present before the profession. Its purpose is only to describe some structures of this kind recently carried out with success, and to make a few comparative remarks upon their main features and merits. In offering the same to this society it is the hope of the author to elicit valuable criticism from different quarters, and by a discussion of a subject on the theory and practice of which very little has been published hitherto, to throw more light upon the many important questions connected therewith. It is a desideratum universally felt in the engineering profession, to have as complete as possible a collection of the designs and details of important engineering structures; a contribution towards such a collection, however incomplete, may not be thought out of place before a society entirely devoted to the advancement of engineering science.

Arched roofs are the production of the conjoint requirements of beauty and strength. So long as the roof is destined to serve as a mere object of utility, an engineer would spend very little trouble in designing fine outlines and selecting noble proportions. Economy of material and workmanship dictate such plainness of design, that, firstly, the engineer shall be able to take out the strains so minutely as to reduce the sectional area to a minimum; and secondly, that the roof is carried by itself and does not induce any transverse strains in the structure supporting it.

* Read before the Society of Engineers.

The usual triangular principle is adopted in such cases. It is a very different matter when a roof is to be made for an architectural building, for instance a large hall, where it is often the main feature of the structure. Fine outlines and simplicity, two main components of noble appearance, will be required most particularly. No obstructions to the view, as ties, struts, &c., are admissible. Architecture having been always represented in stone, forces its newly acquired material, iron, into the customary shape of the pure arch. A more or less powerful horizontal thrust has now to be provided for, and a certain deficiency in the practicability of minute calculation of strains under unequal loads, must be compensated for by the sound judgment of the engineer. Many different arrangements can be embodied in the structure supporting arched roofs, for taking the horizontal thrust, but no rules can be given for it. In each separate instance the arrangement must be adapted to the peculiar nature of the case, and depends for its degree of perfection entirely upon the skilful design of the engineer. A few words on scientific investigations with regard to wrought-iron arched ribs, may not be out of place, before beginning the description itself.

The calculation of strains in arched roofs is one of the most difficult mathematical problems in engineering, partly on account of somewhat complicated principles on which a thorough investigation should be founded, partly on account of a great variety in the position of the different parts of the structure. Unfortunately there is very little information on this subject to be found in English engineering literature, and not much more in that of other nations. The following is submitted as a means of approximately investigating the stability of wrought-iron arched ribs.

It is well known that the way of ascertaining the stability of a stone arch is to draw the curve of equilibrium, which must remain within the depth of the voussoirs of the arch. This is not necessary in the case of iron-arched ribs, which can be strained by tension as well as compression.

The outer forces which act upon an arch are, 1, its own weight; 2, the vertical; 3, the horizontal pressure due to the resistance of the abutments; the latter is transmitted unaltered through the whole of the arch, since there is no other horizontal strain acting upon it but that of the abutments; 4, the pressure of wind and snow.

In every arch there must be somewhere one particular point in which this horizontal strain is not co-existing with any vertical force; therefore, if we cut the arch through this point in two pieces, in either of them the state of equilibrium will be conserved, by replacing the action of the other by that horizontal strain. This point is coincident with the point of action for the resultant of all the vertical forces acting on the whole arch. Thus, in an arch under its permanent load, the section before mentioned will be at the crown; in an arch under both its permanent and unequal loads, it cannot lie in its crown. The curve of equilibrium passes through the section with its vertex.

The way to find the horizontal strain is as follows:—Given a semicircular arch, loaded on n points, whose horizontal distances from the left-hand springing are $x_1\ x_2 \ldots\ldots x_m$ with weights $p_1\ p_2\ p_3 \ldots p_m$ accordingly, and x on the distance of the vertical section before mentioned, we find

$$p_1x_1+p_2x_2\ldots+\tfrac{1}{2}p_m\,x_m=\sum_{x_1}^{x_m} px=\text{H}y,$$

where H is the horizontal strain, and y the rise of the curve of equilibrium.

This equation $\left(\sum_{x_1}^{x_m} px=\text{H}y\right)$ does not determine H or y, but assuming one of them it ascertains the other.

By taking $y=y^m$ (the height of the neutral fibre in section m) the vertex of the curve is drawn through point C (Figs. 1, 2, 3, Plate 14); H is thus determined, and section m is in compression according to H.

It is quite clear that not all the other points of the curve will in this case fall within the neutral fibre of the arch, but will take the position as shown by the dotted line, though it must go through the supports. This causes a tendency for point B to move in the direction of the arrow; and strains in the flanges at that place will be effected accordingly.

If the flanges of the rib in B should really not be strong enough to withstand this strain, there is no necessity yet that they should break, but the case will be as follows:—

$y_1{}^m = y$ is assumed so that the curve of equilibrium passes through B, and renders this point to be simply in compression.

H is determined by the equation $\text{H}_1=\dfrac{\sum_{x_1}^{x_m} px}{y^m{}_1}$

and acts on a lever$=y_1{}^m$, or in regard to section m on a lever $y_1{}^m - y^m$, and will effect a compression in the upper flange and a tension in the lower one at this place. Thus the fact that the section at B is in mere compression is conditional, and depends entirely on the presence of the said strains in the flanges at section m. In respect to these considerations, it is certain that stability and rigidity of an iron arched rib can be fulfilled by different arrangements.

Although it appears strange at first sight that in an arch, of which the architectural outlines are given, there should be no restriction in assuming the rise of the curve of equilibrium, according to which the different sectional areas could be determined, and that nevertheless the stability of the structure can be effected. This will become obvious from the following example:—

Given an elliptical arch, in which the different areas in flanges, &c., have to be determined. The distances of the points where the load acts, and the loads, are determined. Thus the equation $\Sigma p\ x=\text{H}y$ can be formed, by which it can be seen that H, the horizontal strain, might be taken *ad libitum*, and that y will then be ascertained according to the equation. For instance, y may be taken equal to a^1, which is greater than the rise of the arch, the vertex of the curve will be in C^1, and its branches will go through the points of support, as shown in sketch.

H^1 is determined by putting a^1 for y in the equation. The position of this curve leads to the remark, that in the crown, besides the horizontal strain H_1, which is transmitted through the structure and taken by the abutments, there will be a certain tension in the lower, and a compression in the upper flange, due to H_1 acting on the level CC_1; and that, following the line of the curve from C_1 towards A_1 or A, there is a point B_1 or B on each side, where the curve of equilibrium intersects the neutral fibre of the arch, and where only compression exists.

The segment between B_1 and B, therefore acts as a girder, while the joints at these points could safely be replaced by hinges as long as the load is equally distributed. The abutments will, in this case, react with a horizontal strain equal to H_1.

Now, instead of the abutments, a tie may be supposed between A_1 and A, and a screw in it, to effect any required horizontal strain on these points, and it may be arranged so that this horizontal strain is $=\text{H}_2$. By putting this H_2 into the equation, the calculation gives $y=a_2$, which is smaller than the rise of the arch. $\text{A}_1\ \text{C}_2$ A is now the curve of equilibrium.

The horizontal strain H_2 is transmitted through the crown unaltered, but, besides this, there exists at the crown tension in the upper and compression in the lower flange, due to H and the lever CC_2 on which it acts. According to the curve assumed in this case, the whole of the arch will act as a girder under forces acting upwards, and the dimensions of the flanges and diagonals have to be determined accordingly.

No doubt, by means of the supposed crew, a horizontal strain, H, can be applied to the arch, so that the corresponding y becomes equal to the rise of the arch a, in which the entire section at the crown is in compression due to the force H. In other words, by means of a tie and a screw in it, the curve of equilibrium can be forced to pass through the crown, or through any other point in the vertical $\text{C}^1\ \text{C}^{11}$, and if the material is distributed in the structure according to a certain curve of equilibrium, it will enable the abutments to bear the horizontal strain belonging to this curve.

On the other hand, this does not require that a wrought-iron arched rib of a certain shape must have abutments of a certain strength, there being even a chance for the stability of an arch without any abutment or tie. The only consequence of this is that the rise of the curve of equilibrium becomes ∞, and the horizontal strain by the equation becomes 0.

The crown of the arch will, therefore be strained as if it were the centre of a straight girder of the length AA_1. Now the question arises, which curve of equilibrium, among so many which do not exclude a chance of constructing the arch, will be that one according to which the least quantity of material is required?

Although the solution of this question with mathematical accuracy is a matter of almost impracticable complexity, the following consideration leads to a sufficiently practicable result:

namely, it can be proved by simple calculation and by many instances of practical engineering, that a certain load distributed over a given space can be supported in a more profitable way by an arch in which only compression prevails, and which rests between abutments, than by a straight girder. Therefore it is more profitable to arrange the material in a structure so that it is strained only by compression than to have compression and tension co-existing in every part of the structure.

From this truth a rule can be derived to lay the curve of equilibrium so that its points may be as close as possible to those of the neutral fibre.

The further calculation of strains in the different parts of the structure (flanges and diagonals), can be dealt with by starting the an intersection of the curve of equilibrium with the neutral fibre, where the strain is known from the curve and continuing by proper combination of this strain with the vertical loads.

Sydenham Crystal Palace Roof.

There are two roofs of similar construction, but different span. The principals are, in both roofs, arranged in pairs, being 24 feet apart in each pair, but the pairs leaving a clear space of 72 feet between them. The 120 feet span roof is to be described first, the alterations of dimensions in the 72 feet one to be given afterwards, and details being quite alike in regard to their general arrangement.

The principal of this roof is very peculiar in its construction. It is an arch of such a depth that it carries partly as a girder, throwing upon its supporting structure a comparatively small horizontal thrust. The outer and inner outline of the arch is a perfect semicircle, struck from the same centre, the rib has therefore throughout an equal depth of 8 feet—the inner radius being 52 feet, the outer one 60 feet. The rib consists of a bottom and top flange, each consisting again of two L irons, 6 inches by 3½ inches, and a ½ inch plate 10 inches wide having an available sectional area of 9¾ square inches. These flanges are throughout the length of rib of equal cross section, and are connected together by a double lattice-work made of flat diagonal bars. Each side of the rib is divided into eleven equal parts, between its springing and its centre. Each of these parts contains two diagonals one above the other, and struts radiating to the centre; one of the struts being a cast-iron distance strut carrying purlins and connecting them to main rib. The other is a wrought-iron strut made of two channel irons 4 inches by 1½ inch by ½ inch, having two distance pieces rivetted between them. The joints in 6 inches by 3 inches L irons are made alternately at intervals of about fourteen feet, proper distance pieces filling out the 3⅜ inch space between L irons, its ¾ inch rivets act only with single shearing area. At intervals of about 1 ft. 9 in., distance pieces are put between L irons, and fixed also by ¾ inch rivets as in W I struts. The diagonal bars are throughout 4 inches wide, ⅜ inch thick with an available sectional area of 1·2 square inches running always through two diagonals, and are not straight. But they are, for the sake of architectural appearance, so arranged that they cross exactly in the middle of rib, and in one fourth of its depth from its outer and inner outline. They are connected at intersections by a ¾ inch rivet. A round ornamental knob, made in two halves, being connected together by three ⅜ inch tap screws, covers this joint. The ends of diagonals and W I struts are connected with the L irons by a 1⅛ inch bolt.

The cast-iron distance struts are shaped according to the W I structure, which they have to strengthen, and according to the castiron end pieces of purlins, which are bolted to them by six or four ⅞ inch bolts, as they belong to the 6 feet or 3 feet deep purlins.

The strut has accordingly a cross section of 7 square inches sectional area, its ⅜ inch web is widened out to a pocket for letting the diagonals through, intersecting at this point. The web at top and bottom of strut is brought out to two lugs, which fit with a washer between the two angle-irons, and are each bolted to same by one 1⅛ inch bolt. Proper bosses are cast on to the web for eight ½ inch bolts connecting purlins to same. Underneath these struts, ornamental pendants of 5-16ths inch metal, are bolted to soffit of rib by four ½ inch bolts. There are two kinds of purlins, one kind being 24 feet long and 6 feet deep, and the other 72 feet long and 3 feet deep. The first serve for bracing each two ribs of one pair together, the others act as pure purlins between each pair of ribs, that is, they have the only distinction to support the intermediate rafters.

The 6 feet deep purlins consist of a top and bottom flange of two L irons, 3 inches by 2 inches by ½ inch of 2 square inches available sectional area, they are connected by wrought-iron struts and double lattice work. Besides carrying intermediate rafters, they serve as bracing of main ribs for giving them lateral stiffness. The struts are 8 feet apart, and consist of two T irons, 2 inches by 2 inches by ½ inch, with 1½ inch available sectional area, having between them in all cases two diagonals, one above the other, similar to the lattice work in main rib. The diagonals are flat bars, 3 inches wide, 5-16ths inch thick; they are straight, and run always through two divisions of 8 feet. At their ends proper cast-iron distance struts are fastened to L irons by one 1⅛ inch bolt, the web is again widened out properly to a pocket for receiving ends of two diagonal bars, which are each rivetted to casting by one ¾ inch rivet. The 3 feet deep purlins serve only for carrying the intermediate ribs. They consist of a top flange of two L irons, 4 inches by 2 inches by ½ inch, 2·44 available sectional area in centre, and a bottom flange of two flat bars being at end, 4½ inches by ⅜ inch in centre, 4½ inches by ¾ inch, with 4·68 square inches available sectional area. These flanges are connected by vertical struts 8 feet apart, and diagonal tie bars, decreasing in the three diagonals next to end from 11-16ths inch thickness to ½ inch, to 5-16ths inch to ¼ inch. They are respectively fixed to top and bottom flanges by a 1¼ inch, 1⅛ inch, 1 inch, and ⅞ inch bolt. All bars 4 inches wide (the struts are of cast-iron of a X cross section, 2 inches by 2 inches by ⅜ inch); diagonals of wood are put across the diagonal tie bars, 4 inches wide, ½ inch thick, fastened by ⅜ inch bolts.

Both purlins carry above each strut an intermediate rafter, having the same outline as the main rib. It is made of a ½ inch web plate 1 foot high, in length of about 8 ft. 5 in., with a top and bottom flange of two L irons 2 inch by 2 inch by ½ inch in length, of about 16 ft. 10 in. with 1½ square inch available sectional area. A special arrangement is made for bracing purlins sideways to these intermediate ribs. The purlins at each bottom end of their vertical struts are suspended, as it were, by two hanging rods, to points of the intermediate ribs, being just in the middle of two bearings or purlins. For that purpose, a cast-iron shoe is fixed to the bottom L irons of rafters at those points, by four ½ inch bolts of a proper shape, to fix on it the ends of the hanging rods, ⅜ inch in diameter, by keys. The other ends are widened out to an eye fixed to the bottom flanges of the 6 feet or 3 feet purlins by the bolts fixing end of the vertical strut to the same. The details of this connection are for both purlins the same, except the altered angle of the hanging rods: Next to each of the cast-iron end struts of purlins a kind of pocket is rivetted on by eight ¾ inch rivets, consisting of two ⅜ inch plates, with two 1¼ inch thick distance pieces between them, for receiving the ends of wind ties, flattened out to eyes, and fixed by one 1¼ inch bolt each. The wind ties are, throughout, round rods of 1¾ inch diameter, and form the diagonal bracing between main ribs. At the point where they cross each other they are connected by a ring, to which each end of the four is screwed in the usual way. The ring is in this case of cast iron, and has a sectional area of 9⅜ square inches, strengthened by proper bosses round bolt holes, and besides by two wrought-iron rings of 1 inch sectional area, put on while red hot. This connection serves for bringing strain on to these diagonal bracing rods.

The covering of this roof is entirely of glass, on the "ridge and furrow" principle. The main and intermediate ribs carry wrought-iron gutters, 9 inches wide at the top, 7 inches at bottom, 4 inches deep. They are rivetted to top L irons of ribs with ½ inch bolts, about 9 inches apart alternately, and to intermediate main ribs by ⅜ inch bolts in the same way. To the edge of this gutter an L iron 1½ inch by 1½ inch by 3-16ths of an inch, is rivetted on, and to this a piece of wood 1¼ inch by 2¼ inches is fixed by ⅜ inch screws, about 6 inches apart. Into this piece of wood the ends of the sash bars are let in about 1 foot apart; the top being fixed to the ridge. This miniature roof runs right along the whole rib, from the main gutter up to lower standards of ventilator, and is hipped at its ends. The main ribs, as well as intermediate ones, carry at their crown, over the cast-iron distance strut next to a centre, a louvre standard of cast-iron, 5 ft. 10½ in. high, of H cross section. The sides are filled in with wood, to which the louvre plates are fixed.

The ventilator is covered, as the other parts of roof, by a number of similar small hipped roofs, formed by mere slanting sash bars, having in this case only wooden gutters, each supported by the standard in centre of each rib. The outer standards of ventilator are kept up by a diagonal bracing running from each to the other, consisting of ¼ inch round rods, passing through a slotted hole spaced out in the middle one. At the base of outer standards a wrought-iron gutter runs along, supported by wood boarding, for conducting the water which drops down from the ventilator covering to gutters on top ribs. The main rib weighs 10 tons. The purlins which are 6 feet deep, weigh each 12 cwt.; those 3 feet deep weigh each 1 ton 4 cwt. Total of ironwork in one bay of 86 feet weighs 61 tons 3 cwt. Each of the main ribs is supported by two columns, 8 feet apart, so that each of the flanges starts over one of the columns. This is effected by means of a cast-iron square frame, 8 ft. 8 in. wide, and 8 feet high, bolted to top of each column by four 1 inch bolts, and also by four 1 inch bolts to top of girder, connecting top of columns. It consists of two pieces of the same section as the columns, connected by a ¾ inch web with a large circular hole taken out in the middle and smaller ones in the corners. Proper flanges are cast on to the top corners of it, to which each of the flanges is bolted on by six 1⅛ inch bolts, by means of a strong bracket. The cross sections of this frame, through the weakest part of the columns, has 25¾ inch sectional area—columns being of 8 inches outer diameter, octagon 1 inch thick, the web and its flanges ¾ inch thick. The parts of frame acting as bracing to the angles has 9 inches sectional area. Appropriate pockets for receiving ends of diagonals are constructed in the upper end of web, the outline of which is shaped like that of cast-iron distance struts. The two diagonals in the middle are fixed to it by one 1½ inch bolt, and the diagonals at springing of flanges by one 1 inch bolt each On top of outer column of frame lugs are provided for fixing brackets of 6½ inch inner width under water outlets of main gutter by four 2 inch bolts, with 1 ft. 2 in. by 5 inch waterway. The main gutter running along the whole roof is, on the average, 1 ft. 9 in. wide and 11 inches high. It is cast in lengths of 7 ft. 11½ in., 7-16ths of an inch thick, the joints being made by eleven ⅝ inch bolts. The intermediate ribs are supported by cast-iron standards 8 feet high, which rest on one deep cast-iron girder 3 feet deep and 23 ft. 3½ in. long, which serve in the whole building as bracing and floor-carrying girders between columns 24 feet apart. Such girders brace the columns also right under the flanges of main rib lengthways. The before mentioned standards have the section of half a column of 9 inches diameter, are of ⅝ inch metal, and widened out at the top to a bracket, on to which the base of intermediate rib is bolted by six ½ inch bolts. The lowest of purlins connected to top of frame supporting main rib is also connected by four ½ inch bolts to this bracket, and proper lugs are cast on to the top of standard for fixing a bracket, by four ¾ inch bolts supporting main gutter at each 8 feet. The horizontal thrust of the main ribs is transmitted by the cast-iron frame to the system of columns connected by cast-iron girders as described before, and well braced by diagonals fixed to ends of girders by means of keys.

At the intersection of vertical diagonals a similar adjusting connection with a ring and screws, as for wind ties, is applied, the whole being covered by an ornamental joint cover. The entire supporting structure up to the frame being very rigid, and besides loaded heavily by having on the girders below floor level on one side a fire-proof flooring of brick arches, and on the other side cast-iron girders fastened to brick foundations, takes easily the thrust arising more from wind pressure than from the weight of the roof, which is certainly taken partly by the rib itself, it being of so great a depth. The rain water is carried off in the usual style by the hollow columns.

The smaller roof is very similar to the larger one, as already stated; the dimensions of the details being altered only. The principals are arranged in pairs, being 24 feet apart, each pair having a clear space of 72 feet between. The rib of principal has an equal depth throughout of 8 feet, the outer and inner outline of it being struck from the same centre respectively, with a radius of 36 feet and 28 feet, its curve is a true semicircle. The top and bottom flanges are connected by flat bar diagonals, wrought and cast-iron struts. The flanges consist of two L-irons, 4 inch by 4 inch by ½ inch, having an available sectional area of 6·36 inches. The diagonals are throughout flat bars, 4 inches wide by 5/16 inch, having an available sectional area of 1 inch. The vertical wrought-iron struts are channel irons, 4 inches by 1½ inch by ¼ inch, with available sectional area of 1·37 inch. Each of these struts and diagonals are connected by one 1 inch bolts to the flanges, L irons are jointed in lengths of about 25 feet alternately. The arrangement of lattice work is the same as in large roof; pendants being fixed underneath them to soffit of rib in the same way. There are also two kinds of purlins, 6 feet deep; nearly 24 feet long, and 3 feet deep ones nearly 72 feet long. The construction and dimensions of them are like those in large roof. The intermediate ribs are of the same construction and dimensions as on large roof; so is the arrangement of gutters fixed on top of it, and the covering the same. The arrangement of bracing and wind ties is also similar to that of the large roof; the ventilator is also the same. The main rib weighs 4½ tons; one purlin, 6 feet deep, weighs 12 cwt.; one purlin, 3 feet deep, weighs 1 ton 4 cwt.

Iron work of roof only in one bay of 96 feet, that is from centre of one pair of main ribs to the centre of another pair of them, weighs ?5 tons.

The main rib is supported by structure similar to that of the large roof, that is by a frame formed by two shorter pieces of columns connected by a web. To the outer one is the main gutter fixed of same dimensions as on large roof. The intermediate ribs are also like those of large roof supported, all the details of connections being the same. The 72 feet trussed purlins used in these roofs are the same trusses that were used for carrying the roof over the nave of the Great Exhibition of 1851. A large portion of the columns and girders, also employed in the Sydenham Crystal Palace, are the same as were used in the Great Exhibition building.

Main Arched Roof of the Dublin Exhibition Palace and Winter Garden.

The area devoted to the portion of the exhibition covered by this roof is 218 ft. 10 in. by 50 ft. 6 in. The space occupied by the Winter Garden, which is covered by a similar kind of roof, is 353 ft. 6 in. by 50 ft. 6 in., having a transept 33 ft. 8 in. wide and 50 ft. 6 in. long. These two areas are divided respectively into thirteen and twenty-one bays of 16 ft. 10 in. It is proposed to consider the various details together, that is to say the roof proper, comprising the principals, purlins, and covering, and the supporting structure, with the arrangements for taking the horizontal thrust.

The outline of the arched rib principal is semicircular, the radius of the intrados being 20 ft. 6½ in., and the extrados 28 ft. 1½ in. The rib is thus at its crown 1 ft. 6 in., and at its springing 2 ft. 8 in. deep. It consists of a bottom and top flange each of two L-irons 3½ in. by 2½ in. by ⅜ in. throughout its length, connected together by diagonal bars. The four diagonals next to the crown of the rib are 2⅛ inch by 7/16 inch, the next three are 2¾ inch by ½ inch, then follow three of 3 inch by ½ inch, and the last three are 3¼ inch by 9-16ths of an inch, the rivets for connecting the diagonals to the flanges being ¾ inch, ⅞ inch, and 1 inch diameter, according to the strength of the diagonals. At their intersections the diagonals are connected by ¾ inch rivets. At each point where the dimensions of the diagonals vary the purlins are fixed. There are therefore three purlins on each side exclusive of the ridge purlin at the top. The purlins are of cast-iron, and their construction is well adapted for securing water-tight joints where the covering is fixed to them. They are cast in lengths of 16 ft. 10 in., 9¾ inch in height, and ⅜ inch thick, the bottom flange being ½ inch thick. The web of the purlins is ornamentally perforated, the perforations being glazed, and joints of the purlins chipped. For connecting the purlin firmly to the rib and to give it a certain amount of lateral stiffness two ornamental brackets are fixed by four bolts, 1 inch diameter, to the rib, so that one end appears to support the purlin to which it is well bolted, and the part fixed to the rib being ½ inch in thickness acts as a stiff strut.

Under each of these brackets of ⅜ inch metal an ornamental finial is fixed to the soffit of the rib, on which a 7 feet by ⅞ inch board is fastened to cover the open space between L irons. The two upper bolts of those connecting brackets to ribs serve for fixing the wind ties, the ends of which are flattened down in the usual way, and have right and left-hand screws for adjustment.

The roof of the Exhibition Palace is covered with Italian zinc and glass. The zinc is No. 14 gauge on rolls 3 inch by 1½ inch, about 1 ft. 2¾ in. apart. The winter garden is covered with glass on sash bars 2¼ inch, and 2½ inch by 1½ inch, about 1 ft. 2¾ in.

apart. The glass or zinc overhangs centre of top flange of purlin 4½ inch. The ventilation in this roof is effected by a novel arrangement at the top. The ribs carry in their centre cast iron standards, which are connected at the top on each side by one L iron 3½ inch by 3½ inch by ½ inch, for supporting the covering and giving them lateral stability. The space between these two angle irons is used for ventilation, and can be opened or shut by means of a valve consisting of a piece of convex sheet iron fixed to a spindle running along the roof and having a bearing in each of the cast-iron standards. At certain places pulleys and balance weights are fastened to the spindle, from which a cord goes down to the floor of the building. By means of this cord the spindle and valve can be turned, and the opening or shutting of the ventilator controlled. The whole apparatus is covered by a piece of corrugated zinc forming the ridge, and fixed on small cast-iron supports.

The main ribs weigh each 2¼ tons. The weght of the purlins in one bay is 1 ton 1 cwt. 21 lb, and the weight of brackets for one bay is 5 cwt. 42 lb. The entire weight of wrought and cast-iron in one bay, exclusive of covering, is 3 tons 14 cwt. Each of the ribs is supported by a cast-iron column, 45 feet high from floor level, in three lengths. There are other series of columns 32 feet high in two lengths, 16 ft. 10 in. apart from the columns supporting the main roof, thus forming squares of 16 ft. 10 in. The first tier columns carry at a height of 15 feet cast-iron girders 2 feet deep, with ends widened out to brackets supporting the flooring of the gallery. At a height of 32 feet they carry a cast-iron arched roof of 13 ft. 5 in. clear span. The inner columns support the ribs by brackets which are cast on the clerestory columns, the inner curve of which completes the semicircle of 24 ft. 6½ in. radius. The base of the rib is simply bolted to the top of springers with No. 6 1-inch bolts.

The horizontal thrust is transmitted by this bracket, and a flying buttress is fixed to the column. The cast-iron principal of small roof is fixed to the inner and outer columns by bolts. This thrust tends to overthrow both columns outwards from the top, but they are strongly connected under floor level by a cast-iron girder 1 ft. 6 in. deep, and thus form, with the upper gallery girder and the arched roof, a strong frame. By having the connections made sufficiently strong, and the columns increased in thickness at the required parts to enable them to bear the transverse strain, this frame becomes perfectly rigid, and takes the horizontal thrust without the aid of diagonal bracing.

The columns are cast in two lengths, one portion extending to the top of the gallery girder, and the other to the lower and upper gutters in the first and second tiers. They are connected by four 1-inch bolts, two of which fasten the tie-rods for the diagonal thrust of gallery flooring directly to the column. The greater part of the permanent and moving load of the gallery is thus brought directly on to the columns, and the gallery girder is left to take the thrust of the ribs. The columns are nearly alike, and have a uniform cross section.

The capital of column supporting springing of cast-iron side roof is formed by brackets projecting from each side, leaving the column itself to pass through. The water is carried off from the gutters of the main roof by the columns. The two sides acting as flanges in relation to the transverse strain arising from horizontal thrust is ¾ inch thick, the remaining two sides are ⅝ inch thick. The longitudinal girders of the gallery are connected to the columns by dovetails cast on the columns at each end, fitting into corresponding grooves cast in the ends of columns allowing ¼ inch space, which is run with lead.

The bottom girders have 5⅝ square inches sectional area in the top and bottom flanges, and are widened out at both ends so as to form a sort of square box, to which the base of the columns are attached by four 1½ inch bolts. The columns with boxes and girders rest on foundations of concrete. The flying buttress is composed of several pieces, the joints being applied so as to secure correct action and good workmanship. The weight of iron work in one bay of supporting structure is 7 tons 18 cwt.

Arched Roof of the Derby Market Hall.

The area covered by this roof is a squace space 192 feet long and 86 ft. 6 in. wide. It is divided into eight bays of 24 feet each. The roof is hipped at both ends, and therefore there are only five ordinary principals of 81 ft. 5 in. clear span. The principals consist of wrought-iron arched ribs, the inner and outer curves being true circles struck from the same centre with radii of 43 ft. 9 in. and 41 ft. 5 in. respectively, the springing of rib being 7 ft. 6 in. above centre. The height of rib at crown is 62 ft. 10 in. above the floor level. The wrought-iron rib is of the same depth throughout, and consists of a plate girder with 5/16 inch web, and top and bottom flanges of two L irons 3¼ by 3½ by 7-16ths.

At every alternate supporting place of the purlins the web is joined by means of a joint plate 1 ft. 9 in. by 10½ inches by ½ inch thick, which plate is also rivetted on to the web at the other purlins as a strengthening plate. Angle irons extend always over two lengths of web. The web is ornamented in an original way. A neat design of holes is punched out of the solid plate, leaving the material intact, where it acts in a similar manner to diagonals. As holes show much better than mere lines or raised ornaments, the effect is much more powerful; besides, it seems the only right way of ornamenting a plate girder, because the main construction lines, adapted to certain scientific laws, are not only left intact, but even brought out to a greater extent. Ornamentation by casings and ornaments stuck on may be sometimes really required, but if the real working structure can be made in itself good looking its merit is by far greater. These holes (about 6 inches in diameter, the larger ones) were punched out by a simple screw press, with long levers and heavy weights attached to them. When brought once into the swing the mere momentum suffices to drive the punch through the plate, which is 5-16ths inch thick. The base of rib is horizontal, 2 feet long, while the top flange is 2 ft. 5 in. above, carried vertically down. It is fixed by eight 1 inch bolts, on each side of the web, to the supporting cast-iron column, the angle irons of the bottom flange being carried round horizontally for that purpose. Rivetting is done throughout with ¾ inch rivets, about 4 inch pitch. A board 8¾ inches wide by 1 inch is fixed to soffit of rib for mere appearance. The rib carries wrought-iron lattice purlins, at intervals of 6 ft. 9 in. On each side of such purlin a cast-iron strut is fixed to rib and purlin by six ¾ inch bolts. By this connection the projecting of the purlins beyond the ribs is prevented.

The purlins, which are 23 ft. 10 in. long, and 1 ft. 6 in. deep, are radial, and are connected to the main ribs by means of the cast-iron end struts of ⅜ inch metal by two ¾ inch bolts. They consist of a simple truss, the top and bottom flange of which are each formed by two L irons 3 × 3 × ⅜ inch. The top flange is also connected by two ¾ inch bolts to top flange of main rib. Cast-iron struts, 3 feet pitch, and flat bar diagonal bracing 2½ inch wide, increasing from ¼ inch to ⅜ inch, and ¼ inch in thickness, connect the flanges of the truss by ¾ inch bolts serving as pins for diagonals. Wooden diagonals are also used for giving the appearance of a complete diagonal truss. The purlins support at each strut a wood rafter 6 inch by × ¾ inch. Each alternate strut is so enlarged as to form brackets connected to the wood rafters by ⅜ inch bolts, which are employed to keep the purlins in their radiating position. The other struts are brought out at the top to mere lugs fixed to rafter by ⅜ inch coach screws.

On the top of the main ribs a piece of wood 5¼ inches × 3 inches is fixed for nailing the 1 inch boarding thereto.

The 1 inch boarding is coverod by Italian zinc near the crown, and at the lower part by slates. A portion of the roof is glazed.

The ends of the roof, it being hipped, are formed by ribs, which are in general constructed like the ordinary ones, but stronger in cross section.

One ordinary rib weighs 5¼ tons; weight of purlins, standards, &c., for one bay, 9½ tons. Iron work for one bay of roof weighs 14¾ tons.

Each rib is supported on a cast-iron column 23 feet high from floor level to bottom of gutter, of an octagon section, and 1½ inch thickness of metal. The base is also octagon, 2 ft. 10 in. high, and at the bottom of 2 feet inscribed diameter. At a height of 19 ft. 7 in. from floor level it widens out into an octagon capital of 2 ft. 9 in. inscribed diameter at the top. The base is plain. The top is a little ornamented by a kind of raised leaves. Above that the column widens out into a kind of flat box, 4 ft. 2 in. high, with a bracket in front supporting the horizontal plate to which the L-irons of base of colums are bolted. The horizontal plate extends over the middle of the continued column, leaving on each side of bracket oblong openings for receiving outlets of gutters; the column changes above this horizontal plate into a vertical piece of I section, 1 ft. by 10½ in. by 7¾ in. by 1¼ in., 4 ft. 4 in. high. The vertical part of the base of rib is bolted, as already mentioned, to the inner flange 10½ inch wide. The bracket in front, being only a mere web, is hidden by a casing, appearing as an ornamental bracket of the same thickness as the flat box forming part of column, which is in elevation shaped like the two brackets supporting the outlets of gutter on each side of column. The gutter joins the column by a semi-elliptical arch forming the outlet. The casing is here required for the sake of appearance and for saving a core. To the back of the upper part of column (supporting outlets and the upper flange of the I iron), a frame 11 ft. 6 in. long is fixed by six 1 inch bolts. It consists of an arch of 5 ft. 1 in. radius of bottom outline, with a pretty filling-in ornament, and on the top a square frame 2 ft. 6 in. deep. All the main flanges are 8 inches wide, ¾ inch thick, only the upper flange of frame 1 foot wide by ¾ inch, web being ½ inch thick. The other end of the frame is suitably provided with a vertical flange and a lug at the bottom, for resting on the wall, being besides bolted to it by four 1 inch bolts.

This frame would apparently transmit the horizontal thrust to the walls enclosing the hall, but that is not the case. The horizontal thrust is in this roof taken by a very peculiar arrangement. On the top of the frames just described, on each end strong boxes are cast on, each of which contains a pin dropped into it from above. These pins connect the ends of diagonal bracing rods, with eyes on one end and key adjustment at the other. Along the outer boxes a wrought-iron flange runs throughout the length of the building; decreasing towards the end in strength, the diagonals increasing towards them. This flange, consisting of four plates, 1 foot by 1½ inch, and two L-irons, 3 inch by 3 inch by ½ inch in centre, is connected by the pins to the diagonals. On the other hand, the gutter acts as the other flange of this horizontal girder, and is made sufficiently strong, being cast 1⅜ inch thick. The single lengths of gutters are connected together by means of eight 2-inch bolts, being equal in sectional area to the strength of the gutter, of course piercing the web of the I-shaped part of column. The gutter being of cast-iron, and sometimes exposed to tensile strains, requires, therefore, the above-mentioned area. There are eight diagonals, one for each bay, the dimensions of the rods increase from the centre towards the ends. The diagonals having to sustain just the same as the flanges contrary strains must be always of the same sections as them, because they can only act as the ties. At the hip of the roof only simple ties are required as diagonals.

The roof offering in its longitudinal direction a very great resistance, renders it unnecessary to provide for an extra horizontal thrust arising out of the wind-pressure, &c.

The gutter, being 1 foot by 5½ inch deep, 1 foot wide, and 23 feet by 4 inches long, 1⅜ inch thick, has in distances of 3 feet small shoes cast on, which receive the ends of the intermediate rafters 6 inches by 3 inches. The rafters are placed across the 12 foot corridor at a proper slope, laid with 1 inch boarding, and covered, like the large roof, with slates. The other ends of these rafters rest in shoes on the wall surrounding the hall. The gutter is covered by a snow grating, which is 1 foot by 3 inches wide, and cast in length of 6 feet. It rests on small supports fixed by two ⅝ inch bolts to cross pieces cast on the gutter at every second pair of shoes, and serving as distance pieces in the casting, while it cools and prevents it from warping into awkward shapes. These distance pieces must always be made with a top flange; otherwise the other parts of castings prove stronger in shrinking and tear it in the middle. The rain-water is carried sideways by the bracket-shaped outlets of gutter in the column and carried off by the same to the drain-pipes. The cast and wrought ironwork of one bay of roof weighs 14¾ tons. The cast and wrought ironwork of one bay of supportiong structure weighs 17¾ tons.

(To be continued.)

TOWN HALL AND CORN EXCHANGE, FARNHAM, SURREY.

The new buildings, which have been in course of erection during the last twelvemonth, and are now completed, were opened on the 15th ult. The new edifice, which includes a market hall or corn exchange, offices, shops, and assembly rooms, has been built on the site lately occupied by the Goat's Head Inn, at the junction of Castle-street with the Borough. At the corner of the building is a clock-tower, 88 ft. high, in the top story of which is a four-dial clock, by Frodsham, presented to the town by Mr. S. Nicholson, of Waverley Abbey. This tower is surmounted by a belfry, having a slated spire, terminated by a weather-cock, and containing three bells, for the quarters and hour. On the side next the Borough are shops, with cellars below, and two stories of rooms above. The ground-floor on the side next Castle-street is occupied by offices, with an entrance-hall, 32 ft. by 10 ft., in the centre, paved with black and red tiles, for access to the market-hall, which is built behind the shops, and is lighted from the roof and one end. This hall is 70 ft. by 36 ft., and 30 ft. high; it is faced inside with white Huntingdon bricks, slightly relieved with red and black bricks, and is covered by a polygonal ceiling resting on circular arches, formed of three thicknesses of 3-inch planks, bolted together on the Delorme principle, which spring from stone corbels on projecting piers. One compartment of the ceiling on each side of the centre one is filled with rough plate-glass the whole length of the hall, and there is a large three-light window at one end of the room. The rest of the ceiling is boarded, the whole of the woodwork being stained and varnished. On one side of the hall, and entered from it, are offices for the use of merchants attending the markets; there is also a side entrance to the room from the Borough.

The assembly-room is placed on the upper floor, and in the portion of the building fronting Castle-street. This is reached by three separate stone staircases, the chief of which is 7 feet wide, and leads from the entrance-hall in Castle-street. The room is 48 feet by 32 feet, and 30 feet high, with retiring-room and cloak-room adjoining. Its roof and ceiling are constructed on the same principle as that of the market-hall, the ribs springing from carved stone capitals, supported on red shafts of terra-cotta. Both this room and the market-hall are lighted by sun-burners of Messrs. Strode's manufacture, and are warmed by Haden's hot-air apparatus.

The outside of the building, and also the staircase and entrance-hall, are faced with white Huntingdon bricks. All round the roof of the assembly-room is an arcaded parapet, surmounting a moulded cornice, all of terra-cotta; and the arches to the two chief entrances are of the same material. The mullions of the windows are of Bath stone, with carved caps and red terra-cotta pillar-shafts. The entrance doorway in Castle-street has recessed jambs, with carved caps and red terra-cotta shafts. Carved stone caps and red shafts are also used at the outer angles of the lowest stage of the tower, and also to the arched openings at the base of the tower. The windows have gauged semicircular and segmental arches of moulded red bricks, with stone keys and skew backs. All quoins, window and door jambs, arches of tower, and panels for clock-faces, are of Bath stone.

The terra-cotta was supplied by Mr. Blashfield, of Stamford. Mr. F. Birch, of Farnham, was contractor for the general building; and Mr. R. Mulley acted as clerk of works. The architect employed was Mr. E. Wyndham Tarn, of London. The total cost has been about £3500. The style of the building is an adaptation of that prevalent in Italy during the eleventh and twelfth centuries.

ON THE FORCES CONCERNED IN LAYING AND LIFTING DEEP-SEA CABLES.*

By William Thomson, LL.D.

The forces concerned in the laying and lifting of deep submarine cables attracted much public attention in the years 1857—58.

An experimental trip to the Bay of Biscay, in May 1858, proved the possibility not only of safely laying such a rope as the old Atlantic cable in very deep water, but of lifting it from the bottom without fracture. The speaker had witnessed the almost incredible feat of lifting up a considerable length of that slight and seemingly fragile thread from a depth of nearly two and a half nautical miles.† The cable had actually brought with it safely to the surface, from the bottom, a splice with a large weighted frame attached to it, to prevent untwisting between the two ships, from which two portions of cable with

* Read before the Royal Society.

† Throughout the following statements the word mile will be used to denote not that most meaningless of modern measures, the British statute mile, but, the nautical mile, or the length of a minute of latitude, in mean latitudes, which in electric cable reckoning is taken as 6073 ft. For approximate statements, rough estimates, &c., it may be taken as 6000 ft. or 1000 fathoms.

opposite twists had been laid. The actual laying of the cable a few months later, from mid ocean to Valentia on one side, and Trinity Bay, Newfoundland, on the other, regarded merely as a mechanical achievement, took by surprise some of the most celebrated engineers of the day, who had not concealed their opinion that the Atlantic Telegraph Company had undertaken an impossible problem. As a mechanical achievement it was completely successful; and the electric failure, after several hundred messages (comprising upwards of 4359 words) had been transmitted between Valentia and Newfoundland, was owing to electric faults existing in the cable before it went to sea. Such faults cannot escape detection, in the course of the manufacture, under the improved electric testing since brought into practice, and the causes which led to the failure of the first Atlantic cable no longer exist as dangers in submarine telegraphic enterprise. But the possibility of damage being done to the insulation of the electric conductor before it leaves the ship (illustrated by the occurrences which led to the temporary loss of the 1865 cable), implies a danger, which can only be thoroughly guarded against by being ready at any moment to back the ship and check the egress of the cable, and to hold on for some time, or to haul back some length, according to the results of electric testing.

The forces concerned in these operations, and the mechanical arrangements by which they are applied and directed, constitute one chief part of the present address; the remainder is devoted to explanations as to the problem of lifting the west end of the 1200 miles of the cable laid last summer, from Valentia westwards, and now lying in perfect electric condition (in the very safest place in which a submarine cable can be kept), and ready to do its work, as soon as it is connected with Newfoundland, by the 600 miles required to complete the line.

Forces Concerned in the Submergence of a Cable.—In a paper published in 1857, the speaker had given the differential equations of the catenary formed by a submarine cable between the ship and the bottom, during the submergence, under the influence of gravity and fluid friction and pressure; and he had pointed out that the curve becomes a straight line in the case of no tension at the bottom. As this is always the case in deep-sea cable laying, he made no further reference to the general problem in the present address.

When a cable is laid at uniform speed, on a level bottom, quite straight, but without tension, it forms an inclined straight line, from the point where it enters the water, to the bottom, and each point of it clearly moves uniformly in a straight line towards the position on the bottom that it ultimately occupies.* That is to say, each particle of the cable moves uniformly along the base of an isosceles triangle, of which the two equal sides are the inclined portion of the cable between it and the bottom, and the line along the bottom which this portion of the cable covers when laid. When the cable is paid out from the ship at a rate exceeding that of the ship's progress, the velocity and direction of the motion of any particle of it through the water are to be found by compounding a velocity along the inclined side, equal to this excess, with the velocity already determined along the base of the isosceles triangle.

The angle between the equal sides of the isosceles triangle, that is to say the inclination which the cable takes in the water, is determined by the condition, that the transverse component of the cable's weight in water is equal to the transverse component of the resistance of the water to its motion. Its tension where it enters the water is equal to the longitudinal component of the weight (or, which is the same, the whole weight of a length of cable hanging vertically down to the bottom), diminished by the longitudinal component of the fluid resistance. In the laying of the Atlantic cable, when the depth was two miles, the rate of the ship six miles an hour, and the rate of paying out of the cable seven miles an hour, the resistance to the egress of the cable, accurately measured by a dynamometer, was only 14 cwt. But it must have been as much as 28 cwt., or the weight of two miles of the cable hanging vertically down in the water, were it not for the frictional resistance of the water against the cable slipping, as it were, down an inclined plane from the ship to the bottom, which, therefore, must have borne the difference, or 14 cwt. Accurate observations are wanting as to the angle at which the cable entered the water; but from measurements of angles at the stern of the ship, and a dynamical estimate (from the measured strain) of what the curvature must have been between the ship and the water, I find that its inclination in the water, when the ship's speed was nearly 6½ miles per hour, must have been about 6¾ deg., that is to say, the incline was about 1 in 8½. Thus the length of cable, from the ship to the bottom, when the water was two miles deep, must have been about seventeen miles.

The whole amount (14 cwt.) of fluid resistance to the motion of this length of cable through it is therefore about ·81 of a cwt. per mile. The longitudinal component velocity of the cable through the water to which this resistance was due may be taken, with but very small error, as simply the excess of the speed of paying out above the speed of the ship, or about one mile an hour. Hence, to haul up a piece of the cable vertically through the water at the rate of one mile per hour would require less than 1 cwt. for overcoming fluid friction per mile of the cable, over and above its weight in water. Thus fluid friction, which for the laying of a cable performs so valuable a part in easing the strain with which it is payed out, offers no serious obstruction, indeed scarcely any sensible obstruction to the reverse process of hauling back, if done at only one mile an hour, or any slower speed.

As to the transverse component of the fluid friction, it is to be remarked that, although not directly assisting to reduce the egress strain it indirectly contributes to this result; for it is the transverse friction that causes the gentleness of the slope, giving the sufficient length of seventeen miles of cable slipping down through the water, on which the longitudinal friction operates, to reduce the egress strain to the very safe limit found in the recent expedition. In estimating its amount, even if the slope were as much as 1 in 5, we should commit only an insignificant error if we supposed it to be simply equal to the weight of the cable in water, or about 14 cwt. per mile for the 1865 Atlantic cable. The transverse component velocity to which this is due may be estimated with but insignificant error by taking it as the velocity of a body moving directly to the bottom in the time occupied in laying a length of cable equal to the seventeen miles of oblique line from the ship to the bottom—therefore it must have been from 2 miles in $17 \div 6\frac{1}{2} = 2{\cdot}61$ hours, or ·8 of a mile per hour. It is not probable that the actual motion of the cable lengthwise through the water can affect this result much. Thus, the velocity of settling of a horizontal piece of the cable (or velocity of sinking through the water, with weight just borne by fluid friction) would appear to be about ·8 of a mile per hour. This may be contrasted with longitudinal friction by remembering that, according to the previous result, a longitudinal motion through the water at the rate of one mile per hour is resisted by only one-seventeenth of the weight of the portion of cable so moving.

These conclusions justify remarkably the choice that was made of materials and dimensions for the 1865 cable. A more compact cable (one, for instance, with less gutta-percha, less or no tow round the iron wires, and somewhat more iron), even if of equal strength and equal weight per mile in water, would have experienced less transverse resistance to motion through the water, and therefore would have run down a much steeper slope to the bottom. Thus, even with the same longitudinal friction per mile, it would have been less resisted on the shorter length; but even on the same length it would have experienced much less longitudinal friction, because of its smaller circumference. Also, it is important to remark that the roughness of the outer tow covering undoubtedly did very much to ease the egress strain, as it must have increased the fluid friction greatly beyond what would have acted on a smooth gutta-percha surface, or even on the surface of smooth iron wires presented by the more common form of submarine cables.

The speaker showed models illustrating the paying-out machines used on the Atlantic expeditions of 1858 and 1865. He stated that nothing could well be imagined more perfect than the action of the machine of 1865 in paying out the 1200 miles of cable then laid, and that if it were only to be used for paying out no change, either in general plan or in detail, seemed desirable, except the substitution of a softer material for the "jockey pulleys," by which the cable in entering the machine has the small amount of resistance applied to it, which it requires to keep it from slipping round the main drum. The rate of egress of the cable was kept always under perfect control by a weighted friction brake of Appold's construction (which had proved its good quality in the 1858 Atlantic expedition) applied to a second drum carried on the same shaft with the main drum. When the weights were removed from the brake (which could be done

* Precisely the movement of a battalion in line changing front.

almost instantaneously by means of a simple mechanism) the resistance to the egress of the cable produced by "jockey pulleys," and the friction at the bearings of the shaft carrying the main drum, &c., was about 2½ cwt.

Procedure to Repair the Cable in case of the Appearance of an Electric Fault during the Laying.—In the event of a fault being indicated by the electric test at any time during the paying out (as proved by the recent experience) the safe and proper course to be followed in future, if the cable is of the same construction as the present Atlantic cable, is instantly, on order from an authorised officer in the electric room, to stop and reverse the ship's engines, and to put on the greatest safe weight on the paying-out brake. Thus in the course of a very short time the egress of the cable may be stopped, and if the weather is moderate, the ship may be kept, by proper use of paddles, screw, and rudder, nearly enough in the proper position for hours to allow the cable to hang down almost vertically, with little more strain than the weight of the length of it between the ship and the bottom.

The best electric testing that has been practised, or even planned, cannot show within a mile the position of a fault consisting of a slight loss of insulation, unless both ends of the cable are at hand. Whatever its character may be, unless the electric tests demonstrate its position to be remote from the outgoing part, the only thing that can be done to find whether it is just on board or just overboard, is to cut the cable as near the outgoing part as the mechanical circumstances allow to be safely done. The electric test immediately transferred to the fresh-cut seaward end shows instantly if the electric line is perfect between it and the shore. A few minutes more, and the electric tests applied to the two ends of the remainder on board will, in skilful hands, with a proper plan of working, show very closely the position of the fault, whatever its character may be. The engineers will thus immediately be able to make proper arrangements for resplicing and paying out good cable, and for cutting out the fault from the bad part.

But if the fault is between the land end and the fresh-cut seaward end on board ship, proper simultaneous electric tests on board ship and on shore (not hitherto practised, but easy and sure if properly planned) must be used to discover whether the fault lies so near the ship that the right thing is to haul back the cable until it is got on board. If it is so, then steam power must be applied to reverse the paying-out machine, and by careful watching of the dynamometer, and controlling the power accordingly (hauling in slowly, stopping, or veering out a little, but never letting the dynamometer go above 60 or 65 cwt.), the cable (which can bear 7 tons) will not break, and the fault can be got on board more surely, and possibly sooner, than a "sulky" salmon of 30 lb. can be landed by an expert angler with a line and rod that could not bear 10 lb. The speaker remarked, that he was entitled to make such assertions with confidence now, because the experience of the late expedition had not only verified the estimates of the scientific committee, and of the contractors, as to the strength of the cable, its weight in water (whether deep or shallow), and its mechanical manageability; but it had proved that in moderate weather the Great Eastern could by skilful seamanship be kept in position and moved in the manner required. She had actually been so for thirty-eight hours, and eighteen hours during the operations involved in the hauling back and cutting out the first and second faults, and re-uniting the cable, and, during seven hours of hauling in, in the attempt to repair the third fault.

Should the simultaneous electric testing on board and on shore prove the fault to be 50 or 100 or more miles from the ship, it would depend on the character of the fault, the season of the year, and the means and appliances on board, whether it would be better to complete the line, and afterwards, if necessary, cut out the fault and repair, or to go back at once and cut out the fault before attempting to complete the line. Even the worst of these contingencies would not be fatal to the undertaking with such a cable as the present one. But all experience of cable-laying shows that almost certainly the fault would either be found on board, or but a very short distance overboard, and would be reached and cut out with scarcely any risk, if really prompt measures, as above described, are taken at the instant of the appearance of a fault, to stop, as soon as possible with safety, the further egress of the cable.

The most striking part of the Atlantic undertaking proposed for 1866, is that by which the 1200 miles of excellent cable laid in 1865 is to be utilised by completing the line to Newfoundland. That a cable lying on the bottom in water two miles deep can be caught by a grapnel, and raised several hundred fathoms above the bottom, was amply proved by the nine days' work which followed the breakage of the cable on the 2nd of August last. Three times out of four that the grapnel was let down, it caught the cable on each occasion after a few hours of dragging, and with only 300 or 400 fathoms more of rope than the 2100 required to reach the bottom by the shortest course. The time when the grapnel did not hook the cable it came up with one of its flukes caught round by its chain; and the grapnel, the short length of chain next it, and about 200 fathoms of the wire rope, were proved to have been dragged along the bottom, by being found, when brought on board, to have the interstices filled with light grey ooze (of which the speaker showed a specimen to the Royal Society). These results are quite in accordance with the dynamical theory indicated above, according to which a length of such rope as the electric cable, hanging down with no weight at its lower end, and held by a ship moving through the water at half a mile an hour, would slope down to the bottom at an angle from the vertical of only 20 deg.; and the much heavier and denser wire-rope that was used for the grappling would go down at the same angle with a considerable more rapid motion of the ship, or at still steeper slope with the same rate of motion of the ship.

The only remaining question is :—How is the cable to be brought to the surface when hooked? The operations of last August failed from the available rope, tackle, and hauling machine not being strong enough for this very unexpected work. On no occasion was the electric cable broken.* With strong enough tackle, and a hauling machine, both strong enough, and under perfect control, the lifting of a submarine cable, as good in mechanical quality as the Atlantic cable of 1865, by a grapnel or grapnels, from the bottom at a depth of two miles, is certainly practicable. If one attempt fails, another will succeed; and there is every reason, from bynamics as well as from the 1865 experience, to believe that in any moderate weather the feat is to be accomplished with little delay, and with very few, if any, failing attempts.

The several plans of proceeding that have been proposed are of two classes—those in which by three or more ships it is proposed to bring a point of the cable to the surface without breaking it at all; and those in which it is to be cut or broken, and a point of the cable somewhat eastward from the break is to be brought to the surface.

With reference to either class, it is to be remarked that, by lifting simultaneously by several grapnels so constructed as to hold the cable without slipping along it or cutting it, it is possible to bring a point of the cable to the surface without subjecting it to any strain amounting to the weight of a length of cable equal to the depth of the water. But so many simultaneous grapplings by ships crossing the line of cable at considerable distances from one another would be required, that this possibility is scarcely to be reckoned on practically without cutting or breaking the cable at a point westward of the points raised by the grapnels. On the other hand, with but three ships the cable might no doubt be brought to the surface at any point along the line without cutting it, and without subjecting it at any point to much more strain than the weight corresponding to the vertical depth, as is easily seen when it is considered that the cable was laid generally with from 10 to 15 per cent. of slack. And if the cable is cut at some point not far westward of the westernmost of the grapnels, there can be no doubt but it could be lifted with great ease by three grapnels hauled up simultaneously by three ships. (The catenaries concerned in these operations were illustrated by a chain with 15 per cent. of slack hauled up simultaneously at three points.)

The plan which seems to the speaker surest and simplest is to cut the cable at any chosen point, far enough eastward of the present broken end to be clear of entanglement of lost buoy-rope, grapnels, and the lose end of the electric cable itself; and then,

* The strongest rope available was a quantity of rope of iron wire and hemp spun together, able to bear fourteen tons, which was prepared merely as buoy-rope (to provide for the contingency of being obliged, by stress of weather or other cause, to cut and leave the cable in deep or shallow water), and was accordingly all in 100-fathom lengths, joined by shackels and swivels. The wire-rope itself never broke, but on two of the three occasions a swivel gave way. On the last occasion about 900 fathoms of Manilla rope had to be used for the upper part, there not being enough of the wire buoy-rope left; and when 700 fathoms of it had been got in, it broke on board beside a shackle, and the remaining 200 fathoms of the Manilla, with 1540 fathoms of wire-rope and the grapnel, and the electric cable which it had hooked, were all lost for the year 1865.

or as soon as possible after, to grapple and lift at a point about three miles farther eastward. This could be well and safely done by two ships, one of them with a cutting grapnel, and the other (the Great Eastern herself) with a holding grapnel. The latter, on hooking, should haul up cautiously, never going beyond a safe strain, as shown by the dynamometer. The other, when assured that the Great Eastern has the cable, should haul up, at first cautiously, but ultimately, when the cable is got well off the bottom by the Great Eastern, the western ship should move slowly eastwards, and haul up with force enough to cut or break the cable. This leaves three miles of free cable on the western side of the Great Eastern's grapnel, which will yield freely eastwards (even if partly lying along the bottom at first), and allow the Great Eastern to haul up and work slowly eastwards, so as to keep its grappling rope, and therefore ultimately the portions of electric cable hanging down on the two sides of its grapnel, as nearly vertical as is necessary to make sure work of getting the cable on board. This plan was illustrated by lifting, by aid of two grapnels, a very fragile chain (a common brass chain in short lengths, joined by links of fine cotton thread) from the floor of the Royal Society. It was also pointed out that it can be executed by one ship alone, with only a little delay, but with scarcely any risk of failure. Thus, by first hooking the cable by a safe-holding grapnel, and hauling it up 200 or 300 fathoms from the bottom, it may be left there hanging by the grapnel-rope on a buoy, while the ship proceeds three miles westwards, cuts the cable there, and returns to the buoy. Then it is an easy matter in any moderate weather to haul up safely, and get the cable on board.

The use of the dynamometer in dredging was explained; and the forces operating on the ship, the conditions of weather, and the means keeping the ship in proper position during the process of slowly hauling in a cable, even if it were of strength quite insufficient to act when nearly vertical with any sensible force on the ship, were discussed at some length. The manageability of the Great Eastern in skilful hands had been proved to be very much better than could have been expected, and to be sufficient for the requirements in moderate weather. She has both screw and paddles—an advantage possessed by no other steamer in existence. By driving the screw at full power ahead, and backing the paddles to prevent the ship from moving ahead, or (should the screw overpower the paddles) by driving the paddles full power astern, and driving at the same time the screw ahead with power enough to prevent the ship from going astern, "steerage way" is created by the lash of water from the screw against the rudder; and thus the Great Eastern may be effectually steered without going ahead. Thus she is in calm or moderate weather almost as manageable as a small tug steamer with reversing paddles, or as a rowing boat. She can be made still more manageable than she proved to be in 1865, by arranging to disconnect either paddle at any moment; which, the speaker was informed by Mr. Canning, may easily be done.*

The speaker refered to a letter he had received from Mr. Canning, chief engineer of the Telegraph Construction and Maintenance Company, informing him that it is intended to use three ships, and to be provided both with cutting and with holding grapnels, and expressing great confidence as to the success of the attempt. In this confidence the speaker believed every practical man who witnessed the Atlantic operations of 1865 shared, as did also, to his knowledge, other engineers who were not present on that expedition, but who were well acquainted with the practice of cable-laying and mending in various seas, especially in the Mediterranean. The more he thought of it himself, both from what he had witnessed on board the Great Eastern and from attempts to estimate on dynamical principles the forces concerned, the more confident he felt that the contractors would succeed next summer in utilising the cable partly laid in 1865, and completing it into an electrically perfect telegraphic line between Valentia and Newfoundland.

Certificate signed by Persons officially engaged in Laying the Atlantic Telegraph Cable from the Great Eastern in 1865.

1. It was proved by the expedition of 1858 that a submarine telegraph cable could be laid between Ireland and Newfoundland, and messages transmitted through the same.

By the expedition of 1865 it has been fully demonstrated:—

2. That the insulation of a cable improves very much after its submersion in the cold deep water of the Atlantic, and that its conducting power is considerably increased thereby.

3. That the steamship Great Eastern, from her size and constant steadiness, and from the control over her afforded by the joint use of paddles and screw, renders it safe to lay an Atlantic cable in any weather.

4. That in a depth of over two miles four attempts were made to grapple the cable. In three of them the cable was caught by the grapnel, and in the other the grapnel was fouled by the chain attached to it.

5. That the paying-out machinery used on board the Great Eastern worked perfectly, and can be confidently relied on for laying cables across the Atlantic.

6. That with the improved telegraphic instruments for long submarine lines a speed of more than eight words per minute can be obtained through such a cable as the present Atlantic between Ireland and Newfoundland, as the amount of slack actually payed out did not exceed 14 per cent., which would have made the total cable laid between Valentia and Heart's Content less than 1900 miles.

7. That the present Atlantic cable, though capable of bearing a strain of 7 tons, did not experience more than 14 cwt. in being payed out into the deepest water of the Atlantic between Ireland and Newfoundland.

8. That there is no difficulty in mooring buoys in the deep water of the Atlantic between Ireland and Newfoundland; and that two buoys, even when moored by a piece of the Atlantic cable itself, which had been previously lifted from the bottom, have ridden out a gale.

9. That more than four nautical miles of the Atlantic cable have been recovered from a depth of over two miles, and that the insulation of the gutta-percha-covered wire was in no way whatever impaired by the depth of water, or the strains to which it had been subjected by lifting and passing through the hauling-in apparatus.

10. That the cable of 1865, owing to the improvements introduced into the manufacture of the gutta-percha core, was more than one hundred times better insulated than cables made in 1858, then considered perfect, and still working.

11. That the electrical testing can be conducted at sea with such unerring accuracy as to enable the electricians to discover the existence of a fault immediately after its production or development, and very quickly to ascertain its position in the cable.

12. That with a steam engine attached to the paying-out machinery, should a fault be discovered on board while laying the cable, it is possible that it might be recovered before it had reached the bottom of the Atlantic, and repaired at once.

S. Canning (Engineer-in-Chief, Telegraph Construction and Maintenance Company).
James Anderson (Commander of the Great Eastern).
Daniel Gooch, M.P. (Chairman of Great Ship Company).
Henry Clifford (Engineer).
William Thomson, LL.D., F.R.S. (Prof. of Natural Philosophy in the University of Glasgow).
Cromwell F. Varley (Consulting Electrician of Electric and International Telegraph Company).
Willoughby Smith.
Jules Despecher.

New Zealand Canals.—A proposal has been made for the construction of a canal uniting the navigation of the Kaipara and Waitemata and the settlement of a block of provincial land of about 450,000 acres. In the Kaipara district there is an immense territory of agricultural land, and generally of good quality. This land is accessible by the land-locked sea known as the Kaipara, and by navigable rivers and canals providing easy and available means of inland transit, but it is cut off from Auckland, effectually as if it were on the west coast of Canterbury, for all purposes of trade and commerce. A canal of a few miles, through what might be called a level country, from Brigham's Creek to the head waters of the Kaipara, would connect the port of Auckland with that district, and make available to river steamers and barges of light draught about 300 miles of tidal river navigation. The block of land proposed to be given to any company which will construct the canal and cultivate the land is intersected by two navigable rivers. It is generally rich agricultural land.

* It is being done.

ROADS IN INDIA.

There is a question which must soon be faced by the government of India, scarcely less momentous to the welfare of the people, and fully as vast in its proportions, as that of irrigation. Sir John Lawrence, in his evidence before the Committee of the House of Commons on the Colonization of India, said, "we are perishing for want of roads." The expression was not only metaphorically, but literally, true. But for the want of roads, the famines, caused by the absence of irrigation, could never assume the extent or severity that they do. Something has been done to equalize the distribution of food by the construction of the trunk railways; but, without connecting highways, the peasant, 80 or 100 miles from the line, cut off by jungle, ravine, and morass, might as well be a thousand miles off.

Those who have had occasion to travel much in the interior of the country, away from the few great roads which have crept slowly into existence during our century of occupation, must have often had the urgency of this need forced upon their attention. The traveller, as he watches that marvellous combination of sticks and string in which four half-starved oxen drag painfully along his baggage, at the rate of a mile and a half an hour, over hedge and ditch, or through ploughed fields, cannot but speculate on what India might now have been, had twenty or thirty millions been borrowed and expended in a worthy system of roads thirty years ago. Whatever Sir Charles Wood may boast in the House, and local governments in their administration reports, about the thousand of miles of "road" constructed under our sway, every sportsman, every engineer, and every settler, to his cost, knows that, besides the Grand Trunk Road and a few branches, there is scarcely a road worthy of the name in the Bengal Presidency.

What these "thousands of miles" are like, may be supposed from the fact that, in one district at least, as published in an official administration report a few years ago, they cost twelve shillings a mile! The truth is, that two furrows are run with a plough, 50 or 60 feet apart, right across country, hedges and ditches being left to be levelled by successive carts tumbling over or into them, and there you have a "district road." Many of them are simply water-courses, actually sunk six or eight feet below the surface of the country; and we have seen perpendicular falls of three or four feet, with a fine cascade rushing over them, extending right across the road. A mere common obstruction is an irrigation channel, taking the form either of a deep ditch, or an embanked duct, two or three feet high, by which the zemindars have coolly blocked up the road for convenience of irrigation.

Bad as such roads are, they have the advantage of being visible, and so serving as a guide from place to place. But they exist only as exceptions. As a rule there is no road at all between town and town; carts follow each other's ruts over the cultivation, sometimes establishing a defined track for a few hundred yards, but which again disappears in the middle of a ploughed field further on. The zemindars, not content with ploughing up the track, cut trenches, and plant thorn-bushes across it, to drive the carts to take some other route, from which they are in turn diverted by the cultivators of the ground.

A considerable sum of money is spent by local committees from local funds, on communications, but we fear that a great deal of it is simply wasted. Except in the North West Provinces, where there is a civil engineer for each commissioner's division, the money is disbursed without any professional advice or supervision, and hence embankments are made where none are wanted, and *vice versa*; bridges tumble down or are left high and dry, and little good is done. Every civil officer is supposed to be able to lay out a road or build a bridge; although he would probably hesitate to perform an amputation, or to take the command of a frigate. In France all public highways and bridges are under the charge of a highly educated corps of civil engineers, the department of *Ponts et Chaussees*, and even in England, where we delight to do everything the wrong way, the system of parish muddling is giving way to the highway boards who have competent surveyors to advise them. How long will it be before our government accepts the principle of division of labour?

The melancholy results of leaving professional matters like road-making to civil authorities, who have neither the knowledge nor the leisure to supervise them, are nowhere more conspicuous than in the mountain roads of the Himalayas, excluding, of course, those under the Public Works Department.

The aggravating way in which these roads are often aligned, can only be accounted for by a combination of the original perversity of the Puharees, which leads them to take their paths over every hill, no matter how steep, rather than go round it, with the engineering vagaries of a Tehsil Chuprassie, whose sole notion of improving a road is to lengthen it. We have measured a gradient of upwards of 70 in 100 on a hill road, constructed at some expense, where it might have been made shorter, and yet on a fair inclination, at no greater cost. And the most provoking thing is, that year by year, as we have pointed out in a former article, an amount of labour is wasted by Chuprassie engineers, which, under judicious management, would serve to construct an excellent road.

Turning from local funds, which, though considerable in the aggregate, are but a drop in the bucket, compared with the requirements of the country, let us see what hope is afforded by the Imperial resources. We spend something like a million a year on communications, of which one-half goes in ever-increasing repairs. How long will it take to provide India with a decent system of roads even if we continue to spend half a million per annum in making new ones? But we cannot afford to do even so much without a radical change of system. Every mile of new road adds a permanent charge for repairs, which must be deducted from the total grant, before anything is left for future extensions. Already the repairs swallow up half the grant; before many years are over, they will absorb the whole, unless it is largely augmented, of which the increasing demands under all other heads of public works leave little probability.

What then is to be done? First, let us make the most of present means, by transferring the repairs of all except purely military roads to local funds, and reducing the repairs which must still be defrayed by the Imperial government to the lowest point, by improved modes of construction. How the local funds are to be raised, so as to meet the burden thrown upon them, must be determined in detail by local governments, accepting as a fundamental principle that those who most benefit by the road should mainly pay for it. Thus, where a large commercial town is situated on a road, some part of the *octroi* duties should be devoted to this purpose. When the road passes through a rich agricultural district, the cultivators, who are enabled to find markets for their produce, should contribute, whether by a cart-tax, a cess on the land, or statute duty in the shape of supplying materials and labour for repairs. Authorities are agreed that tolls should be dispensed with if possible, but in some cases they will be the only available source of revenue.

With regard to the reduction of repairs, the anticipation that the railways would almost supersede the roads running parallel with them, has been but very partially realised. And the traffic upon feeders and cross-roads must increase as the railways get into full working order. It is pretty evident that the present plan of macadamising with brick, broken stone, or kunkur, expensive as it is, does not last under the heavy and concentrated traffic of the main trunk roads. The cost of continual renewals is crushing, and must be reduced, even if the first outlay for a more permanent surface be very heavy. The most feasible remedy seems to be to lay down a stone or iron tramway, upon which the ordinary carts of the country can run; the tram-plates to be flat, and flush with the surface of the road. This plan has been very successfully used on the Commercial-road and on Westminster Bridge, at home. Now that the railway supplies tolerably cheap carriage, stone or iron tram-plates could be landed on any part of the Grand Trunk Road at a reasonable cost. The experiment is at least worth trying.

Supposing, however, that we could, by such alterations, devote a million a year to new roads, how inadequate is such sum to provide a whole continent! We have a century of leeway to make up, and it will not do now to proceed by such gradual measures as might have sufficed if begun fifty years ago. Commerce will not wait; the newborn prosperity of the country will be strangled prematurely if we do not remove the bonds which choke it. If a man has a valuable plot of ground, requiring only roads and drains to fit it for building purposes, which will quadruple its value, he does not wait till, by painful savings from his income for a series of years, he can realize the wealth that await him. He mortgages his estate to make the improvements which will pay off his loan and enable him to grasp its full value at once. We have in India a vast estate, whose value and revenue may be doubled over and over again by judicious expenditure. Capitalists believe this, they will lend the money on their faith in its capabilities. Why do we hesitate? Debt is not the worst of evils; if war comes we pocket the necessity, and borrow, though the money never returns. Why not borrow when the need is so urgent, and the results so beneficial? Canals may be made by private companies; roads cannot. The railways will never have a fair chance till a proper system of roads feeds them; many of them will continue to be a burden on Government for the guaranteed interest. Suppose we have to pay a million a year to the railway shareholders, will it not be economical to raise twenty millions, wherewith to make roads, that will enable the railways to pay their 5 per cent., and relieve us of this incubus? We shall still only have to pay a million to fund-holders instead of to railway shareholders, but we shall be the gainers by twenty millions worth of roads into the bargain. The railway interest, and the cotton interest together, are all-powerful in the House of Commons; why do they not unite in pressing the Government to give India her crying wants, canals and roads?—*Calcutta Engineer.*

Reviews.

The Principal Ruins of Asia Minor, illustrated and described by CHARLES TEXIER and R. POPPLEWELL PULLAN, F.R.I.B.A. Day and Sons, 1865. Folio.

Asia Minor has proved, as far as it has been examined, a fertile field of architectural and antiquarian research, and that in more phases of art than one; and yet there is something of the charm of novelty still lingering about the discoveries made or to be made there, for it is a region lying more remote, and consequently less visited, than Magna Græcia, Sicily, and Italy, and much of its wealth is but partially known. The early Christian Churches of Rome or Ravenna, and the Greek remains of Athens or Syracuse, are well catalogued and have been thoroughly explored and described, but there are buildings of the highest interest in Asia Minor both of Classic and early Christian character, which it has been the privilege of recent explorers to make known for the first time to the world at large.

The work before us proposes to introduce to the attention of its readers the principal of those ruins which display the character of Classic architecture and sculpture, to be found in various cities along the eastern shores of the Ægean Sea. It appeals, of course, first and chiefly to the attention of students of Greek architecture, but these are in the present day less numerous than they once were—far less so than they ought to be—and the work, perhaps wisely, has been thrown into a shape which, while not too slight in general to be unfitted for the purposes of the architectural student, is sufficiently free from wearisome technical minutiæ to have a claim on the attention of non-professional readers; in fact, it is a work which all persons of taste and culture will be glad to possess.

It is to be regretted, and is regretted by all who would desire to see the architecture of this country assume a place in every respect worthy of our national eminence in other arts, that attention is too exclusively directed to the works of the middle ages, and to the phase of art to which those works belong. Pure beauty of form, refinement, proportion, symmetry, and dignity, are more fully illustrated by the works of Greek art than by those of the middle ages; and we cannot hope to retain these properties in our sculpture and our architecture without a constant recurrence to the Greek source. We welcome, consequently, the appearance of a work like Mr. Pullan's, for the sake of the progress of art, as well as for its own sake, and we believe that it will furnish an effective contribution towards the art education of the present day.

We have called this Mr. Pullan's book, because, although M. Texier's name appears on the title page, this volume being, in fact, a kind of abridgement of that traveller's large work, the responsibility and the credit of this publication belong to Mr. Pullan, who has translated and condensed from Texier's work much of the information contained in the letterpress, and has selected the plates here given, and has added some very interesting and valuable matter of his own.

Mr. Pullan's introduction gives a succinct history of the explorations of Asia Minor which have been carried on by various travellers; commencing with Paul Lucas, who in 1699 traversed the peninsula, but whose work is described as unsatisfactory and incorrectly illustrated; down to his own exact and comparatively recent explorations. This is extremely well though briefly done, and will enable the reader, whose curiosity may be excited by the volume under review, to understand where he may find supplementary information. Of all the various travellers and exploring expeditions which have visited these shores, none have published so complete a record as the French Government expedition, under Mons. Texier, and it is to render the subject matter of this very large and costly volume accessible that the present publication is undertaken.

A map and fifty-one plates, the execution of some of which is extremely beautiful, are given. They refer to the thirteen or fourteen different ruins which have been selected from a large number for illustration, as being the most important and typical. The principal subjects are the Doric Temple at Assos, the Temple of Apollo Branchidæ, that of Jupiter at Aizani, and that of Venus at Aphrodisias, the theatres at Arzani, Aspendus, and Myra, and the Temple of Augustus at Ancyra.

A peculiar feature in the temples here illustrated is the extensive peribolus, or sacred enclosure, within which stood the temple itself. This has entirely disappeared in the case of the vast temple of Apollo Branchidœ where it was of great size, but it is still traceable at Aizani and Aphrodisias; and the details of the order from the peribolus at Aprodisias are among the richest and most effective in the volume.

Perhaps the best illustrations given are those of the theatres of Aspendus and Myra, and these buildings, elaborately arranged and carefully worked out as they were, notwithstanding their apparent simplicity, are well worthy of the study of the modern architect called upon to consider the problem, so well solved in these buildings, of how to accommodate a very large number of spectaters so that they may all hear, see, and be seen, with perfect comfort and safety.

Throughout the work, both details and general drawings of the various buildings are given, so that by the help of them the reader will be well able to appreciate the peculiarities and the great beauties of the buildings illustrated, and we heartily echo the wish expressed by the writer in his preface, that these examples, carefully measured, accurately drawn, and well described, as they are, may be extensively studied, and may tend to promote the improvement and advancement of our taste in architecture.

We propose to conclude by giving some extracts from the introductory matter prefixed to the work itself, showing the history of the principal publications, and first of the Dilettante Society.

"As an appreciation of the elegant architecture of the Greeks became more general, the want of correct delineations was much felt, especially by scholars and antiquaries. Consequently, in 1764, the Society of Dilettanti, which was founded in 1734 by a number of gentlemen who had travelled on the Continent, and who were desirous of improving the public taste in matters relating to architecture, resolved to send out properly-qualified persons to the East, 'in order to collect information, and make observations relative to the ancient state of those countries, and to such monuments of antiquity as were still remaining.' Dr. Chandler was selected as Director to an Expedition, Mr. Revett as architect, and Mr. Pars as painter. They left England in June 1764, and returned in September 1766, having visited during that period the Troad, Smyrna, Clazomenæ, Teos, Ephesus, Miletus, Priene, Heraclea, Mylasa, Stratonicæa, Tralles, Laodicæa, Hierapolis, Colossæ, Sardis, Pergamus, and Thyatira. The results of their labours were published in a 4to volume by Dr. Chandler, in 1775, in two folio volumes of plates with descriptions, issued by the Society in 1769, under the title of 'Antiquities of Ionia:' of these there were two editions. The architectural details of several temples are given in this volume, well drawn and engraved; but as the Mission had no funds for excavations, the information obtained was in many cases incomplete.

"In 1811, a second Mission was dispatched to the Levant to obtain further information, consisting of Sir William Gell, accompanied by two architects, Messrs. Gandy and Bedford. They were instructed to visit Samos, Sardis, Aphrodisias, Hierapolis, Tralles, Laodicæa, Telmissus, Patara, Cnidus, Halicarnassus, Magnesia ad Mæandrum, Priene, and Branchidæ; and also several places in Greece. The results were published in a third volume of the 'Ionian Antiquities,' and in the 'Inedited Antiquities of Attica.'"

After a reference among other travellers to the distinguished and accomplished Professor Cockerell, whose observations in Asia Minor unfortunately remain for the most part unpublished to this day, our author comes to Mons. Texier.

"In 1833, M. Guizot, the enlightened Minister of Public Instruction in France, commissioned M. Charles Texier to explore Asia Minor and Persia. M. Texier spent several years in these countries. He passed through Bithynia and the central provinces, and returned to Constantinople, afterwards visiting Mysia, Æolia, Caria, Lycia. He made careful detailed drawings of all the finest monuments existing in the country. These were published by the order and at the cost of the French Government, upon his return to Europe, in three folio volumes. The engravings were by the best artists, and executed at great cost. On account of the great expense of the work, it has not been generally accessible; consequently the beautiful edifices illustrated in it have not been studied as much as they deserve.

"A second Expedition was undertaken by M. Texier, for the purpose of removing the friezes of the Temple of Diana Leucophryne at Magnesia ad Mæandrum. This operation was successfully performed. The vase of Pergamus and the frieze of the Temple of Neptune at Assos also were then obtained for the collection of the Louvre."

The English expedition, and the visit made by Mr. Pullan himself are thus referred to.

"In 1852 Mr. C. Newton, now keeper of Greek and Roman antiquities at the British Museum, was appointed Vice-Consul at Mitylene, chiefly in the interest of art and archæology. He thoroughly explored most of the islands, and frequently visited the mainland, where he made many interesting discoveries. It had been ever his ambition to discover the site of the sepulchre of Mausolus, king of Caria, which was considered one of the seven wonders of the ancient world. In 1855 he visited Budrum, and there found traces of fine Greek sculpture sufficent to induce him to ask assistance from the Government, which was at once granted. A ship of war, the 'Gorgon' frigate, an officer of the Royal Engineers, Lieut. Smith, and a detachment of sappers, were dispatched to aid him in his operations. In the month of January 1857, he had the satisfaction of ascertaining without doubt that he had come upon the site of the Mausoleum, and before the expiration of the year he had obtained sufficent architectural data to determine the plan of the monument and its general dimensions; and he had brought to light the magnificent series of sculptures now in the British Museum. In December 1857, Mr. Newton proceeded to Cnidus, for the purpose of thoroughly exploring that ancient city, the ruins of which had been visited by Sir William Gell and the second Mission of the Dilettanti Society. Here he made excavations on the site of the Temple of Venus, at the Lion Tomb, the lower theatre, and the *temenos* of Hecate. During the years 1857-58, Mr. Newton and Lieut. Smith were enabled to explore the whole of that part of Caria, from Labranda and Euromus to the Bay of Marmarice, opposite the island of Rhodes. Amongst other discoveries made was that of the Ruins of the Temple of Hecate at Lagina, with the sculpture slabs of its frieze in tolerable preservation. Lieut. Smith identified the site of Labranda, where was situated the celebrated Temple of Jupiter; and Mylasa, Myndus, Bargalia were visited, and the island of Cos was thoroughly explored. Mr. Newton also visited the ruins of the Temple of Apollo Branchidæ, and brought from the Sacred Way which led to it the series of figures now in the corridor of the British Museum. In 1857 I was sent out by the Government to join the Expedition, with which I remained a year. During this time I visited Budrum and Cnidus, explored the island of Cos, and upon my way home visited the site of Troy and Thessalonica."

"In 1861, the Dilettanti Society being desirous of obtaining further information as to the state of the sites of certain ancient temples, commissioned me to visit them, and report to them as to the desirability of excavation at the following places:—The Temple of Bacchus at Teos, which, though it had been visited by a former mission, had not been thoroughly explored. The Temple of Apollo Smintheus in the Troad, the remains of which had been discovered by Captain Spratt. The Temple of Minerva at Priene, and that of Apollo Branchidæ at Miletus, which had been visited by the Budrum Expedition. During the journeys necessary for exploration, I visited the whole coast northward to the Troad from the point that had been reached by Mr. Newton, and in this manner, from the Gulf of Mendelet to Cape Lectum, on the north side of the Gulf of Adrymittium, completed a survey of the coasts of Caria, Ionia, and Æolia, where we know the finest buildings erected by the Greek colonists formerly existed. Upon the receipt of my report, the Dilettanti Society resolved to have the site of the Temple of Bacchus at Teos thoroughly excavated. This was done by me in the spring of 1860, and the details obtained enabled me to complete a restoration of this celebrated building, which I have reason to believe will eventually be published.

"In the present work illustrations of the finest examples of temples and other edifices measured by M. Texier will be found, accompanied by short descriptions taken from his writings and from those of other travellers in Asia Minor, and preceded by an outline of the various excursions made by me for the survey of the coast. This, it is hoped, may prove not uninstructive to the general reader, and may add some little to what is already known of the antiquities of this most interesting country."

NEW BRIDGE OVER THE NIAGARA RIVER.

A few miles above the falls of Niagara is Grand Island, not far from the city and port of Buffalo, on Lake Erie. Here a railway and roadway bridge is to be constructed, to make a further connexion of the lines in the States and in Canada, more especially between the Atlantic and Great Western Railway, and the Great Western and Grand Trunk of Canada.

This, the International Bridge, is in two portions, one between Blackrock Harbour and Grand Island, and the other over the Niagara river to the Canadian shore. The latter will be the principal bridge, and will be 1800 feet long, having six spans of 250 feet each, besides a pivot bridge, 250 feet long, presenting two openings of 105 feet each. The Blackrock Harbour bridge will consist of one fixed span of 112 feet and one of 82 ft. 8 in., together with a swing bridge 205 ft. 4 in. long, forming two openings of 82 ft. 4 in. each. The girders, of which there will be two to each span, will have their top and bottom members formed of a box section, with outside and inside angle irons. The boxes will be 24 inches wide outside the side plates, and 36 inches wide over the top and bottom plates, the depth of that forming the top chord being 36 inches, and of that forming the bottom chord 30 inches. In the 250 feet spans the plates forming the sides of the lower chord will vary from $\frac{1}{4}$ inch to $\frac{5}{8}$ inch in thickness, whilst the top and bottom will consist of from one $\frac{1}{2}$ inch plate at the ends to two $\frac{3}{4}$ inch plates in the centre. The vertical distance between the top and bottom chords will be 18 feet throughout, making the depth of the girders 23 ft. 6 in.

The girders will be placed at a distance of 32 feet apart, this space being divided into two equal portions by a partition 10 feet high, one part being intended for a carriage road, and the other for the railway. There will also be a footway 6 feet wide carried on cantilevers outside each girder. The road and railway will be carried by plate cross girders 24 inches deep, the webs of which will be formed of $\frac{3}{8}$ inch plate, the top and bottom flanges being 8 inches wide, and the former being made of $\frac{1}{2}$ inch, and the latter of $\frac{3}{8}$ inch plate. The angle irons will be 3 inch $\times$ 3 inch $\times$ $\frac{1}{2}$ inch. The cross girders will rest upon timber packing interposed between them and the bottom flanges of the lower chords. The top chords will be connected by light lattice girders, and the diagonal bracing consisting of round rods will be added to both chords.

The top and bottom chords will be connected by lattice bracing placed at an angle of 60°; the struts and ties making one intersection. The ties are to be arranged so that they pass outside the struts; they will be made of ⊢ iron, and in the 250 feet spans their sections will vary from 24 inch $\times$ $\frac{3}{4}$ inch to 8 inch $\times$ $\frac{5}{8}$ inch, the ribs of the channel iron being in all cases 2 inches deep. Where the ties join the top and bottom chords, the ribs of the channel iron will be cut off, and the web will be carried through slots formed in the top plates of the bottom chord and bottom plates of the top chord respectively. The struts will be of plate iron and angle irons formed into a ⊢ section, their width being equal to the distance between the ties, or 23 inches. The plates of the webs will vary from $\frac{1}{2}$ inch to $\frac{3}{8}$ inch thick, and the flanges from 18 inches wide by $\frac{3}{4}$ inch thick, to 6 inches wide by $\frac{5}{8}$ inch thick; the angle irons varying from 4 inches $\times$ 4 inches $\times$ 1 inch, to $2\frac{1}{2}$ inches $\times$ $2\frac{1}{2}$ inches $\times$ $\frac{3}{8}$ inch.

The girders of the swing spans will in each case be attached to a kind of double drum about 40 feet in diameter, made of plate iron. This will be connected to an inner drum 3 ft. $9\frac{1}{2}$ in. in diameter by cross girders and tie-rods, and to this inner drum the steel cap which carries the whole weight of the bridge will be bolted. This cap will rest upon a set of conical steel rollers, which run in a circular channel formed for them, partly in the underside of the cap, and partly in the top of a steel block beneath them. The block just mentioned will rest upon the rounded point of a conical steel casting about 6 ft. 6 in. high, which will be fastened down to the top of the pier. As we have already stated, the whole weight of the swing bridge will rest upon the central point, but steadying rollers, running on a circular rail, will be fixed around the bottom edge of the outer drum.

The greatest depth of water in the line of the bridge occurs in the Niagara River near the swing spans, where it is about 40 feet deep. The height of the bridge above the water level will be about 22 ft. 6 in. The bridge was designed by Mr. Thomas W. Kennard, the engineer to the Atlantic and Great Western Railway.

THE HYDRAULIC LIFT GRAVING DOCK.

A paper by Mr. Edwin Clark, on the above subject, of which the following is an abstract, was lately read at the Institution of Civil Engineers.

It was stated that this invention dated as far back as the year 1857. At that time the Victoria (London) Docks were just completed; and the engineer, Mr. Bidder, being anxious to adopt some cheaper system of docking large vessels, than by an ordinary graving dock, or any modifications of it, considered various schemes for floating docks. These were, however, all found to be more or less objectionable, from the difficulty of designing such large floating structures with sufficient regidity to preserve their form under very variable strains, and of insuring that stability of flotation which was wanting in all floating docks then in use, as well as from their enormous cost. It then occurred to the author, who under the direction of Mr. Robert Stephenson had designed the machinery, and superintended the raising of the Britannia and Conway tubular bridges, that a similar process might with advantage be applied to the docking of a vessel. The problem was simply to raise a given weight to a moderate height in the most rapid and economical manner; and there appeared to be no reason why a vessel should not be dealt with in the same way as any other load. The weight actually lifted at the Britannia bridge, with only three presses, was equal to that of a vessel of 1800 tons.

In noticing the early history of graving docks, it was remarked that the expedients at first adopted continued in use in their original form, the principles involved having in no way been departed from; so that a modern first-class graving dock only differed in its dimensions and details of construction. Allusion was next made to the dry docks at present in use, and the dimensions was given of a work of this kind recently completed at Portsmouth, which was sufficiently large for docking the 'Minotaur,' a vessel of 6621 tons. The inclined plane or slip had also received its share of improvement. In situations where the foreshore was favourable, it was observed that the slipway was peculiarly applicable for small vessels, on account of its economy, and that the hydraulic press had been used advantageously as a hauling power. But a graving dock of large dimensions was necessarily a costly work. It must be approachable by a deep channel, and must therefore be adjacent to deep water. In a gravelly soil, or in rock penetrated by fissures, the difficulties were sometimes nearly insurmountable. Doubtless the great cost of these docks, and the impracticability of making them at all, in some situations, led to the use of floating docks. These were at first built of timber, of moderate size; and a description was given of a work of this kind in the harbour of Marseilles. The same principles were subsequently applied to docks of large dimensions, constructed of wrought-iron, and furnished with elaborate pumping machinery. This system attained considerable development in America, there being timber docks on this principle at New York, Charlestown, Savannah, Mobile, New Orleans, Portsmouth, and Pensacola, a full description of which would be found in Mr. Stuart's 'Naval Dry Docks of the United States.' Those at Portsmouth and Pensacola were so arranged that, after a vessel was placed on the pontoon, it might be hauled ashore on its cradle, on bedways prepared for the purpose. The dimensions of that at Pensacola, which was completed in 1851, with the cost, were given. The floating sectional docks at San Francisco and at Philadelphia were next described. It was contended, that the use of floating docks was necessarily limited, not only by their enormous cost in construction and manipulation, but their liability to accident from mismanagement, of which instances were cited.

It was with a view of meeting, as far as possible, the objections to existing systems, that the author proposed the Hydraulic Lift Graving Dock as an efficient and economical substitute for the requirements of the Victoria (London) Docks. The works were ultimately undertaken by 'The Thames Graving Dock Company,' the site selected being a plot of 26 acres of land lying between the Victoria Docks and the Thames, and below the level of high water. This site admitted of a direct entrance from the Docks, with a permanent water level, without the cost and delay of a special entrance from the river. The soil was a deep bed of bog and alluvial mud, on a substratum of gravel. The only excavation necessary was the lift pit, and its deep entrance to the dock, where a coffer-dam was employed. The depth of water in the lift was 27 feet; over the remaining water space it was only 6 feet, which was the maximum draft of the pontoons. In the shallow-water space there were eight pontoon berths, separated by jetties, for workshops and access. They were all 60 feet wide, and from 300 feet to 400 feet long. The area of shallow water was 16 acres, or sufficient for floating 15 or 20 pontoons, which it was estimated was about the number that might be kept employed by a single lift. The docking of a vessel consisted of two distinct operations:—first, the direct raising of the weight on the lift; second, the transportation of the vessel to any convenient position for its repair on the pontoon. The lift was a direct mechanical appliance for raising the vessel by means of hydraulic presses. It consisted of two rows of cast-iron columns, each 5 feet in diameter, sunk about 12 feet in the ground. The clear space between the rows was 60 feet, and the columns were 20 feet apart from centre to centre, and were placed on each side of the lift pit. There were sixteen columns in each row, giving a length of 310 feet to the dock; but, as vessels might overhang at the ends, there was a practical working length of 350 feet. The columns were sunk in the usual manner, about three or four being fixed per week. When the requisite depth was attained, the base was filled with concrete, and covered with a layer of planks, to act as a cushion for the cast-iron seat on which the press rested. The columns supported no weight, but acted solely as guides for the cross-heads of the presses, which moved in slots, reaching from the top of the presses (just clear of high-water) to the top of the columns. The column was covered by a cap, and each row was firmly connected together at the top by a wrought-iron framed platform, running from end to end of the dock on each side. This platform formed a convenient permanent scaffold for raising the rams. The whole length of a scaffold was 68 feet 6 inches. Each column enclosed a hydraulic press of 10 inches in diameter, having a length of stroke of 25 feet. The rams were solid, and each carried a boiler-plate cross-head 7 feet 6 inches long, thus extending 1 foot 9 inches beyond the column on each side. From the ends of the cross-head were suspended two iron girders, each 65 feet long, extending across the dock to the corresponding column and press on the opposite side. There were thus sixteen pairs of suspended girders, forming a large wrought-iron platform or gridiron, which could be raised or lowered at pleasure, with a vessel upon it. The sectional area of each ram being 100 circular inches, a pressure of 2 tons per circular inch gave 200 tons as the lifting power of each press, or 6400 tons for the whole lift; but to find the available lifting power, it was necessary to deduct 620 tons, being the weight of the rams, cross-heads, chains, and girders, leaving 5780 tons for the pontoon and vessel. The water was forced into the presses immediately beneath the collar at the top, this being an accessible position. The grouping of the presses was an important consideration. Stability was secured by arranging them in three groups; one group of sixteen presses occupying the upper part of the lift, the remaining eight presses on one side forming a second group, and the opposite eight constituting the third group. The presses in each group were all connected, so that perfect uniformity of pressure was secured in each group as regarded its individual presses; while the three groups were arranged so that their centres of action formed a tripod support, upon which the pontoon was seated. As any one point of the tripod might be raised or lowered, without regard to the other two, by the most simple manipulation, the pontoon could be either maintained perfectly level, or any inclination could be given to it that was desired. Any pair of presses might be instantly cut off in the valve room, by means of a plug, even during the operation of lifting, without interrupting the process. It was stated that the raising of a vessel occupied about twenty-five minutes; and that during the severest cold, a few occasional strokes of the engine were sufficient to keep all in motion, and prevent congelation.

This lift was all that was required for raising or docking a vessel, and it was believed that it would be found more economical and convenient than any ordinary dock; but it would accommodate only a single vessel, whereas, by the use of pontoons, an indefinite number of vessels might be placed afloat, whilst the most costly part of the system remained constantly available. The following was the arrangement adopted: An open pontoon, proportioned to the size of the vessel to be docked, was selected. Keel blocks and sliding bilge blocks adapted to the vessel formed part of the pontoon, which was placed on the cross girders, and sunk with them to the bottom of the dock. The vessel was then brought between the columns, and moored securely over the centre of the pontoon. By lifting the girders, the keel blocks were first brought to bear under the keel of the vessel. The side blocks were then hauled in, by chains laid for the purpose on each side of the dock, and the girders and the pontoon, with the vessel upon it were then all raised by the presses clear of the water. The pontoon was provided with valves in the bottom, and thus emptied itself of water. The valves were closed and the girders again lowered to the bottom, but the pontoon, with the vessel upon it remained afloat. Thus, in about thirty minutes, a vessel drawing 18 feet of water was left afloat in a shallow pontoon drawing only 4 feet or 6 feet, and might be taken into the shallow dock prepared for its reception. The details and dimensions of the seven pontoons at present in use were given. The cost of the lift complete and fixed, including columns, presses, girders and pipes, had been £20,300; of the 50 H.P. condensing engine pumps, &c., £3600; and of the connecting pipes, &c., £1628. At the end of last year one thousand and fifty-five vessels had been lifted, of an aggregate tonnage of 712,380 tons, without a single casualty.

The advantages of the pontoon were then discussed, and certain proposed modifications of the system, showing the practicability of enlarging it to meet the requirements of vessels of any size, were described.

In conclusion the author considered the principal features of the system were its economy of first cost, by the short time required for its construction and erection, and in subsequent maintenance, by the simple and durable character of all its parts; its adaptability to almost any situation, especially in harbours or tideless seas, by which any area of shallow water could be rendered available as a dock for the largest vessels; its capability of almost indefinite extension, by the use of additional pontoons, or, as regarded the lift, by the addition of extra columns; its rapidity of manipulation with a small staff, by which even vessels in cargo could be docked, with freedom from all strain; and the convenient accessibility it afforded to all parts of a vessel, and especially in painting iron ships, their free exposure to light and air. These characteristics were the result of direct experience; others might be indicated. Thus it is evident the system afforded ready means, by the construction of a shallow canal, of transporting the largest vessels in cargo, either across an isthmus or over shallow rivers, and of removing vessels of war inland, either for their protection or for their employment as a means of internal defence; or for the laying up under shelter, or building or navigating vessels in any shallow-water space, rendering unnecessary the large area of floating dock accommodation now required, by which a considerable portion of the enormous expenditure which characterised such works might be economised.

NEW CHURCH, THORNCLIFFE, NEAR SHEFFIELD.

(With an engraving.)

This church is of early Gothic design of the French development. It consists of nave, transepts (now used as vestries), and tower at its west end, where is also the principal entrance. The height to the wall-plate of nave is 20 feet, to ridge of nave 44 feet, and to ridge of transept 37 feet. The external dimensions of the plan are 92 feet long, by 68 feet wide; across transept the nave is 36 feet wide; the tower is 66 feet high, to which it is intended at some future period to add a spire. There are galleries over the vestries and lobby in tower; sittings are provided for 333 persons on the ground floor, and in the galleries for 188, making a total of 521. The entire cost was £2650.

The traceries of windows and moldings of doors are very bold and simple. At the east end is a semi-octagonal apse, in which is placed the communion table. The church is built for Messrs. Newton, Chambers, and Co., by whom the heating apparatus is provided. Their apparatus is found to be very efficient, and is very highly recommended by the architects. The walls are 2 feet thick, those of tower 2 ft. 6 in. In the tower are clock loft and belfry loft. The walls are built of range work of native stone; the shafts in doors, &c., are red Mansfield stone: the roof is covered with slates with Delabole bands; the internal fittings are picked red deal sized and varnished; the roof is boarded to collars, in which are ventilators communicating with an exhausting flue in tower. The floor of the church is laid with Godwin's encaustic tiles.

The church occupies a site on the top of the hill, commanding a very extensive prospect, and has been erected almost entirely by the munificence of Messrs. Newton, Chambers, and Co., of the Thorncliffe Iron Works, from the designs and under the superintendence of Messrs. Wilson and Willcox, of London and Bath, architects. The builders were, Mr. Robinson of Barnsley, mason; Mr. Smith, of Hemingfield, carpenter and joiner; Messrs. Leadbeater and Brown for the other trades. Mr. Sykes was Clerk of Works. There have been very few extra.

THE INDIAN TRAMWAY COMPANY.

The Railway system of India is one of the most important in the world, and yet it is one of the weakest, since it everywhere seeks to meet the commercial requirements of immense masses of population by long main lines. These, of necessity, are constructed with reference to the political needs of the Government, as much as with regard to the commercial wants of the people. And even, were it not so, it is evident that the farther a main line of railway penetrates into a country like India, the greater is its inability to meet the enormous traffic which will seek, by its means, an easy and speedy mode of transport to the metropolis. That main lines of railway like that which links together two such cities as Calcutta and Delhi, are altogether unable to meet the demands made upon them, the public have not now to learn. Travellers are filled with astonishment at the traffic of the railway, and wonder at the quantity of produce encumbering almost every station beyond Burdwan. So great, indeed, is the pressure on the resources of the railway, that the construction of a double line throughout its length is a mere question of time, and one upon which there is no division of opinion. But we require a stimulus for local traffic, and a means for fostering trade between neighbouring districts. The external commerce of the country will, to a certain extent, look after itself, but the internal trade is yet in its infancy. The greatest efforts are made to provide for a yearly increasing export trade, whilst little or nothing is doing to break down the barriers between province and province, and to create and stimulate trading intercourse between the various nationalities of India.

The Government is at a loss how to meet this want. It cannot make roads fast enough, and besides this, its first duty is to make the districts easily accessible from the metropolis, rather than easily accessible to each other. There are, however, two companies in the field, who promise to do this last work more effectually than any Government could do. These are the Indian Branch Railway Company and the Indian Tramway Company. We have before us "the Proceedings of the Fourth Annual General Meeting" of this last company; at this meeting the report for the year 1865 was read.

The proceedings, which are accompanied by an excellent map, have reference to the line between Arconum and Conjeveram, in the Madras Presidency. This line was opened for 16¾ miles on the 8th May, 1865, and for the whole distance of a little over 18 miles on the 1st August. Of the total length, 14½ miles were constructed on a Government road, whilst 4 miles were carried across country. The total cost of the line was £75,000. Now, taking into consideration the whole of the circumstances of a railway scheme of this nature, and remembering that a short line is almost as expensive as a long one, we find the line between Arconum and Conjeveram has established the following facts:—
"The railway had been constructed, not only within the capital, but within the mileage cost originally assumed, and the returns already exceeded the highest per-centage ever obtained on any Colonial line during the first few months. A weekly mileage return of £9 would pay 5 per cent., and the line was earning at starting about £7 of that sum, with a constantly increasing traffic. The shareholders were entitled to the full credit of having established the important fact that cheap light lines of railway could be made in India, at a total cost for all expenses, including engines and rolling-stock, of £4000 per mile, capable of transporting loads of 100 tons at 35 miles an hour, at a very moderate cost for fuel, with working expenses commencing at 65 per cent., which had since been reduced to about 50 per cent., and at its earliest opening paying a dividend of 4 per cent."

This should show the Government the value of these subsidiary companies, and induce it to grant them more liberal and favourable terms for the construction of lines of light railways, which shall foster and develop trade between province and province.—*Hurkaru.*

J R Jobbins

NEW CHURCH, THORNCLIFFE, NEAR SHEFFIELD.

WILSON & WILLCOX, ARCHTS.

THE COUNTY LUNATIC ASYLUM, CLARE, IRELAND.

The site of this building consists of 40 acres of land within a mile of Ennis, on the Gort-road, at the northern side of the town. The building faces the south, towards which the ground slopes gently. The character of the building is simple and bold. There is a central tower of good outline; the windows generally are circular-headed, have plain square architraves surrounding them stopped on square sills.

It consists of a front centre building containing the official residences and public rooms, two wing buildings for the patients, with two airing courts at the rear of each, and a rear centre building containing the dining-hall, kitchen, laundry, and other offices: the front and rear centre buildings are connected by covered corridors.

The extreme length is 600 feet, of which the front centre building occupies 80 feet, the wing buildings extend 200 feet at each side, where they return about 100 feet, the remainder of the length being occupied by the infirmaries. The extreme depth of the building at the centre is 330 feet, and embraces the kitchen and laundry offices, with the rear and front centre buildings. The day-rooms average in size 40 feet by 24 feet. The dining and recreation hall is 56 feet by 30 feet, and the height of two stories, with an open roof.

A series of day-rooms, on the ground floor, dormitories on the upper floors, connected by passages of moderate width, have been adopted. It is thought, with the sanction of the Board of Control, that this arrangement in separating the day and night accommodation of the patients, and otherwise assimilating their circumstances to those of ordinary life, is preferable to the usual corridor, or "ward system," as it is termed. The infirmary buildings are placed at the extreme ends of the wings. At the rear, connected with the airing courts of the male wing is a working ground, with suitable workshops opening to the same.

The front centre building, which projects about 50 feet from the wings, is placed at a higher level, and with a terrace front, admits of a basement, in which the kitchens and offices for physician and matron are placed. The chapel, which has a vestry and separate entrance for male and female patients, is situated on the first-floor at the rear of the front centre building. The ground floors of the wings are chiefly appropriated for day-rooms and single rooms. The day-rooms nearest to the centre, at each side, are for the tranquil patients; those more distant for the refractory. These latter are mostly intended to sleep in single rooms, situated in the returns of the wings. The refractory patients all through will be separated from the rest. The tranquil patients will sleep on the upper floor, chiefly in dormitories; and the middle class of patients will occupy the first or middle floor, where day-rooms and dormitories are provided for them. The attendants' rooms are placed next the dormitories, with glazed doors between, and are in the proportion of one attendant to thirteen patients on an average. The whole number of patients for which accommodation is provided is 260; and 25 ft. superficial are provided in the day-rooms for each patient, and 50 ft. superficial in the dormitories, the ceilings being 12 ft. in height.

Infirmary accommodation is provided for one-tenth of the whole number of patients, and single rooms in the proportion of 30 per cent. Two staircases with solid wells are provided for each wing. The kitchen, 33 ft. by 30 ft., adjoins a scullery and a boiler-house. The farm offices, steward's house, &c. are to comprise a separate detached block of buildings.

The walls are built of the local light-blue limestone, and the outside walls are lined with brick of the locality, the quoins and dressings neatly chiselled. Sandstone is used for staircases and door-sills; and, as a check to the spread of fire, should such ever happen, stone-sills, resting on arches, are set across the corridors at intervals of about 40 ft. The cross walls which there occur are carried up to the underside of the slating. The plates for the floors throughout are carried on stone corbels, and wood lintels are very sparingly, if at all used. The roofs of the dining-hall, kitchen, and laundry are formed with open timber framing, and have louvred ventilators. The floors of the water-closets, lavatories, and baths are formed of Valentia slate. Almost throughout the entire building the interior is plastered. The windows have wood sashes, except those to the single rooms for refractory patients, which are of wrought-iron. The ventilation is to be effected by flues from each room, carried into horizontal galvanized iron air-trunks in the roofs, thence into the side towers, in each of which a shaft is carried up, with fire-place at bottom to ensure an upward current. These buildings were chiefly designed by Mr. W. Fogerty, architect, of Dublin, and are being completed under the joint superintendence of Mr. J. Fogerty, of Limerick, and Mr. A. C. Adair, the county surveyor of Clare.

The amount of the present contract, exclusive of boundary-wall, gate and other lodges, farm offices, baths, water-closets, and engineering works, is about £29,000; but it is estimated that when these additional works are completed, the total cost will amount to £35,000. Mr. Michael Meade, of Dublin, is the contractor, and Mr. Fitzgerald clerk of the works.

Obituary.

John Dixon.—John Dixon, of Darlington, civil engineer, died 10th October, 1865. He was the oldest railway engineer of the day, having been the resident engineer on the Stockton and Darlington Railway, under the celebrated George Stephenson when he made his first attempt at railway engineering; and it is singular that, after executing various railways in different parts of the kingdom, Mr. Dixon should return to Darlington to end his days as consulting engineer to the Stockton and Darlington Railway Company, in whose service he died, having been from 1820 to 1865 actively engaged in the construction and manangement of railways. He was born at Cockfield, near Raby Castle, Durham; his father was a colliery owner as well as a land surveyor and colliery engineer; and from him he received that sound practical and scientific knowledge which was of especial service to him in after life. It may be noticed that his grandfather's brother was selected by the Royal Society to go to Bencoolen, in Sumatra, to take observations of the transit of Venus across the sun's disc in 1761, and also to go to observe another transit of Venus at the Island of Hammerfest, near the North Cape, in 1769. When the question of making a communication between the Durham collieries and a port of shipment was under discussion, Mr. John Dixon was able to give some very useful information, having in his possession plans and sections which his grandfather, George Dixon, a man of scientific eminence in the county, had prepared about the year 1760, when he proposed canal communications with the collieries. When George Stephenson was consulted as to the construction of the Stockton and Darlington Railway, Mr. Dixon was engaged to show him the plans and levels in his possession, and to accompany him in examining the district; a strong friendship then sprung up, which lasted through life. During the construction of that line Mr. Dixon remained at Darlington as Mr. Stephenson's resident engineer; and it was during this period that Mr. Stephenson's only son, the late Robert Stephenson, received from Mr. Dixon his first instruction in taking levels and surveys, and in setting out railway works. Mr. Dixon was George Stephenson's resident engineer on the Canterbury and Whitstable Railway, on which was constructed the first railway tunnel. He was resident engineer at the Manchester end of the Liverpool and Manchester Railway; and remained for some years after its completion in charge of the maintenance of the way and works, and of the locomotives, a post of great responsibility, there being at that time no experience to guide engineers as to the relative durability of the different working parts of locomotive engines, or of the best modes of repair. After constructing the Birmingham and Derby, the Chester and Birkenhead, and the Carlisle and Whitehaven railways, he returned to Darlington in 1845, where he remained till his death. Mr. Dixon might perhaps have attained higher eminence, and have been more known to the public generally, had he been a man of of more ambition; but his retiring nature led him at all times to shun publicity.

Alan Stevenson.—Alan, eldest son of the late Robert Stevenson, civil engineer, and designer of the Bell Rock Lighthouse, was born at Edinburgh in 1807. He was educated at the High School and University, where he greatly distinguished himself, and took the then somewhat unusual degree of Master of Arts, and obtained under Leslie the Fellowes Prize for excellency as an advanced student of Natural Philosophy. He afterwards studied in England, and received the degree of Bachelor of Laws from the University of Glasgow.

His own wish was to study for the Church, but he gave it up for his father's profession, in which he soon made himself a name. Though obliged by illness to retire from work when in the fulness of his years and powers, the services he performed as Engineer to the Commissioners of Northern Lighthouses were such as to entitle him to lasting remembrance in the annals of our highest scientific achievements—in a department at once so perilous, difficult in its nature, and so inestimable in its results. During his connection with the board, he introduced many improvements in the dioptric system of illumination, and erected numerous lighthouses on the coasts, including his masterpiece, the renowned Skerryvore, which breasts the mighty *fetch* of the Atlantic, which, whether we regard the beauty of its design, its magnitude, the perfection of the work, or the difficulties of its beginning, may safely be said to be unsurpassed by any similar structure in the world.

There is little doubt that the mental tension caused by the responsibilities and difficulties of this work, acting upon his sensitive, chivalrous, and unsparing nature, was the main cause of the sudden shattering of his nervous system, which in 1852 made it necessary for him to withdraw absolutely from his profession and the world. His decease took place at his house at Portobello, on the 23rd December last, in his fifty-ninth year. Besides his purely professional excellences, Mr. Stevenson had genuine literary genius—not receptive merely, but in the true sense original. Mr. Stevenson was a Fellow of the Royal Society of Edinburgh, a Member of the Institute of Civil Engineers; and had medals presented to him by the Emperor of Russia and the Kings of Prussia and Holland, in acknowledgment of his great merits in lighthouse engineering. His most important work was the "Account of the Skerryvore Lighthouse, with Notes on the Illumination of Lighthouses" (4to. A. and C. Black, 1848.) He was also author of a biographical sketch of the late Robert Stevenson (Blackwood, 1861); "History, Construction, and Illumination of Lighthouses" (Weale, London, 1850). He was a contributor to the "Encyclopædia Britannica" and the "Edinburgh Philosophical Journal." He was the elder brother of the well-known David and Thomas Stevenson.

Decorations of Edifices in Paris.—The conclusion of the works of the new church of St. Augustin, in the Boulevard Malesherbes, affords a good opportunity of estimating the large amount of work created in Paris for artists and art-workmen by the authorities. In the first place, the three principal doors of the church, which have recently been hung in their places, are executed in copper by the galvano-plastic process, after the designs of M. Baltard, the architect of the church. The upper part of the central door is occupied by figures of the cardinal virtues—Justice, Fortitude, Prudence, and Temperance, modelled by M. Mathurin Moreau; the corresponding portions of the two smaller doors are decorated with small figures of angels bearing the signs of the Passion, by the same sculptor. The lower portions of the doors are ornamented with foliage, intermingled with shells, rushes, vine leaves, and ears of corn—emblems of baptism and communion. Embedded in the stonework over these doors are three medallions of the theological virtues, Faith, Hope, and Charity, enamelled on lava, by M. Paul Balze. Between the arches of the porch are prominent brackets, on which are placed the apocalyptic symbols of the Evangelists—the Eagle of Saint John, the Angel of Saint Matthew, the Lion of Saint Mark, and the Bull of Saint Luke; these figures are sculptured in stone by M. Jacquemart. In niches above, decorated, and divided by small columns, are large statues, in stone, of the Prophets Moses and Elias, by M. Chevalier; Jeremiah, by M. Chambard; Isaiah, by M. Farochon; Daniel by M. Chardigny; and Ezekiel by M. Gruyère. The principal decoration of the façade consists of a frieze, representing Christ and the Twelve Apostles, by M. Jouffroy. Two small lateral friezes contain figures of the Fathers and Saints—Saint Leon le Grand, by M. Farochon; Saint Augustin, between Saint Monica and Saint Ambrose, a bas-relief, by M. Bonnassieux; and Saint Gregory, by M. Chambard. In niches, on each side of the great frieze, are large figures of Saint Augustin and Saint Thomas Aquinas, by M. Cavalier. On each side of the great rose window over the portico are figures of angels, beneath palm branches, bearing the tables of the Old and New Testament, the work of M. Lepère. On the parapet, over the pilasters, on the side walls of the portico, are groups of children and various religious emblems, by M. Cordier and M. Carrier Belleuse. On the summit of the pediment is a cross, supported by two angels, bearing the cup and crown of thorns, by M. Schroder. These exterior decorations alone amount to forty-five figures, sculptured in stone, and three paintings, besides the metal doors; there are, moreover, several minor decorative works, such as bronze candelabra at the entrance, and ornamental water-spouts. The interior will be decorated in keeping with the exterior, but the former is not in the same state of advancement as the latter, and is expected to occupy the whole year.—Two fine statues in marble, one of Mdlle. Mars, by M. Jules Thomas, and the other of Mdlle. Rachel, by M. Duret, have just been placed upon socles on each side of the vestibule which leads to the noble staircase lately constructed in the Théâtre Français. The *foyer* or saloon of the same theatre is richly decorated with a bas-relief and statues, and it is connected with a gallery in which are busts of a large number of the most celebrated dramatic authors and actors. The decorations of the former are new; the gallery has been in existence for a long period, but its contents are being constantly augmented.

Introduction of Gas into India.—The introduction of gas into the territories of the Nizam is an event of no ordinary kind. In a state where the telegraph wires are regarded with the gravest distrust, and where the prospect of a railway engineer's appearance is discussed on deep political and religious ground, one might well have supposed that the preparation of so mysterious an agent as gas, almost at the very gates of Hyderabad, would have excited the liveliest apprehensions within. However this may be, one house in Chudderghaut is now brilliantly illuminated with gas; and the experiment, tried at the risk and expense of one individual, has proved so successful, as to induce the hope that in a short time oil and candles will be entirely superseded in the principal houses of Chudderghaut. The gas, which is prepared either from common oil or from seeds containing a fair per-centage of oily matter (especially the castor-oil seed, of which one pound yields over ten cubic feet of gas), appears free from any noxious properties, and furnishes a pure and brilliant light, at a very trifling expense. Though, as is usual in such cases, private enterprise has taken the start of public action, it is to be hoped that the machinery brought out from England by Mr. Marrett (the civil engineer in the Nizam's service) may not be confined entirely to private purposes.—*Times of India.*

Excavations at Rome.—At Rome, the Via Appia has been anew excavated at a spot known by the name of Santa Maria Nuova, at the expense of Count Tyszkiewicz; the researches have led to the discovery of a draped statue of considerable merit. In laying bare a tomb, remarkable for its peculiar interior disposal, the explorers found a mosaic pavement representing a rather uncommon subject, viz., a skeleton reposing on a couch, with the inscription in Greek letters which Socrates had observed on the Temple of Apollo, at Delphi, "Know thyself." Near the spot were also found colossal fragments of architectural ornaments, supposed to have formed part of a splendid tomb of the Antonine period. On the 22nd ult. the Roman Pontifical Academy of Archæology met, under the presidency of Professor Salvatore Betti. Commander Visconti, perpetual secretary, furnished details of the excavations now carried on at the Palatine, at the expense of the Pope and Commander Constantine Baldini, minister of commerce and public works. Already saloons of considerable dimensions have been brought to light, adorned with paintings, stucco-work, and marble. He also described the investigations now continuing in the neighbourhood of Ostia. The Rev. Felice Profils, rector of the Pontifical Seminary, and secretary of the Commission of Sacred Archæology, also gave an interesting account of the excavations which have taken place in the Catacombs of Rome, from November 1860, to May 1865.

Railway Carriages.—It appears that new carriages have been built in Milan to run upon the long line of railway from Susa to Brindisi, which is to convey the Indian mails and travellers from England. Some of these carriages are adapted for families or parties of friends. They are rather longer than the usual carriages, and divided into three compartments, communicating by sliding doors. There is the ante-room for servants, the sitting-room with four convenient sofas, upon each of which one person can sleep, a bed-room with a bed for two persons, washing apparatus, &c., while in the daytime the travellers can walk up and down through the three compartments.

THE LATE MR. DAVID ELDER, ENGINEER.*

By James R. Napier.

The history of so remarkable a man as David Elder must be interesting to many on account of his connection with works which have made Glasgow and the Clyde notable, and given to his employer a fame which is known over the engineering world. A respect for his memory, and the great benefits received from his advice and experience, induced the author, in the absence of those older and more able for the duty, to make the attempt. The author is indebted to an old friend of Mr. Elder's family for an account of his early life, of which he has availed himself.

David Elder was born at Little Seggie, near Kinross, in January, 1785. His father was an Anti-Burgher elder, and in consequence of the religious strife in the district, he was deprived of such education as the parish school of Orwell then afforded, a loss he ever after regretted.

About the age of 15 he was put to learn his father's business, that of a country wright, and at this period the repairs of Craigie Mill, at which he was occasionally employed, afforded him an early opportunity of studying mill work. The intermittent noise of this mill, which had wooden cogs and rungs, and a *flat* bar for the axle of the trundle, attracted his attention, and taught him his first lessons in wheel work and gearing, which he afterwards practised so successfully. It appears that as his studies were not in accordance with his father's wishes, he resorted to Little Seggie Glen to study Simson's Euclid, and a work on algebra translated from the French—which he had travelled 18 miles to get possession of; and when his seniors would be devoutly employed at a tent-preaching, David Elder would be found studying hydraulics before some old water-wheel in the neighbourhood, or the architecture of some old castle.

On one of these occasions he found out a simple approximate rule for estimating the weight of water in pipes. A tin can of his mother's, which happened to be three inches diameter and four inches deep, he found held, as he said, just a pound of water; and as the square of the diameter multiplied by the length was equal to 36, so David Elder settled that a pipe a yard long held as many pounds of water as there were inches in the square of its diameter. It was sufficiently accurate for the most of his requirements, and very easily remembered, and he constantly used it.

In 1804 he went to Edinburgh, and was employed at Charlotte-square buildings, and borrowed such books as he could get to study, from a bookstall in the Luckenbooths in the High-street, for a penny a night.

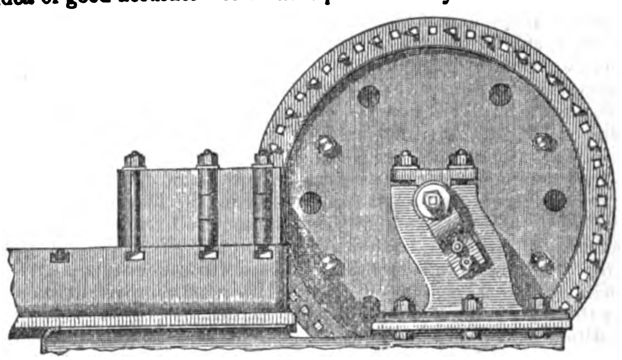
While repairing a mill about this period, at some very inaccessible part of which he had been working for two or three days and nights consecutively, in a dirty hole partly filled with water, and was therefore very tired, he was so disgusted, when giving the last turn, as it were, to one of the nuts, to find that the thread of the screw had stripped, and rendered all his labours useless, that he vowed if ever he had a chance he would make bolts and nuts whose threads would never strip.

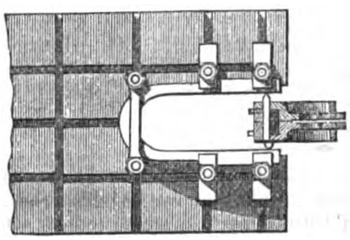
In 1814 we find him married, and employed by Messrs. J. Clark and Co., of Paisley, and afterwards superintending the building of their factory at Mile-end, Glasgow. He was afterwards employed by Mr. James Dunlop, in the erection of Broomward Mill. One of the walls of this building having got bent, he contrived a large truss of timber all the length of the building, laid on one of the floors, and, by means of bolts passing through the frame and walls, attempted, by screwing up the nuts, to straighten the building. He succeeded merely in compressing the timber. This lesson he never forgot.

About the year 1820 he appears to have made a business connection which was unsatisfactory to himself, and in 1821 he became manager of Mr. Robert Napier's engineering works, then at Camlachie.

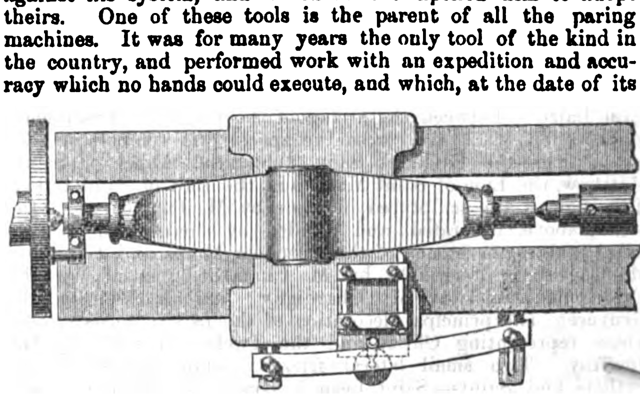
A circumstance which induced his employer to commence and prosecute the manufacture of marine engines, and which need not here be mentioned, gave Mr. Elder an opportunity of putting in practice many of those improvements in machinery the want of which had previously caused himself so much discomfort, and of originating many others.

About the year 1822, his employer had contracted for his first marine engine for a steamer called the Leven, to ply between Glasgow and Dumbarton. The few tools at Mr. Elder's disposal at this period may surprise many. A few 10 inch to 14 inch turning lathes, with wooden sheers and small narrow pulleys and belts constantly slipping, a rude horizontal boring mill, and a smaller vertical boring machine, constituted the greater part of the stock. With these he succeeded in making a piece of work to which he often afterwards referred with pride. Many of the improvements of the marine engine were first introduced by him in this one. He faithfully fulfilled his vow about the nuts which had so annoyed him at an earlier period, by making them 1½ times the diameter of the bolt,—a practice which, however unnecessary such dimensions may be considered to be now, with all the advantages which the accurately cut screws Mr. Whitworth's lathes have since produced, was then a genuine improvement. In the Leven's engine also he first introduced his improvements in the air-pump, condenser, and slide valve, which shall be presently noticed. His first difficulty, however, was with the workmen, the old millwrights of the period, whose idea of good accurate workmanship was so very different from his





own, that he preferred always to work with good cartwrights or house-joiners, and selected the most intelligent of these to superintend the different departments, and for any important tool, believing that they would carry their ideas of close-fitting joints of wooden structures along with them, when they would be called upon to construct iron ones. In this belief he was not disappointed, and in order to assist in working it out he contrived many tools which would execute the work better, and make him independent of the services of those who rebelled against his system, and would have compelled him to adopt theirs. One of these tools is the parent of all the paring machines. It was for many years the only tool of the kind in the country, and performed work with an expedition and accuracy which no hands could execute, and which, at the date of its



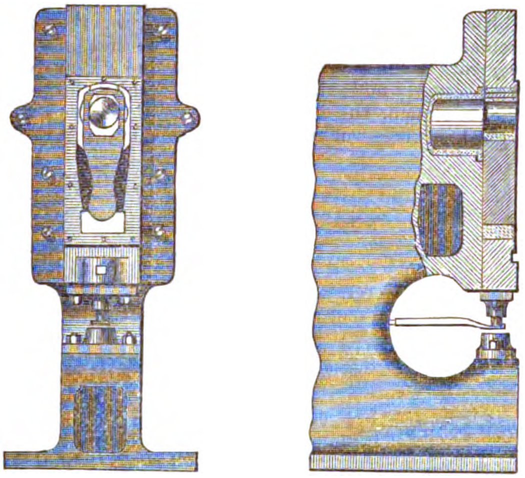
construction (1833) did the work of those *legal* hands, as they called themselves, who had then combined to stop the works by their Union. They called it the "devil." It was the greatest "nob" ever entered the establishment, and was designed principally for finishing the straps of the connecting rods and side rods; but, like every tool which has ever been constructed, it got other work to execute, and was therefore seldom idle, and led to works being undertaken which were formerly unthought

* Read at the Institution of Engineers in Scotland.

of, on account of the difficulty and expense attending their execution. He afterwards designed a much larger tool on the same principle.

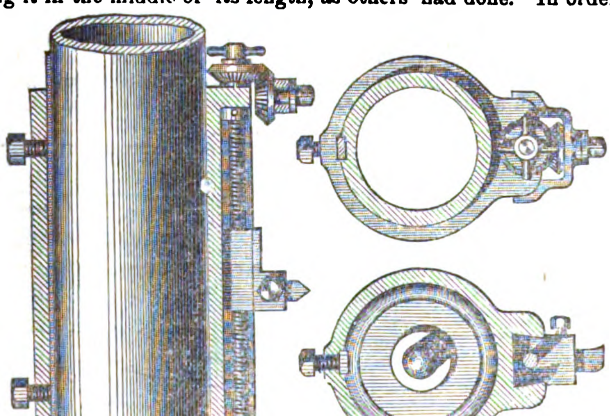
A simple addition to an ordinary turning-lathe secured the greatest strength with the smallest quantity of material in his side-rods, crossheads, &c.

The link of his punching machine, or piercing engine, may be instanced as one among many of his improvements in tools. In this the loss by friction is reduced to a minimum when the pressure is greatest



His knowledge of the forces which acted on the different parts of a machine, appeared as a sort of instinct, and for which he provided in the most scientific manner. He prevented the possibility of any work being performed by the joints of the frames, and so economised the available power of the engine, by having every joint metal to metal, and as much bearing surface and as closely fitted as it was in the power of the men and tools at the time to execute; and in the bolts and nuts which fastened these frames, each and all of them were so turned and fitted by draw-filing, and the seats for the bolt heads and nuts made so fair, that every thing was bearing iron to iron. The neglect of this sound mechanical principle in some of the works of competing engineers, led to their rapid deterioration. The perfection of modern tools has made these shaky works much less frequent than formerly.

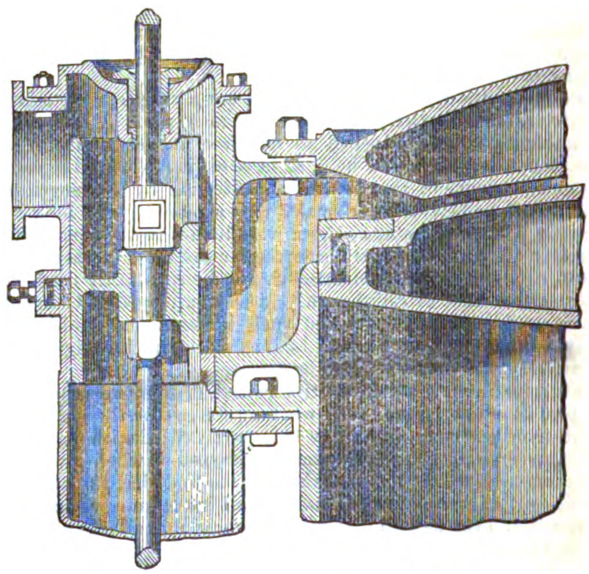
The trouble which the loss of vacuum in the condenser often gave to other engineers, from leakage round the main centre, he avoided entirely, by the simple expedient of casting a tube through the condenser, into which the main centre was driven; and also by the greater rigidity he gave to the main centre by not reducing it in the middle of its length, as others had done. In order



that this main centre should be thoroughly fixed and rigid under the greatest strain that could possibly come upon it, he invented a tool for boring the tube. This tool was self-acting in its feeding motion, and bored itself a conical hole, so that when the main centre was prepared, and thoroughly driven home by the force of large rams suspended from the ceiling of the fitting-shop, it was immovably fixed. This tool for boring conical holes he used on many occasions afterwards. The main centre itself, notwithstanding this care in its fitting, was prevented from turning in the tube by three keys driven in *above* it, and none below, as some were wont to do, thereby taking all the stress due to the weight of the levers, &c. &c., off the keys.

The first double engine he designed was for the Eclipse, a vessel which sailed between Glasgow and Belfast. At the starting of this vessel, in July 1826, he was nearly killed. The hot well was open above, as was then usual, the one engine had formed the vacuum, and the other had got hot, sending the hot water and steam through the hot well into the engine-room, and severely scalding Mr. Elder, who was the last to get out of it. This accident led him to raise and close the top of the hot well, and lead a waste pipe to the outside of the ship, as is now universally done.

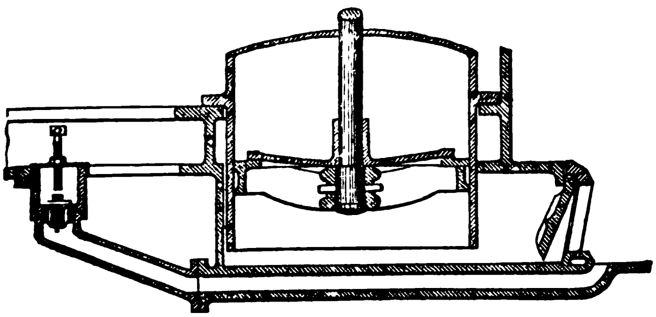
He economised to the utmost the power required to work the long **D** valve which he commonly used, and greatly reduced the cost of keeping it in efficient order by a skilful disposition of the packing. He lengthened the valve upwards and downwards beyond the face, so as to get the packing immediately opposite the port, thereby reducing the pressure both upon the valve face and packing. Some of the old arrangements of packing are to be seen in the enginesof Boulton and Watt, and others, in Tredgold's work on the Steam Engine, as well as the old arrangement of air-pumps, which Mr. Elder made efficient by the simple expe



dient of lowering the working barrel of the pump to within a short distance of the bottom of the well. However self-evident such an arrangement may appear now, or when pointed out, a different practice was followed in the marine engines of the period preceding the commencement of Mr. Elder's career.

His early practice of what modern engineers call cushioning the steam, by the cover which he invariably put on the eduction side of the valve, so that the steam left in the ends of the cylinder, in the ports, and passages would, at the end of the stroke, be up to the pressure of the boiler at the beginning of the next stroke, showed that he was as well acquainted with the practical advantages of a system which he had reasoned in his own way to be true, as Dr. Rankine, our worthy Professor of Engineering, is, with his theoretical deductions on the same subject. He was, at the same time, quite alive to the effect this cover on the valve would have on the steam escaping from the cylinder to the condenser, and to the necessity of having larger ports to let the steam out of the cylinder than to let it in, owing to the reduced pressure after it had done its work. When others, therefore, were working with small ports, Mr. Elder had gained a decided advantage in the greater power and efficiency which his arrangement produced. The author believes he was the first to apply expansion valves to steamers, in the engines of the Berenice, built for the Honourable the East India Company, drawings of which will be found in Tredgold. A comparison of the performances of this vessel with a sister ship, built in London, showed very favourably for the economy and efficiency of the Clyde ship.

An accident to one of the Dundee and London steamers, the Perth, about the year 1832, when off the north of England, on her voyage to London, arising as he imagined from water getting into the cylinder from the condenser, caused him to make an alteration in the position of the snifter valve, which made it



nearly impossible for such an accident ever to happen again from the same cause. Although these snifter valves had been originally placed on the *condensers* of land engines by Boulton and Watt, in their marine engines, they were attached to the well of the *air pump*. He believed that the snifter valve had not shut after the engine was blown through at starting, that the air which entered through it prevented the foot valve from opening. The condenser would then be filling with water, till it got above the lower edge of the lower port of the cylinder, into which it would enter, and then the whole power of the engine would spend itself in breaking its weakest parts. When these valves are placed in direct connection with the condenser, any leakage of air through them increases the pressure in the condenser, reduces the supply of water, and shows itself on the vacuum gauge and speed of the engine.

From his own early experiments and later experience of wooden structures, he took care, in giving the builders of the wooden ships the plans and directions for the framing and fastening of the engine keelsons, paddle beams, and all that affected the rigid fastenings of his engines to the ships, that these parts should be thoroughly well secured; and was wont to boast regarding the Atlantic steamer, British Queen, that whatever else of the vessel would break up, if she happened to get wrecked, this part of his, connected with the engine, would stick together; as it certainly did, to the great disgust of those who afterwards purchased the vessel on the Continent, to break her up. It certainly cannot be said that such caution was unnecessary either for the safety of the ship or machinery. Competing vessels on the Atlantic line had their engine frames broken, probably from the weakness and twisting of the vessel; and the fate of the President will, by those who saw her deformed state, and the means taken to hide it before her departure on her last voyage, be ascribed to a want of that anxious caution and forethought on the part of her constructors which was so thoroughly engrained in Mr. Elder's character. For similar reasons, he continued the sole plate under the cylinder, and was the first (in the author's belief) to do so.

The fitting of the malleable iron columns to the sole plate and entablature of H.M.S. Thunderbolt, may be instanced as an example of his care and caution. One of his maxims was to make the machinery depend on itself for its rigidity, and not at all upon the vessel. His cast iron Gothic frames, so well known for their elegance and simplicity, could be well secured to the sole plates, and to each other, by flanges and bolts of any dimensions; and the two engines also could be similarly secured to each other, so that, let the ship roll, and pitch, and perhaps twist, as she might, the engine was not to twist; it was to be affected in the least degree possible by the probable twisting of the vessel. In order to secure as far as possible the same advantages for the malleable iron frames of the Thunderbolt as for the cast iron, he constructed a large template frame, having the holes for the eight columns carefully bored in it. When this was laid across the two engines in the fitting-shop, the boring-bar was fitted, and conical holes bored through all the extent of the casting for the lower bearing of the columns. The bearings in the entablature were bored from the same template. The columns were turned at top and bottom, to fit these holes throughout, and draw-filed afterwards, so that there could be no possibility of motion. The entablature dropped easily over the heads of the columns, and by the depth of the sockets below, and of the entablature above, the frame was rigid, almost without cross-bracing.

About the year 1840, our Government was induce to contract with Mr. Robert Napier for the machinery of two of their war vessels—the Vesuvius and Stromboli. In March 1843, the House of Commons ordered a return of the cost of repairs, &c., of a number of steamers, including these. From this return, which was printed in June 1843, the author then arranged the data as in the following table, and made the deductions there noted, as it shows more clearly and forcibly than anything that can be said on the subject, that the care Mr. Elder bestowed on all his works was in the highest degree economical to the country, and ought to have made his employer the chief of Government contractors, and put the Clyde above all competitors. It is here reproduced. It shows, moreover, as applied to mechanics that which many have to learn in regard to other matters, that the *best* is the cheapest.

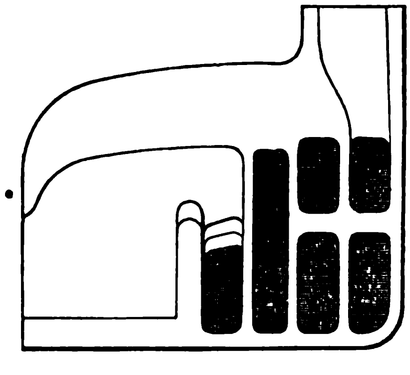
	Seaward.					Maudslay.	Napier.	
	Alecto.	Gyser.	Cyclops.	Prometheus.	Polyphemus.	Devastation.	Vesuvius.	Stromboli.
Days under repair ... =	393	50	164	353	162	92	38	51
Days in commission	1173	273	912	1095	639	486	912	942
Days in 1000 *under repair*	335	183	180	320	253	189	42	54
Cost of repairs ......£ =	1158	89	800	1012	240	250	38	68
Cost of engine ......£	10997	14373	23009	11015	10914	19331	13880	13480
Expense of repairs for every £10,000 *of prime cost*.........£	1053	62	347	918	220	129	27	50
Cost of repairs .....£ =	1158	89	800	1012	240	259	38	68
Time of commission	1173	273	912	1095	639	486	912	942
Expense of repairs per day during commission	19/8¾	6/6¼	17/6½	18/5¾	7/6	10/3¾	0/10	1/5¼

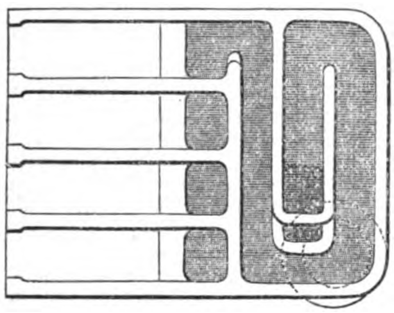
NOTE.—The chief engineers and captains of the Vesuvius and Stromboli can testify that neither of these vessels were ever laid up for a single day for repairs of machinery. The repairs of the Vesuvius were for repairing carpenter work, damaged at Acre during a storm; and the Stromboli's, time for enlarging and making new coal-bunkers.

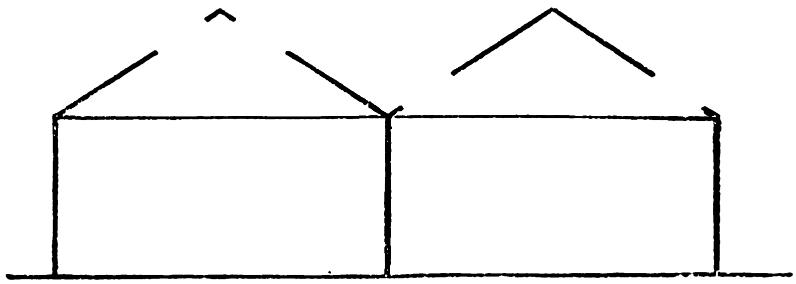
Mr. Elder's ideas of an economical marine boiler are embodied in those flue-boilers of the British and North American Mail Company's steamers, the Cunard line, as it is commonly called. High and roomy furnaces, so that the gases may be as thoroughly mixed, and their combustion as perfect as the dimensions of the boiler would admit of, before getting cooled against the roof of the furnace, and thereby rendered incombustible, with water spaces so large and accessible that every part can be repaired in the vessel.

When Mr. Robert Napier extended his business so as to embrace iron shipbuilding, Mr. Elder, believing that it was impossible to make sound work with the ordinary process of rivetting long hot bolts, had the keel plates of the Vanguard, the first iron steamer launched from the new shipbuilding establishment, bored, instead of being punched, and the rivets made of soft charcoal iron, turned, carefully fitted to their holes, and rivetted cold. This was in the year 1842. Those who know how important sound workmanship is in those parts of the vessel which are so long inaccessible, and often so heavily stressed, will appreciate Mr. Elder's foresight and caution—a caution which the inexperienced youth who shortly after took charge of the shipbuilding had much need to learn.

Mr. Elder's ideas of the position of roof-lights for sheds or workshops, should be practised more often than they are. These lights are often placed next the ridge, the one light showing







through the other, and little light upon the floor or the work on it. When the light is lower down the roof, near the furrow, the whole is better lighted.

His love of music, and early acquaintance with a celebrated organ-builder, led him to construct an organ for his own use. He afterwards erected one for his employer at Shandon, and as the exercise of bellows-blowing was to have no part in the intended pleasure, he made the water from the hills perform that duty in its passage through an engine. This engine has been described in Vol. VII of the Transactions of the Institution of Engineers in Scotland.

Mr. Elder thought for himself; he did not do as other people did (and as some are told to do, by those whose only excuse for preventing the free action of that faculty with which the Creator has endowed us, must be their own ignorance), if he could do a better thing, or even something as good, of his own.

The author feels that, in the foregoing remarks, he has very imperfectly illustrated Mr. Elder's work. He has said little about that great enterprise which first succeeded in establishing a steam ferry on the Atlantic Ocean itself, which astonished the world for its regularity, due to the sagacity of the late Sir Samuel Cunard, the spirited conduct of a few Glasgow merchants, and Mr. Robert Napier. The machinery of these vessels, that which produced the regularity and gave that feeling of confidence which was so marked a feature in its success, differed little from the other works previously executed by Mr. Elder, except in the greater care he bestowed in simplifying and making as accessible as possible every thing in the least degree likely to go wrong or to require attention, either at sea or in a foreign port.

Mr. Elder's connection with Mr. Robert Napier was a happy one for himself, and a fortunate one for Mr. Napier and his family. When, some years ago, he ceased to be actively employed by the new firm of R. Napier and Sons, it was a very great grief to himself, and an irreparable loss to the author. He died on the 7th Feb., 1866, in the 82nd year of his age.

DR. EDMUNDS' SYSTEM OF VENTILATION.*

By Dr. J. M. Barry.

My object in bringing Dr. Edmunds' system of ventilation under the notice of this society is, first, because I have experienced its utility in preserving life and promoting health on board the ships of her Majesty's Emigration Commissioners; and, secondly, because I believe, with very little alteration, the apparatus can be adapted to ventilating the crowded dwellings of the poor, the ill-ventilated rooms inhabited by whom do not materially differ from the confined space allotted to emigrants on board ships during their transit across the pathless deep. With respect to the necessity existing for a better system of ventilation on board ships than any hitherto devised, we have only to refer to the frightful mortality in crowded passenger ships, arising from typhus, cholera, and dysentery. In the ships of her Majesty's Commissioners, in whose service I hold the office of superintendent, the average mortality during the most unfavourable seasons never exceeded two per cent.

Last year the system of ventilation I am about bringing under your notice was introduced into the service. Some of the ships have accomplished the passage without the loss of a life, many of them being altogether free from fever, dysentery, or diarrhœa, the principal sources of mortality at sea. Another satisfactory result is the reduction of infantile mortality.

In some Australian passenger ships I could mention, one-third of the children under five years have died. In the Commissioners' ships fitted with Dr. Edmunds' apparatus, worked by a steam jet, the results have been truly gratifying, some of the vessels—the General Caulfield, for instance—not losing any children. The system has been introduced into the Royal Navy; and while the mortality in the mercantile marine is three times greater than in the Navy, the mortality in her Majesty's ships fitted with Dr. Edmunds' system is much less, while the diminished sick list amply testifies to the better sanitary condition of the sailor's dwelling.

To illustrate the necessity that exists for improving ventilation in ships, and to preserve them from premature decay, I may refer to the observations of eminent writers on ship-building. Murray remarks that the means at our command for the purpose of preserving timber from premature decay may be summed up in two words—seasoning and ventilation—thorough drying of the timber on shore, when practicable; but by all means good ventilation on board. If these well-known and universally approved principles were properly carried out, we should hear but little of rotten gunboats, or hasty repairs to frigates after a first commission. What is most urgently required is, that there shall be as little stagnation of air as possible. However well seasoned and dry the timber may be when a vessel is launched, it will rapidly absorb moisture from the damp atmosphere of the hold, unless evaporation from its surface be kept up by a forced circulation of air. The beneficial effects of Dr. Hales' system of ventilation were evidenced by the fact, that from 1753, when it was first employed in the old Prince, to 1798, when the use of it was discontinued, the durableness of ships was materially improved, as well as the health of the crews of those ships to which it was applied, especially transports.

The Earl of Halifax, in a letter to Dr. Hales, stated that the mortality of the ships on the coast of Nova Scotia which were not ventilated was, in comparison with those which were, as twelve to one. Dr. Hales proposed to keep up a circulation of air with windmills and air pumps. Mr. Parkins followed his system, substituting fans.

But what is most urgently required has not yet been practically realised—the producing a constant disturbing force on the

* Read before the Royal Dublin Society.

lower part of the hold, which should give motion to the foul air that has a natural tendency to lodge there, while suitable means are, at the same time, in operation for carrying it off, and supplying its place by the introduction of pure air. The constant operation of some means to produce this effect is necessary for the preservation of ships, the health of the crew, and the ship's stores.

The introduction of pure and dry air into the hold is requisite to carry off the humid particles which adhere to the interior of a ship, and excite the latent elements of decay which, under circumstances favourable to their development, are soon apparent. Fincham, in his "Outlines of Ship-Building," remarks that it is in the hold of a ship, more than in any other part, that the destructive agents accumulate—moisture and impure air, arising from the decomposition of animal and vegetable substances which fall into the hold, or accumulate from the defective manner of stowing ships. The want of proper ventilation will produce the most serious results to the health of the crew and the condition of the ship.

To accomplish what is desired, a system of ventilation is needed which will ensure a pure atmosphere in every part of the hold, and between the decks. In order to prevent the destructive effects of air-heat and moisture, and to produce thorough ventilation, some disturbing force should be employed. It being thus evident that persons best qualified to form an opinion on the subject, conceive that an sufficient system of ship ventilation is necessary for the preservation of ships from decay by dry rot, and as a means for preserving the health and promoting the comfort of passengers and crews; for as damp and insufficient ventilation cause the destruction of the ship, so they prove equally injurious to the health of her occupants; and if an effectual remedy can be found for dry rot by removing its causes, by the same means will the ship also be rendered healthy. The inventor of the system of ventilation which I now submit for your consideration has, I think, accomplished what has been so long required.

Dr. Edmunds, Staff-Surgeon in the Royal Navy, has had his attention strongly directed towards the subject of ventilation by painful experience of disease and discomfort arising from the inefficient and uncertain measures usually adopted to lessen the stagnation of air in the close and confined decks of vessels of war. The construction of a ship, which is often considered to oppose so many obstacles to free ventilation, in Dr. Edmunds' opinion, in reality offers facilities, which are now for the first time made available by his invention. The important object is attained by means of a novel system of air-shafts and channels, through means of which the perfect ventilation of the ship's timbers, and of the inhabited decks and cabins, is secured. It is well known that dry rot, or decay, misnamed dry rot, is caused by the dampness of the timber surfaces forming principally the sides of the openings or timber spaces, which are close channels leading up from the bilges at the bottom of the hold; these have a vent in the between-decks, and it is for the purpose of their ventilation, to prevent decay or dry rot in the timbers, that they are left open; otherwise, but for so important an object, such a source of foul smells, malaria, and consequent disease, would never have been allowed so long to pollute and poison the air of a confined space in which so many have to live and breathe.

It would be a parallel case if persons on shore inhabited a crowded apartment, into which the foul air from a damp underground cellar, with drains running through, had vent by numerous open channels; but the passive circulation which takes place is insufficient for the purpose intended. The openings are usually in a damp state; and any timber employed in the ship's framework, if not well seasoned, is sure to decay. The premature decay of the gunboats, hastily built during the Russian war, is conclusive evidence of this. By the first part of the new system the operation of these openings or channels is reversed; they are converted, from their present action of fouling the air, into the most effectual means for purifying it. This is effected by making them all branch air-channels of one large air-shaft on each side of the ship, which being led into the funnel in steamers, or into hollow iron masts or tube and cowl ventilators in sailing vessels, a constant updraught is created through them, up from the bilges and hold, and down from the mess deck, to the shaft, carrying all their foul contents into the open air, preventing contamination from the bilges and hold by creating a constant current of air flowing through the timber spaces. The timbers will be effectually ventilated, and dry rot prevented. Probably, even if the ship were built of unseasoned timber, all endemic causes of disease existing in the ship, and which occasionally cause, or at least promote, the ravages of fevers in tropical climates, will be removed by this plan. In most cases of malignant fevers occurring on board ships in the Royal Navy, the bilges and timber spaces have been found choked with decaying matter; and there can be no doubt that in the mercantile marine similar causes prevail, with leakage from cargo superadded.

In the reports of the Social Science Association, it is stated that, notwithstanding the great advantages of selection, diet, and discipline enjoyed by the royal navy, the rate of mortality is much above the civil population; whereas, from the healthful life led by sailors, being removed to a great extent from many causes of disease, we might fairly expect them to enjoy better health. To complete the ventilation of the decks, channels are provided. These are nothing more than the substitution of a strongly constructed air channel, in place of one or more of the planks forming the ceiling on each side of the deck to be ventilated. These planks vary in thickness from three to five inches in a channel of the same depth, and from eight to twelve inches in width, in proportion to the size of the ship, and can be constructed so that the iron plate completing the channel above may also act as a stringer plate, greatly increasing the longitudinal strength of the ship. It occupies no apparent space, and is in the best possible position for ventilating the decks, as it acts immediately upon the air between the beams, where all the foul, heated, and rarified air collects. The deck channels are ventilated similarly, with openings into the main shaft. Together they form a perfect system of ventilation in steam ships, as nearly as possible self-acting, available where ventilation is most needed, and causing no draught, as the action is diffused by communicating cross channels, two sides of each being formed by a portion of the cross beam and the deck, completed by a thin wooden batten perforated with holes. It will be seen that this system promotes natural ventilation, through aiding the escape of foul air, and providing outlets in the most convenient places for it. The funnel draught is most powerful at all times, but particularly when steam is up. Hollow iron masts, forming three outlets for discharge, are equally effectual in steam or sailing vessels, as they have a constant powerful updraught. Tube and cowl ventilators in connection with these shafts are available in sailing ships, with the advantages of being used either as uptakes, or, when a fresh dry wind is blowing, the cowl may be faced to the wind, when a stream of pure air will be forced through the ship. By either mode the deck atmesphere will be rendered pure. But, as a rule, ventilation by exhaustion is to be preferred. Pure air will naturally take the place of the foul, admitted through hatchways, ports, and scuttles Other means of ventilation are also available in connection with this system of shafts, such as a steam jet, fans worked by hand, or a fire draught otherwise applied. With this plan of ventilation the practice of stuffing the timber spaces with tons of salt, or other protecting substances against dry rot, is totally unnecessary. The existence of foul air in the hold, damaging cargo, as well as causing disease and discomfort, is impossible. The shafts and channels are of easy construction, and, once established, are always available.

Dr. Edmunds' system has already been introduced, by order of the Lords Commissioners of the Admiralty, on board Her Majesty's ship Royal Soverign, the Zealous iron-cased frigate, and the Favourite. Although under great disadvantages as regards ventilation, necessarily attendant upon their construction, and not having side ports or scuttles, still they will be undoubtedly the best and most healthfully ventilated ships ever built. With respect to the application of his system of ventilation to emigrant ships, I have received from Dr. Edmunds the following observations:—"Of all classes of ships in which ventilation requires the most careful consideration, emigrant vessels occupy the first place. In them we have large numbers of helpless men, women, and children, mostly for the first time in their lives crowded together in the narrow decks of a ship; unused to the motion of a vessel they become physically prostrate, and mentally depressed; and but for the excellent rules of Her Majesty's Emigration Servce, carried out under the direction of experienced medical officers, their condition would soon become most deplorable. But even under present advantages it has been found impossible to effect perfect ventilation of those crowded decks. Effluvia from the hold still further contaminates the air already vitiated to a great extent, particularly in calms and in bad weather, when it is necessary to close the hatches more or less. It is at these times that the foul air from the holds and bilges becomes most apparent and injurious, collecting chiefly in the highest part of the deck. It is only under exceptional circumstances that the carbonic acid evolved by the lungs or generated by vegetable decay escapes."

Most of the endeavours to ventilate ships have been directed to supply fresh air chiefly by windsails, but they are too uncertain; and in calms, when most needed, are valueless. Those only who have been becalmed in an emigrant ship on the Equator can fully comprehend the stagnation of air which prevails, particularly during the prevalence of heavy rains, which compel the passengers to remain below. The introduction of air in the ordinary way cannot be always accomplished without creating an amount of damp and discomfort, especially to those berthed in the vicinity of the windsails; and nothing is more common than to find the mouths tied up, passengers preferring the close and vitiated atmosphere to a cold damp draught from the windsail. When we remember that the apertures in the ship's lining are at the same time discharging the foul air from the hold, we can understand the utility of enclosing those openings in the longitudinal tube connected with the perpendicular air shaft, which conducts the objectionable air into the atmosphere. As the heated and vitiated air escapes through the cowl-headed ventilator, cool and pure air occupies its place in the hold and between decks, so long as there is any wind. During calms it is necessary to have some supplemental means of keeping up a circulation of air throughout the ship; a steam jet here becomes a valuable and powerful auxiliary, always available when the aerial current fails us.

The steam jet is directed into the shaft, and escapes through the cowl ventilator, which when steam is used must be turned from the wind; it should be placed near the centre of the ship, and for a vessel of 1000 tons ought to be two feet in diameter. Through this every upcurrent of one foot per second velocity will discharge 10,800 cubic feet per hour of foul air—with a breeze blowing, the velocity will be about ten feet per second; this is amply sufficient to renew thoroughly the vital air in every part of the structure, without creating the least perceptible draught. During the day the air is drawn equally from the passenger deck, hold, and bilges, but at night almost exclusively from the passenger deck, the hatches communicating with the hold being then closed. The respiration of an individual during one hour is estimated at about ten cubic feet, the quantity mentioned as carried off; and an equal quantity of fresh external air introduced is at the rate of 400 cubic feet per hour for each of 250 individuals. The source of the steam jet in vessels propelled by sails is the condenser. The difficulty of stowing sufficient water in a ship for a long voyage has led to the use of distilled water, which is found, when properly aerated, to be perfectly sweet and wholesome; therefore a distilling apparatus is provided in Government emigrant ships, from which a supply of steam can always be obtained, of course diminishing the quantity of condensed water, which a few additional hours' distilling will compensate for, and will, in lieu, create at the time of the greatest need a "circulation of air" of vital consequence to the health of the emigrants. The action of a jet of steam is well known to carry up with it a quantity of air in proportion to the pressure from which it is liberated: a half-inch jet at 20 lb. pressure escaping at the rate of 2000 feet per second, led up a ventilator of two feet diameter, will exhaust the air through it at a velocity of twenty feet per second. But, though this is the manner in which it has been hitherto used, one fourth the quantity of steam divided into a number of minute jets will create a draught of equal strength, with the additional advantage that the escape of steam is almost silent, whereas a large jet creates considerable noise. It will be seen that this velocity of 20 feet per second circulates upwards of 20,000 cubic feet of air per hour, double that caused by the unaided action of the wind, and at a time when such increased ventilation is so much needed. In iron ships, where timber spaces do not exist, or some vessels of war in which they are blocked up, the deck channel becomes available as a perfect means of communication with the mess deck. In steamers, the necessary updraught is created by connecting the shaft with the funnel, up which there is always a draught of from four to eight feet per second, and when steam is up from twenty to twenty-five. Hollow iron masts, which are now coming into very general use, are valuable ventilators in connection with this system; they have a constant updraught of from four to ten feet per second. Doctor Edmunds has recently received a report of the practical working of the system, first employed in the Royal Sovereign, in 1863, for the ventilation principally of the ship's framework, otherwise totally unprovided for; it answers this purpose perfectly, removing all foul smells from the bilges, and keeping the air of the between-decks pure; its utility is proved by their foul state returning whenever its action is suspended. Captain Sherard Osborne writes:—I "consider your apparatus well qualified to ventilate the decks of ships devoid of scuttles or ports, and I attribute to it much of the health and comfort my crew enjoyed in the Royal Sovereign. Doctor Elliott, surgeon of the ship, states:—"I have much pleasure in bearing testimony to your system of ventilation, which has acted so thoroughly in removing the foul air from the bilges and hold of this ship; I consider it one of the best sanitary measures introduced on board Her Majesty's ships." The Admiralty have directed Dr. Edmunds to prepare plans for most of the ships now being built. In the commencement of the year 1864, Her Majesty's Emigration Commissioners, ever anxious to make the ventilation and other arrangements of their ships as perfect as possible, permitted Dr. Edmunds to carry out his system in three of the ships taken up by them—the Art Union, the Earl Russell, and the General Caulfield.

The report upon the working of the system specially required by the Commissioners has established its success. The surgeon superintendent of the Earl Russell reported to the Commissioners that it was the most perfect system of ventilation in theory and practice he had ever seen. Dr. Carroll, of the Art Union, in the course of an elaborate analysis of its effects, states that in the hot latitudes he found the temperature between decks lower than he had ever before experienced; very little unpleasant smell was observable in the between decks, and the heated and foul air that is usually observed arising at night and from the deck ventilators was in this instance absent. In the calms about the Equator the steam jet was much used; the temperature during its use was reduced, and a very perceptible draught created, evinced by holding a candle at the air holes, and the strong current observable at the cowl head. In the General Caulfield, in which ship I had an opportunity of testing Dr. Edmunds' apparatus, the results were fully in accordance with the foregoing statements. While the steam jet is in operation very little water can be obtained from an a paratus capable of distilling 500 gallons of water per day of twelve hours. An extra quantity of coal must therefore always be estimated for; I should say about ten tons, the cost of which is quite insignificant in comparison to the valuable results accruing from the use of this apparatus. In a sanitary point of view, independent of the use of the steam jet, and depending on the wind, I consider it a vast improvement, superior to any other system of ventilation I have ever examined in the course of my experience in superintending emigrant and passenger ships; and I can only conclude that in Dr. Edmunds' method we have every requirement to ensure the effective ventilation of vessels of war and passenger ships. In directing its adoption generally in the ships taken up for the conveyance of emigrants, Her Majesty's Emigration Commissioners have not only conferred a great boon on these poor people by making their temporary abode upon the waters more healthful and agreeable, but the ships will also, in consequence of their timbers being kept dry and ventilated, resist the dry rot, and last longer—although this in the eyes of the philanthropist is a very secondary consideration to the preservation of life and health at sea. By conducting the steam jet into the ventilator we increase the current, and thereby discharge the foul air more rapidly—the conclusion arrived at being, that if we succeed in discharging the foul air, the vacant space will be occupied by pure. In the case of steamers we conduct the channel into the funnel, or, if preferred, connect it with the fireplace. As to the adaptability of the system for ventilating houses, I think a very simple arrangement would prove effective, by sifting some of the boards in each room, and converting the space between the joists into a box three sides air-tight, the bottom perforated with minute apertures penetrating through the ceiling of the room below, the air box to communicate through the medium of a tube with the flue, the updraught in which would be precisely similar to the funnel draught in steamers. By this simple arrangement the flues of rooms, at all times valuable ventilating agents, will be rendered more perfectly so, and the heated air of a room, ascending to the ceiling, more effectually carried off. To a certain extent also I should imagine this arrangement would be a remedy for smoky chimneys. To insure a supply of pure air, not generally obtainable in close narrow streets inhabited by a large population of the working classes, I would suggest an opening in the ceiling of the top landing, terminating in a cowl ventilator on the roof; arranged to turn with, and towards the direction of the wind. This would insure the purest air obtainable being supplied to the staircase, hall, and passages. In the skirting board of the rooms the insertion of a perforated plate would admit this purer atmosphere. I should be glad to have the opinion of practical men as to the expense of this ventilating arrangement. I cannot think it would amount to more than a few pounds; and surely the owners of property let in tenements would not hesitate, if this may be deemed an important sanitary measure, to tax themselves in a small degree to increase the health, promote the happiness, and prolong the lives of a large and important section of the community.

ON THE SAFETY AND SEAWORTHINESS OF VESSELS.*

By John Ferguson.

Recent events have excited an unusual amount of interest about, and inquiry into, the safety and seaworthiness of vessels, and it may be well for an Institution such as this to give an expression of their opinion, as to whether any course might be adopted which would insure greater safety to our mercantile navy, either in their build, equipment, or management. It is a fact that every year there is a great number of losses among the vessels belonging to or trading to and from this country. I am not aware that the losses are increasing in a greater ratio than the increase of shipping; still, from the greater supervision which vessels are subject to, and the improvements which are taking place in their construction and outfit, together with the application of steamers to nearly all our maritime commerce, we should expect that the casualties would be decreasing. However, we must bear in mind, that with the introduction of steamers into so many trades there necessarily follows a system of starting on their voyages at stated times, regardless of the state of the weather; and also that, in order to keep punctually to their days of sailing, they are kept going on at times and in circumstances which may not be favourable, or even safe. To prevent as much as possible casualties to passenger steamers, the Board of Trade have appointed surveyors at the principal ports of the kingdom, who periodically inspect the machinery and hulls, granting certificates to all vessels which are fitted up with their requirements, such vessels being provided with boats, lights, and sundry other fittings specified by the Board of Trade. In addition to these, there are rules laid down defining which side vessels are to take when passing others, and also certificates are required that the compasses of iron vessels have been properly adjusted. In fact, they employ means to insure the safety of life and property from shipwreck, or other accidents, in so far as they consider it consistent to interfere with the arrangements of shipowners. To prevent vessels from being shipwrecked on our coasts, we have lighthouses to guide, storm signals to warn, and harbours of refuge to shelter. To prevent shipwreck through damage to hull and machinery, the surveyors examine that all is efficient as far as can be ascertained. To prevent loss by collision there are sailing regulations, fog horns, steam whistles, &c. To prevent loss by fire there are fire-hose, engines, &c. For prevention of loss through errors in the compasses there is the requirement of a certificate from a competent adjuster for all iron vessels. Then, in the event of accidents, they are not unmindful that boats, life-buoys, rockets, &c., are all efficient. Still, for all the precaution and care taken, shipwrecks occur occasionally, under such appalling circumstances, that we are led to ask, Can nothing further be done?

The foundering of the London and Amalia, and the immense loss of life and property on our coasts during this winter, together with the inquiries instituted by the Board of Trade into the causes of the loss, especially regarding the two above-named vessels, has brought out many suggestions and opinions as to how accidents to the same class of vessels in like circumstances might be prevented, besides indicating what were the immediate causes of the destruction of these vessels. All our members must have read with painful interest the particulars given in the newspapers of the investigations as to the loss of these vessels—vessels which we have every reason to believe were strong and faithfully built and well equipped, able to stand the severe buffettings they were subject to without straining, and yet they had to succumb to what we might call trifling defects in their deck arrangements. From such events we have much to learn; and if we have arrived at the true causes of these catastrophes, it is a duty which devolves on us to discuss the subject, to see whether any remedy may be found which might tend to prevent the recurrence of such accidents. And I would notice that it is evident from the reports that the foundering of both these vessels was preceded and accelerated by the immense body of water which was shipped on deck. In the case of the London, the lower part of the ports for taking water off the deck was about 16 inches above the top of the deck, in consequence of there being a box waterway or spirketting which extended up to that height, so that, until the decks were filled with water up to the top of that spirketting, it had no way of getting off except by the scuppers, and if these were filled up by the coals washing about the deck, then we can understand what difficulties the crew had in their endeavours to close up the engine hatch after the skylight was washed away, especially when we are informed that the coaming of the engine hatch was only about 11 inches above the deck to the check, thus showing that the water on deck would be flush with the top of the permanent coaming before it could get egress by the side ports, even if the ship was lying level. The quantity of water the deck would contain below the level of the ports would probably exceed 100 tons, and this weight would be increased more than fourfold when the water would be up to the main rail. It can easily be imagined that such a weight thrown on the top of a ship would tend to make her unmanageable, besides the risk of the water breaking into the holds or engine-room through any of the deck openings, or into the poop or deck-houses, while to aggravate the evil, it would prevent the crew from doing anything to mend matters by pumping or stopping the openings on deck. Shipbuilders and owners are aware of such results being likely to follow the carrying of a large body of water on deck, and hence in vessels intended for stormy passages provision is made for lessening the evil by having high coamings of iron at the engine-hatches, inclosed stock-hole gratings, and in some cases the front of the poops are made of iron, besides having the ports in bulwark as low as possible. Various suggestions have been made to remedy the evils complained of, such as raising the engine-hatch coamings, deck pumps, and sounding-rod tubes to a considerable distance above the deck; and some people are of opinion that the great length of steamers in proportion to their breadth causes them to be less seaworthy than if they were broader or shorter. It may be an evil to make vessels of extreme proportions of length to breadth, inasmuch as that the weight of the upper part of the vessel is increased by the additional strength required; but I am not aware that vessels built of iron, of the usual proportions and construction, are more liable to foundering than shorter vessels.

If we are correct in our inferences, drawn from the reports of the loss of the London and Amalia, viz., that their destruction was accelerated by the masses of water which they took in on deck, we would naturally conclude that if vessels were so constructed as to be free from the liability to retain water on deck, then they would be free from the liability to founder under similar circumstances. It is the opinion of many that if our large steamers, which have to sail in all weathers, had spar-decks, the evil of having the main decks filled with water would be overcome, as in vessels of that construction the water could have no lodgment on the upper deck, and as prevention is always better than cure, it surely must be safer to keep the body of water off the top of the vessel than to have it remaining on, especially when its presence is attended at times with such disastrous consequences. It may be unnecessary to describe the points of difference between a spar-deck ship and one with an ordinary main deck, further than to state that most of our large steamers which carry passengers, and have no spar-deck, have poop and forecastle, or deck-houses, amidships, all above the main deck; some have poop, forecastle, and deck-houses arranged so that the vessel is nearly all covered in, excepting in the part between the poop and the forecastle, bounded by the bulwarks on the one side and the deck-houses on the other. This open space is where any body of water which breaks on board lodges, and where in being confined it is so injurious. In such ships the crew are accommodated generally under the topgallant forecastle, and the officers in the midship deck-houses. In spar-decked ships the arrangement of the forecastle, officers' rooms, cabins, &c., may be pre-

* Read at the Institution of Engineers in Scotland

cisely the same as just described, but the entire upper part of the ship is covered in, the side of the vessel being carried up to the upper beams. The spar-deck is generally surrounded with an iron railing and stanchions instead of the high close bulwarks required for the other description of vessel. The fact of the spar-deck being seven to eight feet above the main deck, shows that the sea would have to rise that additional height before it could get above the vessel; and even should it get on the spar-deck, there are no barriers to prevent it getting off at once without the same risk of doing damage by breaking into poop, engine-room, coal-hatches, &c., owing to the deck openings being so much above the load line, which in all cases should be regulated by the main deck. I believe that the principal barrier to the adoption of spar-decks for our large passenger steamers is, that being built in that style, they rate much higher in their tonnage than vessels with the same accommodation which have the poops, forecastle, and deck-houses. In the latter class of vessels, the tonnage of the space occupied by the crew is not included in the tonnage of the vessel, unless it exceed one-twentieth of the gross tonnage, when the excess is included in the tonnage; while in ships with spar-decks the space occupied by the crew is included in the tonnage, although the arrangement on the main deck may be precisely the same in both cases. It seems an anomaly that such should be the case, as it is manifestly unfair.

There may have been some good reason for making the law as it now stands, but it is difficult to understand why it should be continued, if it encourages a system of construction in vessels which has disadvantages, some of which I have endeavoured to enumerate. And as the Board of Trade are about to introduce some changes in the tonnage laws, as regards the measurement of steamers, it might be worthy our consideration whether we should call their attention to the matter at present.

It will be in the recollection of the members of the Scottish Shipbuilders' Association, that after the reading of a paper by Mr. Lawrie on the new measurement tonnage, a committee was appointed who memorialised the Board of Trade respecting the remission of tonnage of all spaces occupied by the crew in all vessels, to an extent not exceeding one-twentieth of the gross tonnage, as at present allowed for forecastles and houses on the upper deck. This memorial was sent in 1863, and in answer the Board of Trade replied "That in the event of any further legislation on the subject of tonnage, the points to which you have directed attention will receive the careful attention of their Lordships." Besides having that reply from the Secretary to the Board of Trade, Mr. Moorsom, the late Surveyor-General for Tonnage, in concluding a letter addressed to Mr Lawrie on another part of the subject, in aliuding to the question of the remission of the space appropriated to the crew, in whatever part of the ship it may be situated, whether above or below the upper deck, says—"I have much pleasure in stating that I cordially concur in the views expressed by your chairman (Mr. George Smith) on this subject, and which were so unanimously accepted by the meeting; and I thought it my duty so to express myself to the Board of Trade on their late reference to me of the papers of the Association on the question."

Thus it seems to me that if the Board of Trade and the late Surveyor General for Tonnage were at that time favourable to the remission of the tonnage of the crew space, even although it was under the main deck, I think that, when we now bring forward as an additional reason that the remission of that tonnage would encourage the constructing of vessels which I have endeavoured to show would be much more safe and seaworthy than the others before mentioned, at the present time, when they contemplate making alterations in the law, it would be well for us to send up a memorial on the subject without delay, asking them to take the subject into consideration.

The overloading of vessels is another subject which has lately been brought prominently before the public, and it seems to have been under the consideration of the Board of Trade, as to whether they should exercise any control over the loading of vessels, as reported in the newspapers. Mr. Milner Gibson, President of the Board of Trade, in reply to a question put to him in the House of Commons, said—"In consequence of the reports on the loss of the London and Ama'ia, the question whether the deep sea line could be permanently marked on all vessels carrying passengers and merchandise, had been considered by the Board of Trade, but the difficulties were found to be insuperable, the Government officials having no means of marking the deep water line applicable to all circumstances, or of deciding how deeply a vessel may with safety be immersed in the water."

There is no doubt but there may be difficulties in the way of determining the depth to which vessels should be loaded; but if it is a fact that the loss of many a vessel may be traced to overloading, it is surely worthy of an effort being made to arrive at what would be a fair depth to which vessels might be loaded. The underwriters recommend that ships should have three inches of side from the top of the deck to the deep load line for every foot of depth in hold; but we fear that in many cases such a recommendation has no weight or authority.

In steamers, which carry a large quantity of fuel for long voyages, and which by the consumption of fuel are getting lighter every day, it is not so easy to define the depth at which they should leave port. But surely our steamship owners could give sufficient data as to what has proved to be safe immersions. This, with the information from other sources, might decide on the depth to which vessels could be safely loaded according to the season of the year. It might be a question for our consideration whether the draft should be regulated by the depth of hold amidships, or whether the sheer or height forward and aft should be taken along with the midship depth, or in vessels with a great breadth in proportion to their depth perhaps the breadth ought to form an element in determining the deep load line. There may be some other elements to be taken into account, and I believe that if we could suggest any reasonable proposal to the Board of Trade it would receive their favourable consideration.

In reference to the large number of wrecks which have taken place on our coasts during the past winter, they were nearly all sailing vessels driven on shore by stress of weather. And we see that steps are being taken for the erection of a lighthouse at a part of our Western Islands where it cannot fail to be of service to vessels driven towards that dangerous coast. I think also that the erection of a breakwater in Lochindaul, Islay, would be the means of giving shelter to many vessels which are obliged to try for shelter among the islands, when they cannot manage to get through the North Channel. Lochindaul seems to be a natural harbour of refuge, although at present it is not safe, owing to the want of some artificial shelter.

There are many cases of shipwreck or foundering through a variety of causes which it is not easy to foresee or provide against, but it is a duty which devolves on all connected with shipping to remedy defects wherever they are known to exist; and I hope the members of this Institution will give the subject their best consideration.

In the discussion which followed the reading of the paper,

Mr. George Smith, jun., said that he heartily approved of the suggestion made in the paper, that in the tonnage measurement of vessels allowance should be made for the space occupied by the crew, whether it was above or below the deck. He could not see any reason why the Board of Trade should place large vessels in a more favourable position than small ones in that respect; for if any advantage was to be given to either, surely the small vessel's owner required it more than the other class. Besides, he was of opinion that nothing should be done by the Board of Trade that would prevent the crews of vessels being as comfortably situated in the ship as possible. In ships sailing in northern latitudes, in early spring or winter, the topgallant forecastle was a very cruel place to put the crew, because of the openings of the hawse pipes both in front and at the entrance from the main deck. He had known that in some of his own firm's vessels the bottoms had been washed out of the bunks by seas coming through the hawse holes. The discomfort was not so great if the vessel was going on a southern voyage; but if it was going a North American one, keeping in cold latitudes all the way, it was exceedingly uncomfortable for the crew. It seemed to him a matter only of common fairness that the space in which the crew was accommodated should not be included in registration. Mr. Moorsom, the late Surveyor-General for Tonnage, was likewise of that opinion, and promised that in any future legislation on the subject the matter would receive attention, so far as he could influence the Government. He believed that it was to the Scottish Shipbuilders' Association that the public were indebted for the Iona, and other vessels of that class. Previously it was usual to calculate all such deck-houses as they possessed, and include them in the tonnage; but on the representation of that association the Board of Trade agreed to exclude them, and hence the public have been benefitted thereby. He had no doubt that if space were allowed for the crew it would also confer a great benefit on seamen.

(*To be concluded in our next.*)

THE PERMANENT WAY OF RAILWAYS.*

By Robert Richardson, C.E.

The term, "Permanent Way" is employed to distinguish the iron-edge railways on which we travel, from the old cast-iron tramroads, and from the temporary wrought-iron ways used by contractors in the construction of railway earthworks. For constructing these works the temporary, or contractors' way, is beyond doubt a great advance upon the old Dobbin carts, which are still used for removing earth in the formation of docks and canals.

A contractors' way is made up of light wrought-iron rails spiked down to transverse wooden sleepers. It is strong enough to carry two or three tons of earth in each waggon. The old cast-iron tramroads were principally used for bringing coal from the pit's mouth to the shipping ports. A short time before a railway is opened for traffic, ballast is spread over the line, and the contractors' or temporary way is replaced by heavier rails and larger sleepers. These constitute what is appropriately called the Permanent Way; and to this I intend, as far as possible, to confine my remarks in the paper which I now bring before you.

From the beginning of this century to the present time there have been many experiments and trials of new inventions for permanent way, but without practical results of any great importance; for many inventors, ignorant of what had already failed, have re-invented and tried the very same supposed improvements over and over again, each in his turn being unwilling to admit that his scheme was not new. Some of the first inventions suffice to produce a good ordinary permanent way; and, with the exception of some important improvements in details, we find ourselves, after a lapse of more than thirty years, using very much the same sectional figure of wrought-iron edge-rail as was then adopted.

Besides the transverse sectional forms of cast-iron trams and wrought-iron edge-rails that have been more or less used or suggested, there are very many other slight sectional variations used in repairing roads; for engineers are seldom satisfied with those adopted by their predecessors.

In Mr. Smiles' "Life of George Stephenson," he says that a Mr. Beaumont employed wooden rails as early as 1630. According to another author, he laid them near Newcastle in 1602; but, as might be expected, little encouragement was at that time given to the invention. According to Mr. Nicholas Woods, the books of the Colebrook Dale Company furnish reliable evidence that in 1767 five or six tons of rails were *cast*, and from about this time dates the birth of cast-iron rails. They were probably angle-iron for some tramroad; for it is elsewhere mentioned that an iron tramroad was laid near Sheffield, by Mr John Curr, in 1776, which was destroyed by the colliers. That this was merely a tramroad is confirmed by the fact that, three years after, Mr. William Jessop first used cast-iron *edge*-rails as a new invention.

In 1814, light wrought-iron square bars, two feet long, were imported from Sweden. They were laid on longitudinal timbers, by Mr. G. Stephenson, on the Killingworth Colliery Railway. Rails are now rolled as long as thirty-five feet. Two years afterwards, the same gentleman patented a cast-iron edge-rail, which he soon abandoned, returning to wrought-iron edge-rails. Up to this time, railways for the public transit of passengers were not used to any extent, and little was done until 1825, when Mr. G. Stephenson adopted Mr. Birkenshaw's patent fish-belly wrought-iron rails for the Stockton and Darlington Railway. This last kind of edge-rail was laid on the Liverpool and Manchester Railway in 1829, for the competitive trials of locomotive engines, which were to run only by the simple adhesion of their wheels on the rails. Before this time locomotives had been armed with cog-wheels, that geared into iron racks laid down upon the road to assist their propulsion. It is worth while observing that this company at one time seriously contemplated carrying only goods, some of the directors thinking that to carry passengers was not worth their attention, and would never pay. The first Parliamentary sanction for an iron tramroad was granted in the year 1801, for a line from the river Thames at Wandsworth to Croydon. Wrought-iron fish-belly rails were, in after years, proposed by Mr. I. K. Brunel for the Great Western Railway; and a model was exhibited by him to the Committee of the House of Lords, previously to the company receiving their Act of Parliament in 1835.

Before the present great railway system was carried to any extent, Mr. Henry Robinson Palmer, an engineer of surpassing ability, and one of the founders of the Institution of Civil Engineers, invented a railway having only one single rail to travel on. The rail was elevated more or less above the ground, and upon it was placed a wheeled saddle, from which panniers to carry passengers were suspended on either side, as they are from the back of a mule. To this carriage a rope was attached, and it was drawn along by horses. About a mile of this road was laid at Cheshunt in 1830, and another length was laid shortly afterwards in Woolwich Victualling Yard. Mr. Palmer then proposed a double elevated railway, so as to enable the centre of gravity in the carriages to be brought nearly down to the level of the rails. This scheme was abandoned, as being too expensive. The next change in the form of edge-rails was made by Messrs. Stephenson and Locke, and with their united thoughts they produced a double-headed rail. This rail was simply fastened with a wooden key into a cast-iron chair, which was spiked down to transverse wooden sleepers, or fastened to stone blocks. Mr I. K. Brunel soon abandoned his first theory of fish-belly rails and narrow gauge, for a hollow single-headed rail and a seven feet gauge, which is the system still used on the Great Western line. This rail is screwed down to a longitudinal timber, and between the two are placed thin slips of hard wood, with their grain running across the sleeper. A somewhat similar solid rail was invented by Messrs. Stephenson and Vignoles. This rail is now universally used throughout France. It is screwed down to transverse wooden sleepers with galvanised iron-wood screws; and, to prevent the workmen from driving instead of screwing them, a little detector is raised on the head of the screw. About twenty years ago the traffic on railways began rapidly to increase, and the great cost for upholding and repairing railways was sorely complained of. With a view to economy, Mr. W. H. Barlow invented a rail, in which both rail and sleeper were rolled in one length of metal. This rail takes its own unaided bearing in the ballast, and has the least number of detached parts of any system to keep in repair. It has done great duty on the Midland line, between Gloucester and Stonehouse, for the last twelve years. Though somewhat harsh to run over at high speeds, for, lines of light traffic, and where the decay of wood is rapid, such rails form a most economical system in construction and maintenance.

Some speculative minds have thought it necessary to make a permanent way elastic. This is fallacious for many reasons, and would be extremely dangerous to travel on at high speeds. What is required is a way that will absorb the violent concussions or blows of a heavy locomotive engine, and only just sensibly yield to the passing load; but this impression on the rails must not on any account amount to elasticity, in the true mechanical meaning of the word. Again, the other extreme of a very deep and very rigid rail has failed, partly because the top surface of the rail spreads out or crushes under the weight before it becomes fairly worn, and this is caused by the unequal expansion and contraction of the metal between the top and bottom surfaces, as they never can be placed in an equal temperature. The vertical section of a rail, to secure this desideratum of contraction and expansion, should never exceed five inches; for even in England, in summer weather, the temperature of the top surface is often as high as 130 deg. Fahr. in the sun; and there is a sensible ringing noise as that temperature alters by the passage of a cloud in the sky, which is a sign that contraction has gone on throughout the depth of the rail, and that the fibres are not being displaced, as they must be in a very deep rail under the same circumstances.

There have been no striking improvements in railway chairs, nor do they seem to admit of any, except in the proper admixture of metal in their manufacture. They have been cast solid, and rolled in two parts, to dispense with wooden keys, and the keys have been drawn in place by screws, but no advantage has been gained. They must be simply attached to the rail, and any complicated arrangement only increases the number of parts to be kept together. Railway keys have been made of many materials—papier-mache, rolled iron rings, cast-iron, and wood. They have been made in one, two, and three parts, and driven or screwed into the chair both vertically and horizontally. The spikes to fasten the chairs are sometimes hollow, at others solid, twisted or split. They are driven at almost every angle into the sleeper.

* Read at the Inventors' Institute.

I will now refer to the schemes for securing the rail-joints. Until 1847, double-headed rails were simply fastened by a wooden or iron key in a cast-iron chair. The rail ends were constantly parting, and under traffic the incessant tipping of the rails and joint sleepers involved a serious expenditure for maintenance. With a view to mitigate this evil, in 1845 and 1846 I suggested and carried out some practical experiments, by removing the joint-chair, and suspending the rails at the joints between two common intermediate cast-iron chairs on sleepers, through which one long wooden key was driven on one side of the rail only. This answered beyond my expectation. It prevented the longitudinal tipping, and greatly reduced the cost of maintenance. Improvements in this arrangement, one of which was the application of two wedge-shaped iron keys instead of one long wooden one, with other schemes for this purpose, were secured by me, in conjunction with Mr. W. B. Adams, by letters patent, and called by him fish-jointing. We then bolted the fish-plates to the rails, and, after some four or five years of further experiments, solely through the determination of the Permanent Way Company, the system began to be appreciated; and fish-jointing, with its improvements, has now, under the guidance of this company, gradually spread wherever railways exist. The annual saving in maintenance, with all its collateral advantages of safety and diminished wear and tear of rolling stock, amounts annually to millions. Mr. Woodhouse, of the London and North Western line, gave in evidence that, by the use of suspended fish-joints, there was, on his line, a saving of seventy-five per cent. in maintenance —an economy which, in other words, represents a dividend. Several improvements in fish-jointing have since been made; and the rapid increase in the use of Mr. William Pole's invention, of tapping one fish-plate to dispense with nuts, is fast superseding all other plans for new lines.

With the present traffic on railways, the bearing surface of sleepers should never be less than 10 square inches per foot forward on a 4 ft. 8½ in. gauge, this surface increasing as the gauge widens. Sleepers have been made of earthenware, stone, cast-iron, wrought-iron, and wood—the last being the material most employed, on account of its cheapness, and because it is thought to dispense with the harsh sensation which is supposed to be caused by iron sleepers, but which is often due to many other circumstances. One of the advantages of timber is its great dead weight; and if it were not for its rapid decay, and destruction under the chairs and fastenings, no material could be better adapted for sleepers in cold climates. The durability of wooden sleepers is in some measure increased by the use of preservatives. They have been charred, soaked in salt water, and in solutions of mercury, zinc, lead, iron, oil, tallow, resin, creosote, and sulphate of copper. This last-mentioned material is very valuable, and through the kindness of the Permanent Way Company I am permitted to offer the members of the Inventors' Institute copies of Dr. Boucherie's pamphlet, descriptive of his process for preserving timber sleepers from decay, by forcing a solution of sulphate of copper through them. His experiments have now extended over twenty years. In hot climates, besides decay accelerated by the high temperature, the ravages of the white ants and other insects render even preserved timber worm-eaten, and the preservatives make them brittle; consequently other materials must, for economy, be used. Of these cast-iron is, beyond doubt, the best. It possesses many advantages; it has a thick, hard crust, to resist oxidation; its dead weight is considerable; it is easily re-cast when broken; it may be constructed so as to present a great bearing surface, and to be free from what is called swerving and rocking; and, by proper arrangements, rails laid on cast-iron sleepers may be made quite as easy to travel over as when they are placed in cast-iron chairs on wooden sleepers. Many miles of cast-iron sleepers, the invention of Mr. P. W. Barlow, have for the last sixteen years been under traffic on the South Eastern Railway in the neighbourhood of Hastings, and for fifteen years on the Enniskillen line. On the Great Eastern line, Mr. James Samuel laid down some timber-bedded cast-iron sleepers, which were under heavy traffic for ten years. These sleepers, with their timber linings, possess the merit of having great strength and dead weight. Mr. Hugh Greaves's system of sleepers, made like inverted bowls, has been for many years used in Egypt, India, and Brazil. Mr. De Bergue's circular plates are used in Spain, and Messrs. Livesey, Griffin, and other gentlemen, are engaged in laying down cast-iron sleepers, arranged according to systems invented by them. A few years ago the Permanent Way Company prosecuted a series of experiments for ascertaining the breaking strain of cast-iron sleepers, the results of which were presented to the Institution of Civil Engineers; and I am still engaged in preparing experiments on a new form for cast-iron sleepers. Mr. Wilson is at present laying corrugated wrought-iron sleepers on the Indian Branch Railway, though as yet there has been little experience as to their durability.

It is far beyond the limits of a paper like this even to refer to the many inventions that have been made for permanent way; I must therefore, as much as possible, confine my attention to the bare outlines of the general principles which should regulate the construction of a good road. Some kinds of permanent way answer very well in one locality, but often fail in another; and what makes a tolerably good road in one kind of ballast may soon go to pieces in ballast of another description. It is, therefore, impossible to devise any particular system that is best under all circumstances.

The proper laying out of railway curves forms a very important feature in their construction, and great care must be taken to increase the width of the gauge as the radius of the curve diminishes. To permit of a high speed on curves, the outside rail must be elevated more or less, to suit the maximum speed and radius; in a word, gauge and elevation of outside rail have to be accurate, but not uniform; and when this is carefully done, slight curves, instead of being objectionable, are preferable to straight lines for high speeds, for they give steadiness and even pressure in the one direction or the other, while the straight line causes constant vibration. When a railway cannot be made level throughout to work with economy, the necessary inclines should be short, and constantly falling and rising. On a line with very steep inclines the top surface of the rail is sometimes more rounded than on a level line, and when the metal is soft an engine can ascend a steeper incline on such rails than on those which have a flatter surface; but this necessarily implies destruction of the rails. I know of a case where an engineer of a railway laid down rails considerably rounded, on an incline, in opposition to the wish of the locomotive engineer, who delared he would soon flatten them; and with the hard steel tires of his locomotive he shortly fulfilled his promise, so that the rails were soon worn out, and had to be removed. If Mr. Bessemer's steel rails had been employed, there is little doubt that the result would have been the other way; for, on the London and North Western line, one of his experimental steel rails has worn out eighteen faces of common rails. I will now devote a few words to turn-tables and switches.

In turn-tables, very few improvements of any importance have been made since they were first introduced. Where there is not sufficient room to work them, Mr. Dunn's traverser—which may be seen at most large stations—is very useful and ingenious, as a substitute for them. Before the invention of switches, by which an engine is enabled to run out of the main line on to a siding, two main line rails were made to turn out, so that their ends came in line with the first two fixed rails in the siding. This arrangement was the cause of many accidents, to avoid which Mr. Curtis invented his double-shifting turn-out rails; but still accidents from running off continued, until Sir Charles Fox invented and patented a safety switch, by the use of which it became impossible for an engine to run off the rails. Sir Charles notched the main rail to receive the point of the switch, and Mr. H. C. Wild, by housing the point under the top flange of the main rail, dispensed with this notching, and thereby strengthened the main rail. The point of a switch may be made very stiff, and, at the same time, effectually prevented from jumping up, by housing the end under both the top and bottom flanges of the main rail.

Among the worst faults in laying out a line are incorrect elevation of the outer rails in curves, irregularities in the tilt and gauge, want of sufficient ballast and of room for expansion in the rails, deficient bearing surface in the sleepers, imperfect drainage, and bad iron. These are some of the worst features in the fixed portions of the work, the destruction of which is accelerated by bent carriage-axles, oval worn wheels, and inequality in the springs of the engine and of the carriages, which produces a jumping motion. Straight lines form the source of another kind of evil. When passing rapidly over them there is a zigzag motion given to the engine and carriages, by which not only the rolling stock, but also the line, is soon thrown out of repair. There is no doubt that the wider the gauge, the greater may be the motive power; but it does not necessarily follow that the safety is increased by a wide gauge. This is fully born out by the practice on the Festiniog 2-foot gauge railway, which has proved to be as safe as a 7-foot gauge. Almost every gauge has been employed—2 ft., 3 ft., 3 ft. 4 in., 3 ft. 6 in., 3 ft. 7⅝ in., 4 ft., 4 ft. 8½ in., 4 ft. 11½ in., 5 ft., 5 ft. 3 in., 5 ft. 6 in., 6 ft., 6 ft. 2 in., and 7 ft. Often, where the traffic is not sufficient for a broad gauge, it becomes remunerative on a very narrow one; the gauge may represent the requirements of a district, and should as far as possible be determined according to those requirements. It may be taken as an axiom never to be lost sight of, that freedom from noise implies perfection in travelling, as it does in arresting destruction; for whenever there is noise there must be friction and heat, which are the prime causes of all destruction of materials.

In conclusion, I may observe that travellers are by no means aware of the almost daily improvements that are gradually going on throughout the entire rolling stock and permanent way of railways. They would more fully appreciate these improvements if they could run out of a first-class line, at a high speed, on to one of the old original lines, such as the Liverpool and Manchester, with its rattle and jolting. Now, indeed, it is far more safe for one to be continually travelling, than to pass an active life under almost any other conditions. This statement is borne out from the official returns of the persons whose deaths were due to causes beyond their own control on the railways in the United Kingdom. Their number has decreased from 38 in 1844 to 23 in 1859, and to only 15 in 1864, while the numbers that travelled during the last-named year amounted to the enormous figure of 229,350,000, or nealy eight times the whole population of the kingdom. Thus the chance of death is 1 in 15,290,000, which may be taken practically as no chance at all. Let this be compared with the liability to fatal accident from horse conveyances in London alone, with its population of nearly 3,000,000. By the returns from the Registrar-General's office during the year 1865, there were 215 persons killed by horse conveyance, or 1 in every 14,000 of the population. The railway return already quoted gives a result of 1 in every 2,000,000 of population, or 1 in every 15,290,000 of travellers; so that, taking this estimate by population, the railways are 150 times more safe than the streets of London; while, if it be taken by the numbers travelling, they are nearly 1100 times more secure against fatal accidents.

ON THE SECURITY OF IRON SHIPS.

By William Fairbairn, C.E., LL.D., F.R.S.

It must appear obvious to every person connected with iron shipbuilding that much has yet to be done before it can be affirmed that the iron ship is perfectly safe and perfectly seaworthy. It will be observed that we have the material—of all others the best—to attain desiderata of such immense importance, but it requires careful consideration, and sound judgment in its application, to fulfil all the conditions of which it is capable in construction. In the form and build of merchant vessels intended for long voyages, and adapted for passengers and cargo, it is desirable to have them properly considered in reference to speed, capacity, &c.; but this class of vessels—if we were to judge from the strengths, forms, and other conditions of the Royal Charter and the London—do not appear to inherit all the qualifications necessary to render them safe and comfortable at sea. For the attainment of speed great improvements have unquestionably been effected, in giving to the bows fine lines of entrance and an equally fine run to the stern; but the question arises whether this sharp, cut-water shape is not destructive of other good qualities necessary to be observed in sea-going vessels. The introduction of iron as a material of construction has given to the naval architect and builder facilities never before attained for the introduction of the forms best calculated to meet the requirements of high speed. Vessels of that class are, however, better adapted for the navigation of rivers and lakes than the open sea.

In this communication it may not be without interest if I endeavour to show the advantages and disadvantages of the leading features of these high-speed constructions, and to exhibit the differences which should exist between a vessel intended for the navigation of smooth water, and another that has to contend with the rolling seas of the Atlantic.

For the first class of vessels it is necessary to have great lengths, narrow beams, and diminished depths; for the second, it is important that these dimensions should be altered in order to meet all the contingencies of strain in a rough sea. For example, if we take a vessel 320 feet long, 40 feet beam, and 26 feet deep, we arrive at the following proportions, of eight times the beam and twelve times the depth, for the length. Now, a vessel of this construction, with fine lines, is admirably adapted for speed, whether propelled by wind or steam, but her security may be doubtful, if heavily laden, when subjected to pitching and rolling in a tempestuous sea. A vessel of this description would be wet and most uncomfortable, and her want of buoyancy at the stem and stern would cause her to bury her bows to a considerable depth when pitching, and sweep her decks with tons of water as she rises to the surface. But this is not all, as at every plunge the ship labours heavily, and suffers severe strains by the weight of water she has to lift in ascending from the middle to the crest of the wave. In every case of high speed in smooth water these proportions and fine lines are highly advantageous; but in those intended for long sea voyages it is questionable whether or not some light sacrifices should be made as regards speed, and some modifications effected in the build, in order to meet all the requirements of a safe and convenient vessel.

In this communication it will not be necessary for me to enter upon the calculation of resistance to strains in such vessels. My object is to show that they are in actual existence; and some, from their slight build and great length, have comparatively but a small margin of strength, and are therefore not trustworthy in cases of a heavy cargo and foul weather at sea. To render vessels perfectly seaworthy, I would venture to recommend that their lengths should never exceed seven times the breadth of beam and ten times the depth. In these proportions I am assuming that the ship is strong, and substantially built, and that in place of the lines of least resistance being observed at the bows and stern, additional buoyancy should be given, in order to enable the ship to rise freely on the sea; and by increased displacement the discomfort of the sea sweeping the decks would, to a great extent, be avoided. I have been led to these considerations, not so much from the lamentable accident which overtook the ship London, as from the conviction that the safety of a vessel does not so much depend upon its speed as it does on its sea-going properties; and these, accompanied with sound construction, would tend to reduce the number of accidents, which of late years has produced such lamentable results.

From these observations it is not my intention to depreciate the value of speed in any class of vessels, whether employed in the war or mercantile marine. On the contrary, I think it is a desideratum in both that a saving of time and quick manœuvring should be obtained, but there appears to be some risk of carrying the question of speed too far, and that to the exclusion of other valuable properties entitled to consideration in connection with commerce and the extended security of vessels subjected to all the trials and contingencies of long voyages and stormy seas.

It is now some years since I endeavoured to impress upon the minds of naval architects and builders the necessity of increased strength in the hulls and upper decks of iron ships, in order to balance the two forces of tension and compression. I also pointed out the advantages to be derived from the longitudinal keelsons, cellular principle of construction, water-tight bulkheads, and double bottoms; and when we consider that the strength of a vessel is the maximum resistance of its weakest part, it follows that any n crease of material where it is not required is the very reverse of useful, and never fails to prove injurious. In every structure subjected to strain it is desirable that uniformity of strength and the laws of proportion should be strictly observed; and I am of opinion that a close adherence to sound principles of construction in iron shipbuilding would not only mitigate the evils of which we complain, but would ultimately lead to increased efficiency, and an important saving of the lives and property of the country.

I have ventured on these remarks for the purpose of directing attention to what I consider some of the defects of iron-built ships; and taking into consideration all the circumstances connected with the disasters which overtook the Royal Charter and the London, I venture to predict that, with proper attention to definite laws and sound material in construction, in the first instance, and with careful distribution and proper loading of the cargo—including trim rigging and clear decks—in the second, we should not have to investigate the causes of so many disastrous shipwrecks as have occurred during the last ten years.

ON RADIATION AND ABSORPTION, WITH REFERENCE TO THE COLOUR OF BODIES AND THEIR STATE OF AGGREGATION.*

By John Tyndall, LL.D. F.R.S.

The speaker referred to the relation subsisting between the sensible phenomena of nature, and those processes lying beyond the range of the senses on which the phenomena immediately depend. He spoke of the function of the imagination in picturing operations which, though great in their aggregate results beyond all conception, are too minute individually to be capable of observation. He referred to the luminiferous ether that fills space as the most striking illustration hitherto known of the production of a line of thought from the domain of the senses into that of the imagination, and affirmed the existence of this wonderful medium to be based upon proofs at least as strong as those which sustain the theory of gravitation.

Dwelling briefly on the relation of this ether to the atoms and molecules which are plunged in it, he illustrated, by reference to the phenomena of sound, the difference between good and bad radiators. A naked tuning-fork vibrating in free air imparted so small an amount of motion to the air that it ceased to be heard as sound at an inconsiderable distance; the same tuning-fork brought into union with its resonant case produced a sound which could be heard by thousands at once. The naked fork was a bad radiator, the combined fork and case was a powerful radiator. This combination of the fork and its case, as regards sound, roughly represented the influence of chemical combination as regards radiant heat. By the act of combination the power of the combining atoms as radiators might be augmented ten thousand-fold. As an example of this the vapour of water was selected; and it was affirmed that a pound of this vapour taken from the top of a high mountain, there heated and exposed before the cloudless heaven, would radiate nine or ten thousand times—possibly twenty thousand times—as much heat into stellar space as could be radiated by either of the constituents of the vapour when uncombined.

The speaker also referred to the well-known analogy between the pitch of a sound and the colour of light; and, throwing a large spectrum upon a white screen, mentioned the relation between the various colours to the rapidity of ethereal vibration. The space from the red to the blue embraced an infinite number of rates of vibration, gradually and continuously shortening without any interruption. It might be typified by an infinite number of tuning-forks of gradually augmenting pitch, and all sounding at the same time. This spectrum was derived from the carbon points of the electric light; but it was shown that in the case of various other incandescent substances the spectrum was not of this continuous character. The magnificent stream of green light produced by the volatilisation of silver in the electric lamp was shown upon a screen, and afterwards the light was analysed, and found to produce two bands of brilliant green, differing but slightly from each other in refrangibility. Here the case is typified, not by an infinite number of tuning-forks, but by two tuning-forks of slightly different pitch. And just as the rate of vibration in the case of the tuning-fork is a fixed rate, so the rate of vibration of the atoms of silver vapour were fixed. And as the colour of the vapour depended on its rate of atomic vibration, the constancy of this rate secured the constancy of colour in the vapour. We cannot make the vapour of silver white hot, however we may exalt its temperature. We may augment the brilliancy of the particular rays that it emits, but we cannot cause it to emit that variety of rays the blending of which together produces the impression of white.

Like the vapour of silver, the vapour of water has also its definite periods of vibration; and they are not such as to enable the vapour, however high its temperature may be raised, to emit a white light. It can hardly be said to emit any light at all. The flame of hydrogen, for example, is composed of intensely heated aqueous vapour, but it is hardly visible; and it is easy to give the vapour of water a temperature sufficient to raise a solid body placed in the vapour to a bright red heat, while the vapour itself remains absolutely dark. Now the powers of radiation and absorption go hand in hand, and the body which cannot emit luminous rays is incompetent to absorb them. Thus the sun's luminous rays pass freely through the aqueous vapour of our atmosphere; while it is the impediment offered by this same vapour to the radiation from the earth which checks the sudden drain of terrestrial heat, and thus renders our planet inhabitable.

This power of electric absorption was illustrated by the action of two tuning-forks which sounded the same note. Both forks being mounted on their resonant stands, one of them was first sounded. The silent fork was then brought near the sounding one, and held near it for five seconds. The vibrations of the excited fork were then quenched, but the sound did not cease to be heard. In fact the silent fork had taken up the vibrations of its neighbour, and continued to sound after the latter had ceased to vibrate. Again, one fork being permitted to remain on its stand, the other was dismounted, and thrown into strong vibration. Detached from its stand, its sound was too feeble to be heard by the audience; but on bringing it near the mounted fork a mellow sound rose which filled the room. Thus the vibrations of the one fork were transmitted through the air and imparted to the other. To effect this transference it was necessary that the forks should be in perfect unison; the fixing upon either of them of a bit of wax not larger than a pea was sufficient to destroy the power of the forks to influence each other.

Thus one sounding body absorbs the vibration of another sounding body with which it is in unison; and here we have in acoustics the representative of that great principle which in optics lies at the base of spectrum analysis, namely, that bodies absorb those rays which they can themselves emit. Thus green vapour of silver, if interposed in the path of a beam of white light, will absorb the green which it can itself emit. Thus also the incandescent vapour of sodium, itself intensely yellow, cuts clearly out the yellow band of the spectrum. And the same is true of aqueous vapour. Its periods of vibration synchronise with those of the rays, or more accurately waves, emitted by the warmed earth, and hence its power to intercept those waves by taking up their motion. But it is in dissonance with the luminous waves emitted by the sun, and hence those waves pass through large quantities of it with scarcely sensible absorption.

This incompetence of aqueous vapours to absorb luminous rays is shared by all really transparent bodies; in fact, they are transparent in virtue of their incapacity to absorb luminous rays. Now transparent bodies in a state of powder are always white, and in white bodies luminous rays have no power. The light of the sun, for example, cannot warm white sugar, nor cannot it warm table-salt, nor flour, nor a white dress; it cannot even melt snow. The most powerful luminous beam may be concentrated upon a surface covered with hoar-frost without melting a single spicula of the frost crystals. How, then, it may be asked, does sunshine clear away the snow from the mountain heads? Two or three days' sunshine on the mountains suffices to obliterate the traces of a heavy snow-fall; how can this occur if sunshine has no power to melt the snow crystals? It is not the luminous rays of the sun which perform this work, but a body of rays which, though possessing high calorific power, have no light in them. By a process of transmutation these dark rays may be converted into luminous ones, but as they come from the sun, and fall upon the mountain summits, they are utterly incompetent to excite vision. Every stream which channels the glaciers or tumbles down the valleys of the Alps is the direct product of this invisible radiation. To it also the glaciers owe their birth as well as their dissolution. For while the luminous rays of the sun falling on the tropical ocean penetrate the water to great depths without considerable absorption, the dark rays are in great part absorbed close to the surface of the ocean; they therefore heat the water at the surface, and are thus almost the sole excitants of evaporation. Not only, then, do those invisible solar rays, by the fusion of the ice, give birth to the rivers of Switzerland, but it is they that lift the material of these rivers from the sea, and store it on the frozen summits of the mountains.

Gathering up the rays emitted by a powerful electric lamp, and concentrating them upon a small focus, water, alcohol, or ether placed at the focus speedily boils, some of them i[illegible]ed almost instantly. But they are not boiled by the luminous rays, though these produce an impression too dazzling to be borne upon the eye. Interposing in the path of the concentrated beam

* Read before the Royal Institution of Great Britain.

a glass cell containing pure distilled water, the light of the beam is not sensibly diminished, but it is no longer competent to boil or even heat water at the focus. Placing a piece of ice at the luminous focus it is not melted, though, if blackened wood be placed there, it is set on fire. The moment, however, the cell of water is withdrawn the ice melts—melts because the dark rays previously absorbed by the water of the cell are now absorbed by it. There are liquids of very low boiling points—bisulphide of carbon, for instance—which, when placed at the focus where the whole radiation, dark and bright, of the electric lamp is converged, cannot be caused to boil, can hardly be warmed. Water, for instance, requires a temperature of 212 deg. Fahr. to boil it, bisulphide of carbon requires only 118 deg. 4 min.; still the former is boiled in a time insufficient to warm the latter. This arises from the fact, that while water powerfully absorbs the dark calorific rays and allows the luminous ones free transmission, the bisulphide of carbon is transparent to both classes of rays, and hence is warmed by neither of them. Thus also, when it was stated that sugar could not be warmed by the light of the sun, the invisible solar rays were meant to be excluded, for when the total radiation of the sun is converged upon white sugar it is immediately burnt up, the agent of its combustion however being the dark radiation.

It is possible to filter the composite radiation from the sun or from the electric light, so as to detach almost completely the visible from the invisible rays. It has been already stated that bisulphide of carbon is transparent to both classes of rays; now iodine, a substance which dissolves freely in the bisulphide, is eminently transparent to the invisible rays alone. Hence, a combination of these two substances furnishes us with a ray-filter, which, while it pitilessly cuts off the bright rays, allows the dark ones free transmission. At the dark focus we can boil water or alcohol, but we cannot warm bisulphide or bichloride of carbon. Bromine also, notwithstanding its volatility, bears exposure to the focus without being heated. Sulphur also bears the temperature of the focus for a considerable time without ignition. Common phosphorus, a combustible so quick that the warmth of the fingers when in contact with it suffices to provoke combustion, bears for twenty or thirty seconds without ignition the action of radiant heat at a focus where, in the fraction of a second, platinised platinum is raised to a white heat. The phosphorus is in a great degree transparent to radiant heat. The red iodide of mercury strewn on paper and exposed at the focus has its colour discharged where the invisible images of the carbon points fall upon it, but, owing to the transparency of the iodide to radiant heat, it requires some exposure to produce the thermograph. This red substance is far less absorbent of radiant heat than white paper, and hence it is sometimes easier to obtain a thermograph of the carbon points by exposing to the radiation from the lamp the back of the paper on which the iodide is strewn, than by exposing the face covered with the iodide. It is often, indeed, more easy to burn a thermograph through the paper than to discharge the colour of the iodide. Hence, white paper may be protected from radiant heat by being covered with a substance like the iodide of mercury.

We are here naturally reminded of the experiments of Franklin, which consisted in placing cloths of various colours upon snow, and observing the depth to which they sank in the snow when exposed to direct sunshine. Franklin concluded that the lighter the colour of the body the less is its power of absorption. The generalisations founded on this experiment are for the most part fallacious. Results long ago obtained, establishing the vast influence of the chemical constitution on radiant heat, led the speaker to contrast iodine, an element, with alum, a body of highly complex character. Both substances were in powder, the one being dark, the other white. Exposed to the radiation from various sources, the white powder proved itself in all cases the most powerful absorber. The dark powder of amorphous phosphorus was also compared with the hydrated oxide of zinc, but the white powder was the best absorber. Bodies of the same colour compared together showed similar differences. The red oxide of lead for example was contrasted with the red iodide of mercury, and the oxide proved the most powerful absorber. So also the white chloride of silver was compared with the white carbonate of lead, the lead salt proved by far the most powerful absorber. In this way it was proved that, as regards the absorption of radiant heat, white in some cases exceeds black, black in some cases exceeds white, and the other colours are equally capricious; all evidently depending on the chemical constitution of the substance.

In the case of Franklin's white cloth exposed on snow to sunshine, there is no reason why it should sink at all; there is, on the contrary, reason to conclude that it must rise relatively to the snow surrounding it. For, as regards the luminous rays of the sun, they are alike powerless to warm the cloth or to melt the snow. Whatever effect is produced is therefore due to the dark solar rays. Now, snow absorbs these rays with greater greediness than any other substance; hence the white cloth, which absorbs less than the snow, really defends the snow underneath it from the action of the sun, and owing to this protection the cloth, if exposed for a sufficient time, will rise in relation to the surface round, just like a glacier table.

But though the cloth is not so good an absorber as the snow, it is nevertheless a very powerful absorber; it comes near the snow in this respect. And when, as in the case of the black cloth, we have added to the absorption of a large portion of the dark rays by the cloth, the absorption of the whole of the luminous rays by the dye, the sum of the absorption of both classes of rays exceeds the absorption by the snow of the dark rays alone. The black cloth will therefore sink in the snow. This is the explanation of Franklin's experiment.

The lecturer concluded by referring to various experiments on the transmission of radiant heat through rock salt; to the influence of science as a means of intellectual culture; and to the necessary defects of any system of education in which the study of nature is neglected or ignored.

PORTLAND CEMENT.

By M. Leblanc.

Having been charged, since the commencement of the year 1860, with the construction of the floating basin of the port of Boulogne, we have employed in the masonry works of that basin many thousand tons of Portland cement. We have thus been able to make some observations, which have been checked by experience upon a large and a small scale, upon the qualities which ought to be sought for in this cement, and the best conditions for its employment. Our first researches had reference to the influence of the density of the cement upon its quality.

We took a certain volume, V, of light cement—a cement weighing about 1200 kilogrammes to the metre cube, the weight of it being ascertained by means of a box containing 100 litres, which was filled so as to avoid the pressing of the cement in the most perfect manner possible. We mixed this with two volumes 2V, of gravel, and then, after carefully stirring them we made them into bricks of sixteen centimetres sectional area. We then weighed the same weight of the first choice heavy cement—a cement which weighed 1500 kilogrammes to the metre cube—whose volume, *v*, was rather less than the volume V, and we mixed this with 2V of gravel likewise. We made this mixture into bricks, in the same manner as the first.

The resistance to an effort tearing the specimens asunder were—

	5 days. Kilos.	15 days. Kilos.	1 mth. Kilos.	3 mths. Kilos.
Mortar of light cement ... V cement 2V gravel ...	45	90	90	180
	65	70	90	180
	45	70	90	130
Average	51	76	90	130
Or in English lb. ...	112¼	167¼	198	286
	Kilos.	Kilos.	Kilos.	Kilos.
Mortar of heavy cement... *v* cement + 2V gravel ...	65	130	130	190
	85	130	150	190
	85	130	170	210
Average	78	130	150	196
Or in English lb. ...	173¾	286	330	432¼

Thus proving the incontestable superiority of the heavier cements.

We asked M. Hervé Mangon to analyse these cements, at the School of the Ponts et Chaussées, and he found they were of the following composition:—

	Light cement.	Heavy cement.
Silica...	26·30	24·45
Alumina and peroxide of iron	8·75	8·70
Lime...	62·35	65·60
Sulphuric acid	0·35	0·45
Water and loss	2·25	0·80
	100·00	100·00

"These analyses prove distinctly," he further wrote, "that the second sample alone approached the true type of Portland cement, while the composition of the first sample was much nearer the composition of the cements which have a rapid setting, such as the Roman cements of Pouilly, Vassy, &c." M. Hervé Mangon then dissolved and shook up, in a cold state, two grammes of each sample in a half litre of water, containing 10 grammes of the nitrate of ammonia. After a contact of twenty hours he filtered the liquid, and found in the residue of the clear liquid:—Lime dissolved, 0·825 in sample No. 1; 0·505 in ditto No. 2. Thus the product of this comparatively feeble dissolvent was less in the same proportion as the quality of the cement was better. M. Hervé Mangon terminated his letter in these words:—"I cannot take upon myself to affirm that the manufacturers may not succeed in making a cement that should possess the bulk of the properties of Portland cement, and yet should be of a light specific gravity. Many trials are being made with that object. Some of these have yielded curious results; but this is certain, in my opinion at least, that in the existing state of the manufacture of cements it is impossible to unite, in the same product, the lightness of the material with the precious qualities of the true Portland cement. I think, then, that it would be advisable to forbid the use of light Portland cement in all government works until new experiments, continued over long periods of time, should allow of this rule being set aside, which, I may add, is dictated by the most simple rules of common sense."

The actual inferiority of the light Portland cements, compared with the heavier varieties, being peremptorily proved by the facts above recorded, the administration would have the greatest possible interest in substituting, in the specifications that it issues, the dosing by weight to the dosing according to volume. It would thus relieve the contractors from any question of the density of the compound, and these men exercise the most regrettable pressure upon the manufacturers in order to obtain the lightest cements possible. It would at the same time render frauds more difficult, if not impossible, without the connivance of the agents charged with the superintendence. Now-a-days, as M. Hervé Mangon justly remarks, these weighbridges are instruments as simple as they are economical; the dosing of the mixture of cement and sand by weight has become as practical a method as the dosing by volume.

Here it is necessary to define what is meant by heavy cement. We shall hereafter call cement "heavy" when its weight, ascertained by the means of a box of the capacity of 100 litres (that is a parallelopipidon of right angles of 0·50m. long, by 0·50m. broad, by 0·40m. deep), filled in a manner to avoid the pressure as much as possible, should never be less than 1350 kilogrammes in weight per metre cube, without the box. According to the mistaken notions of the marine engineers (for a proof of which we may refer to the last specifications issued at Cherbourg), we should say perhaps more exactly, a heavy cement is one whose specific gravity is superior to 1200 kilogrammes when, for the purpose of ascertaining this gravity, the cement is poured in, without pressure, a measure of a litre, of a capacity of 1·10 on the side. For the purpose of insuring greater exactness the litre ought to be filled twenty-five times in succession, with the same precautions, and the specific gravity will be ascertained from the results of the twenty-five weights thus formed.

It is to be observed that the heavy cements generally set with less rapidity than the light cements. Thus, when such cements are employed, it is not advisable to attach much importance to the proof after the first forty-eight hours, which is nevertheless very convenient in general works, as it permits the stock to be renewed more readily. The proof after the lapse of five days can alone with these heavy cements be considered conclusive.

Mode of using Portland Cement Concrete under Water.—The concretes of Portland cement that are immersed in water suffer an energetic washing, which is to be accounted for by the fact that every piece of stone that comes in contact with the water is immediately deprived of the mortar which surrounds it; it does not, in fact, retain a trace of this mortar. Portland cement mortar is not rich and soapy, in the style of the lime mortars, properly so called. It does not stick to the trowel, but it is like pounded glass that is moistened, so bad an aspect does it present when it is rather stiff. Treated with sea water, this mortar separates into three parts or strata. The upper stratum A, is only a simple lime water; it does not set, and remains soapy unless it is dried. The middle part B, acts as would a mortar that is of the kind known as "thin;" whilst the residue C, appears alone to preserve some qualities of the mortar; but composed as it is of the heaviest grains, which are also the best burnt portions of the cement, it does not set with anything like rapidity. It is, moreover, diminished in strength by the mixture of a great part of the gravel, which enters into the composition of the mortar, which falls with it into the intervals which are left between the stones. Indeed, the density of the Portland cement is much nearer that of gravel than that of lime is. It would appear then that the tendency of the elements of the mortar to separate would be less in the case of Portland cement mortars than it would be in those made of ordinary lime. But there is not the same adhesion in the grain of Portland cement to the materials with which it is mixed. Moreover, the cements that are met with in commerce do not weigh more than 1200 kilogrammes, when not pressed, and measured in a box containing 100 litres. The best gravel from the shore of Boulogne, measured in the same way, weighs as follows:—1 deg., when very dry, nearly 1700 kilogrammes; 2 deg., when moist, nearly 1500 kilogrammes. Adopting this last figure, the density of the gravel would only be 25 per cent. greater than that of light Portland cement. But in salt water this difference between the densities of the cement and the gravel becomes notably exaggerated; for the effective weights in salt water become 200 and 500 kilogrammes, that is to say, that after the immersion the weight of the gravel would be found to be more than double that of the cement. It is this fact that may account for the ready separation of the elements that enter into the composition of the mortars that takes place in water.

M. Hervé Mangon has kindly repeated this experiment of washing, with pure cement. The cement that he operated upon presented the following composition:—

	At moment of arrival.	Supposed depriv. d of the water.
Silica	25·60	26·61
Alumina and peroxide of iron	8·95	9·30
Lime	61·35	63·77
Magnesia	0·30	0·32
Water, carbonic acid, and matters not dosed	3·80	—
	100·00	100·00

It weighed 1440 grammes when it had been sifted, and it left, in the course of that operation, the following results:—

Grains of 1½ millimetre diameter	0·70
Grains varying from 1½ to 1 millimetre diameter	0·70
Grains varying from 1 to ½ millimetre diameter	0·40
Grains stopped by a sieve 36 meshes to the centimetre	28·20
Powder passing through a sieve 36 meshes to the centimetre	70·63
	100·00

The cement in its natural state, and mixed with the ordinary precautions, sets immediately under water. The parts that were extremely fine also set with equal success. The grains that were kept back by the sieve did not work up well, and they retained the appearance of sand; but with time, and even under water, this product set, and acquired a considerable degree of hardness. Thus the cement fulfilled all the conditions that were required, either as regards the chemical composition, the burning, the density, or the degree of pulverisation. M. Herve Mangon then dissolved in ten litres of water 800 grammes of this cement; he shook it, and then he poured off the water that had been allowed to clear itself. Lastly, he poured the cement thus washed into a smaller vase, where it divided itself into three layers, which presented the following differences, according to the chemical analysis:—

	A.	B.	C.
Silica	7·15	10·20	22·30
Alumina and peroxide of iron	5·30	3·00	4·30
Lime	18·80	25·60	48·00

Magnesia	2·00	1·00	0·30
Water, carbonic acid, and matters not dosed, traces of the chlorides and sulphides ...	66·75	59·40	25·10
	100·00	100·00	100·00

Or supposing these mortars to be deprived of the water and the carbonic acid that they contained, their composition would become—

	A.	B.	C.
Silica	21·5	25·2	29·7
Alumina and peroxide of iron	15·9	9·3	5·7
Lime	56·6	63·1	64·1
Magnesia	6·0	2·4	0·5
	100·00	100·0	100·0

The layer A was, in fact, a pure lime water; the lime was in part replaced with magnesia, which being more voluminous than it was, opposed everything like a cohesion of the product. The layer B having been thinned by the mixture of a small portion of the cream of lime, was principally distinguished from the layer C by the differences in the physical states of the layers. The layer C alone set in a satisfactory manner. In this case, again, the chemical analysis explained sufficiently the facts that had been experimentally observed. It must however be said that, in the opinion of M. Herve Mangon, there does not exist in the actual state of the fabrication of cements a product of that nature which would resist such an energetic washing, particularly in sea water.

This being settled, let us examine the conditions of the laying of the beton on the level of the water and under the water.

Case the First.—The ordinary practice—that consists in laying the fresh concrete a little behind the mass already in place, and then compressing it by rammers, so as to cause the wet concrete to swell and advance forward, while it always presents the same surface to the part in advance—is not possible with the Portland cement; the mortar is not sufficiently stiff, it is not soapy enough for that. The long slidings, which are occasioned by the widening of the mass that is spread out, and which is flattened in laying, causes the beton made with lime to advance slowly, and it is accompanied with an insensible degree of washing; these slidings do not take place with Portland cement, generally speaking. It is almost impossible to keep up a gentle slope with this description of beton. Now when the slopes are very steep, the stones detach themselves and roll down, and thus the washing is produced. In this matter there may be observed in the whole height of the mass (but particularly about the level of the surface, where the action of the waves is most distinctly felt), through the stones that are washed clear of the mortar, caverns imperfectly filled with gravel and the coarser grains of the cement, which constitute a mortar that is very thin, that covers the rest of the cement mixed up with a cream of that material, more or less mingled with the cement. Above the water the concrete is excellent.

Let us now consider the case wherein the concrete is executed under water, by means of boxes of a capacity which, as will be seen hereafter, it is advantageous to make as large as possible. The heaps of concrete are disposed one by the side of the other, but which have necessarily their slopes very steep, for the reasons before enumerated. In each heap the heart alone can be very sound, so that if the position should contain any springs, it is tolerably certain that they will appear upon the surface of the layer of concrete when the excavation of the interior shall be laid dry; the springs will, in fact, follow the lines of the washed stones. It is true that these effects may be produced with lime mortars; but we believe we may affirm, without fear of being contradicted by facts, that they are much more serious with the beton made with Portland cement. The layers of mortar made of lime flatten more; we have in their case to deal with a complete layer, not with heaps that are juxta-posed. But laid dry, the concrete made with Portland cement reassumes all its advantages over the concrete made with ordinary lime. Thus we have often noticed that a spring from below has forced a passage through the concrete made with Portland cement, like a hole pierced by a ball; the water had passed through, but the concrete only allowed its passage through the passage that was strictly necessary. All around the hole, from the top to the bottom of the spring, the cement mortar retained its goodness. The concrete was pierced like a chimney whose diameter was reduced to just the dimensions that are absolutely necessary.

In the same manner water runs over fresh concrete without any serious consequences, except in the case of great speeds and great falls. To fill, by the means of the basin of the floating dock of Boulogne, that reserved portion, we had formed with complete success, on one half of the width of the passage, the first portion of the bed of concrete, the water being allowed to flow over the other part; afterwards we passed over the fresh bed of the current—the stream of water that was retained by a rim formed in the earth—and we filled the half that had remained empty, and thus on successively passing the water over two sides.

We have thought that the stability—if we may express it thus —of the Portland cement mortar was in a great measure due to its great weight, which is more than half as much again as that of ordinary lime. In fine, if the concrete made with cement is with difficulty applied in water, it is possible to apply it dry in land charged with springs without inconvenience. If, however, it were absolutely necessary to apply it in water, we would recommend the use of machinery, in the style of "tremies," in preference to any others; for the two facts we have mentioned prove that a layer of Portland cement concrete may be spread under the water with the tremies with less alteration than a similar layer of lime mortar. We also would recommend that the concrete should be made with rounded stones, rather thin, with angular stones that are the result of the breaking of the ballast, for it is extremely important to facilitate the sliding of the materials one upon another, to make up for the want of an unctuous character in the Portland cement. We may here observe that a round pebble from our shore seemed to us as difficult to detach from a gangue of Portland cement mortar as a stone that was broken could be.

Mode of using Portland cement mortar in masses of masonry.—In the execution of masses of masonry we think that it is a good practice to employ the mortar of Portland cement sufficiently soft, so that it should more easily assist in the formation of beds that would form the seating of the stones, otherwise there is danger of the formation of many vacua under the masses; for the stiff Portland mortar acts as ordinary earth when it is worked with the trowel. Soft, however, it assumes a distinct character; it becomes more unctuous, and spreads more easily in the beds.

An excess of water, as might have been expected, has produced a weakening of the mortar; but if the stiff mortar yields resistances that are superior to those of fluid, and very fluid mortars, it does not yield results that are comparable to those of the normal mortar, even when this is mixed with a great quantity of water.

Under stones used as ashlar and laid in elevation, the mortar of Portland cement which does not stick to the trowel (we may observe, moreover, that the ashlar stones of the floating basin at Boulogne, which are obtained from the carboniferous limestone of the valley of Hereuse, in the neighbourhood of Marquise, are of a marble that is very smooth) tends in throwing off the excess of its moisture, and in hardening, to allow the formation of hollow spaces by the effect of shrinkage under the beds, of which the existence is brought to light in times of rain. Thus by reason of the porosity of the material, the rain water, driven by the wind, can fill up the hollow spaces, which are made apparent when the rain ceases, by the permeation of the moisture. The greatest care must, therefore, be taken to ensure the strict obtainment of the beds that should be perfectly resisting, and this would imply great skill on the part of the mason charged with the setting.

The following seems to us the best method to be observed in these cases:—The workmen commence by spreading upon the beds of masonry a layer of mortar of two or three centimetres thick that is sufficiently stiff; they place about the angles of the face two wedges of a wood that is very tender, and these are driven in throughout their length; they equally wedge up with a piece of stone the back side of the stone that is intended to be laid; then the front wedges are gradually withdrawn, and the piece of stone then is inserted in the opposite direction, the stone being forced down to its place with blows of a mallet. The wooden wedges do not serve in this case to do more than prevent the stone from floating upon its bed of mortar. They hinder in this manner the undulation of the layer; they can be easily withdrawn by hand as soon as the bed of mortar has hardened a little.

The shrinkage that the Portland cement is exposed to ought to cause its rejection for the use of pointing mortars that are too rich. The best composition of this description of mortars seems to us to be that which is produced by a mixture of 700 parts of Portland cement to 1000 parts of gravel. To diminish as much as possible the porosity of the joints it is necessary to stipulate for a most energetic method of the compression of them by the tool that is used to draw the joints—in French, by the *dagne*. The mortar is, moreover, much solidified by this operation. Now we have had occasion to observe practically that bricks made with compressed mortar offer a resistance that is much greater than in bricks which are made in ordinary mortar prepared in the ordinary manner.

Amongst the remarkable properties of Portland cement mortars it is important to mention that it is beyond the effects of frost. The Portland cement mortars do not freeze, as our masons say; and this allows the execution of masonry in the cement in the winter season in cases of need. Thus, portions of Portland cement mortar which we had exposed to the frost immediately after they were prepared, had cracked very deeply after they were made, and before they had taken their definite form, in consequence of the freezing of the water, and had even partially fallen to pieces to a great extent, but after the thaw had preserved in the detached morsels the greatest hardness.

We will terminate this note by some words upon the influence of the degree of tenacity of the inert matters mixed with the cements, and upon the ultimate resistance of the mortars. We for this purpose made bricks that were composed of the following ingredients, namely:—

Rich mortar	1 of Portland cement and 2 (in bulk) of the gravel of la Creche 1 of Portland cement and 2 of the Downs sand (all in bulk).
Thin mortar	1 of Portland cement and 4 of the gravel of la Creche. 1 of Portland cement and 4 of sand.

The sand that was obtained from the Downs was employed very fine; it did not leave any residue upon a sieve of eighteen meshes to the centimetre. The grains of gravel, on the contrary, were retained in about the proportion of one-third by this dimension of hole. We obtained the following resistance to tearing asunder, that are found in this table:—

Composition of the bricks.	Weight producing rupture by tearing asunder after—					
	5 days.	1 month.	3 months.	6 months.	1 year.	2 years.
1 vol. Portland cemt. 1 sand....	45 ,, 50 ,, 45 ,, } 46·67	80 ,, 100 ,, 90 ,, } 90·00	100 110 100 140 185 140 } 120·83	160 140 165 180 175 185 } 167·50	200 180 170 } 183·33	190 210 190 } 196·67
1 cement. 2 fine sand	40 ,, 42 ,, 47 ,, } 43·00	80 ,, 110 ,, 100 ,, } 96·67	110 120 117 80 100 100 } 104·50	145 145 145 155 150 140 } 146·66	180 150 160 160 140 140 } 155·00	190 190 } 190·00
1 Portland 4 gravel	7·00 2·50 7·00 ,, ,, ,, } 5·50	25 30 25 ,, ,, ,, } 26·67	,,	40 45 53 94 85 ,, } 63·40	88 80 ,, 80 80 ,, } 81·25	,,
1 Portland 4 fine sand	2·50 2·59 2·50 ,, ,, ,, } 2·50	10 12 10 ,, ,, ,, } 10·67	,,	15 25 36 30 25 ,, } 30·20	35 42 ,, ,, ,, ,, } 38·50	,,

It follows that the relation of the loads carried by the rich and the thin mortars, or those that were mixed with large proportions of sand, were as follows:—

	After 5 days.	After 1 mnth.	After 3 months.	After 6 months.	After 1 year.
Rich— Sand .. Gravel	43·00 / 40·67 = 0·92	96·67 / 90·00 = 1·07	104·50 / 120·83 = 0·86	146·66 / 167·50 = 0·87	155·00 / 183·33 = 0·85
Thin— Sand .. Gravel	2·50 / 5·50 = 0·45	10·67 / 26·67 = 0·41		30·20 / 63 40 = 0·48	38·50 / 81·25 = 0·41

After 2 years it was for rich mortars .. .. 190 00 / 196·67 = 0·96

This would lead to the prescription, in a general manner, of the use of fine sand in the preparation of thin mortars.

These materials are then, carbonate of lime, nearly pure, to which the sea water has added a little magnesia. We find moreover similar matters everywhere that the water can penetrate through the mortar that is made of cement.

ROADS AND RAILWAYS IN INDIA.

By Sir William Denison, K.C.B., Colonel, Royal Engineers.

Looking to the fact that the Government of India, although it has expended large sums upon roads and railways, as well as upon canals, when opportunities of constructing these were afforded, has yet many thousand miles of road to make, and fresh lines of communication to open, I cannot but think that an inquiry into the circumstances which influence the cost of transport in India, and a comparison of the advantages presented by different modes of communication, would be useful, not merely to the Government, but to the capitalists who may be disposed to invest money in works of this kind, and who, of course, would wish to derive from such investment the largest returns.

Such an inquiry, will I think, tend to prove that the local features of the country, the character of its climate, the peculiarities of the people, and the nature of their industrial system, influence, far more largely than many are apt to think, the discussion of questions which would seem, to most, to be simple matters of engineering experience.

Before, however, I enter upon this inquiry and comparison, I must premise that the facts which I propose to classify and arrange, as the basis of any inferences I may draw, have reference to the Presidency of Madras, which occupies by far the largest portion of the southern extremity of the Peninsula of India. There is, however, a marked similarity between the state of things in the different Presidencies; and, with some trifling allowances for local peculiarities, I think that what I have to say about railroads in Madras will be found applicable to the whole of India.

General aspect of the Country.—The Peninsula of India extends from Cape Comorin in latitude 8° N. to latitude 20° or 21° W., at which point its width is about 14° of longitude or 800 miles or thereabouts.

A range of mountains from 6000 to 8000 feet high runs parallel to the western coast at a distance of about 50 or 60 miles from the sea. This range is broken through at one point, where there is a gap of about 40 miles in width, the height of which is not more than 1200 feet above the sea. The fall of the ground to the westward is therefore rapid, while, speaking generally, there is a gradual and much more gentle slope to the eastward, which is interrupted occasionally by abrupt secondary ridges rising to a height of 2000 or 3000 feet. Nearer the east coast the land slopes gradually towards the sea, at the rate of about 4 feet per mile, in great plains, where there is but little to catch the eye, or to relieve the monotony of the landscape. It follows from what has been said above, that the rivers flowing to the west coast have short and rapid courses; though, as they flow through a narrow belt of alluvial soil near the sea, they are often navigable for small craft for some miles from the mouth. Those that flow to the eastward have a much longer course, and, as they drain a much larger area of country, they bring down, during the rainy season, a very heavy body of water; as, however, the supply is but temporary, as will be seen when I speak of the climate, these rivers do not afford any facilities for water communication in their unimproved state.

Climate.—The position of the Peninsula, within the northern tropic, exposes it to the action of the periodical rains. These are modified in their action by the relation of the peninsula to the great mass of the continent from which it projects, and assume the form of two distinct monsoons. The south-western, which is by far the most extensive in its action, commences about the middle of May, and, so far as the Peninsula of India is concerned, expends its force principally upon the west coast, and the range of mountains parallel to it, where, during the months of June, July, August, and part of September, there is a steady down-pour with an occasional break; the average rainfall may be put at 180 inches.

Of course a large proportion of this water returns rapidly to the sea on the west coast; the effect being to lessen the saltness of the sea, to such an extent as to kill the fish and all the plants which are naturalized in salt water, for several miles from the coast, and to cause thereby a most disagreeable putrescent effluvium along the coast, and for three or four miles out to sea.

A portion of the rain of the south-west monsoon is discharged upon the eastern slopes of the mountain range, and drains into the water-courses which form the heads of the large rivers, such as the Godavery, Kistnah, and Cauvery, which discharge themselves into the Bay of Bengal; causing heavy floods into the lower portions of these rivers. In October the wind veers to the northward of east, and is called the north-east monsoon. It brings with it the rain which it has sucked up in the Bay of Bengal, and discharges it upon the eastern slopes of the Peninsula. The amount however of this discharge, which continues at irregular intervals through November and December, is not nearly so great as that of the south-west monsoon. The average of twenty years gives thirty-one inches as the amount of rain at Madras during the north-east monsoon, and further inland the average is much less, not exceeding thirteen inches.

Rain may be said to fall from May to December in some part or other of the Peninsula; but the 4½ or 5 months from January towards the end of May may be termed emphatically the dry season. No vegetation takes place, except in situations where water can be found to irrigate the soil; the sky is cloudless, there is nothing to impede the action of the sun upon the ground, which is baked to the hardness of a brick where the aluminous element prevails, and is reduced to a dust where its consistency is less compact.

Cultivation.—From the foregoing description of the climate, it may be inferred that the productiveness of the country depends altogether upon the periodical rains. Should nature pause in her action for a single season, the result of this short cessation would be such a wide-spread famine as would destroy millions upon millions of people, and reduce the country to a desert.

On the west coast the rain falls with such regularity, and the atmosphere generally is so moist, that few or no attempts are made to retain the water discharged upon the range of mountains bordering the coast. On the east side of these mountains, however, the case is very different. Here the rain is scanty and irregular, and care is taken to secure as much as possible of the drainage of the country. In every water-course or line of drainage, dams will be seen following each other in regular succession, till all or nearly all of the drainage water is caught, and retained for agricultural purpose; the surplus, which finds its way into the rivers, is again stopped by *anicuts*, or dams constructed across them, from distance to distance, and channels are taken from above these dams, by which the water of the river is distributed as extensively as possible. When all this has been done, there is but a small proportion of the cultivated land which is susceptible of irrigation, the remainder is dependent upon the ordinary action of the rains, and is sown with what are termed "dry crops;" namely, various kinds of millet and raghi, and also with oil seeds, gram, and other leguminous plants. This dry cultivation imposes upon the farmer the obligation of completing his agricultural operations rapidly: he cannot plough before the first rains have softened the ground; he cannot sow till he is pretty certain of continual showers of rain. The result is that he is compelled to maintain, or at all events to employ, a pair of bullocks for every five, or at least for every eight acres of land which he cultivates, as he would not be able with less animal power to carry through the various ploughings and hoeings which the land demands. The crop springs up rapidly under the influence of rain, and of a sun nearly vertical, and is ready for reaping in four or five months. It is then reaped, trodden out by bullocks, as was done in the time of Moses, and winnowed by the wind in a manner as old-fashioned as the threshing. When all this has been done, the farmer, unless he has land which he can irrigate, and from which he can get a second crop, has no work for his bullocks during the five or six months of the dry season; they are, consequently, employed in conveying produce to market, and the farmer or cultivator, leaving his land to take care of itself (which it does by producing a plentiful crop of coarse grass and weeds) attaches his bullocks to a light cart or bandy, and becomes a common carrier, being satisfied of course with very small profits, as every penny which he receives, in addition to the amount required to maintain his bullocks, is clear gain.

Population.—The population of the Madras Presidency may be put at 24,500,000, of which about 16,800,000 are employed in agriculture. About 450,000 are congregated in Madras and its suburbs. There are, however, few large towns, though in each district there are three or four towns about which the population congregates more densely than in the rural districts. As a general rule, the population is more generally diffused ever the face of the country than is the case in England, where the agricultural portion of the community forms a much smaller portion of the whole than is the case in India.

Wages.—A necessary result of this dissemination of the people, and of their employment in the rude processes of agriculture, is that wages are low everywhere. The capital expended by the different companies upon railways and irrigation works has, by increasing the demand for labour, raised *locally* the rate of wages; but even now, in parts of the country a little distant from lines of railway, from Rs. 2½ to Rs. 4 per month, or from 2¾*d.* to 3*d.* per day, may be considered as the ordinary and average rate of wages; while, generally speaking, the whole of the agricultural labour is paid for in kind. The hire of a pair of bullocks and a man to drive them, and to plough at the same time, is five annas or 7½*d.* per day.

Roads.—Though men and cattle may be hired at a very low rate, as shown above, yet the coast of transporting commodities must depend very much upon the character of the road over which the traffic is to pass. The main lines of road throughout the presidency are, generally speaking, in a fair state of repair, much money having been spent upon them. The principal obstacles to ready communications are the nullahs and water-courses, many of which are not bridged: during the rainy season these are torrents altogether impassible; while in the dry season the river beds are filled with a loose drifting sand, across which the ordinary carts or bandies, carrying about half a ton, require, to be assisted by many men. The cross roads are in a pretty good order for the character of the traffic which passes along them; indeed, during the dry season, roads though deep in dust do not oppose any great obstacle to the movement of goods or produce. A great proportion of the work of transport is accordingly done in that season; the cost of conveyance being about 2½ annas, or 3¾*d.* per ton per mile.

During the rainy season the cost of conveyance is much enchanced: in the first place, the roads are soft and damaged by the rain; the bridges are carried away by floods, culverts blown up, &c. The actual labour and risk of conveyance is therefore much greater. In the second place, the rainy season being the working period of the agriculturists, the whole of the animal power of the ryot is expended upon his cultivation, and he cannot spare any to be employed upon road traffic, and there is therefore less competition; to set against this however, there is less traffic at that time of the year, and I am disposed to consider the figures above given as the cost of conveyance, and which were taken from a return furnished by the Commissary General, of the contract price for Government transport, to be a fair average for the whole year.

Railroads.—Of these, the Madras, or South Western line, is completed from coast to coast, a distance of 406 miles. The North Western, which is eventually to communicate with Bombay, is open for a distance of 41 miles from its junction with the Madras line. The Great Southern of India line is finished from Negapatam to Trichinopoly, a distance of about 80 miles, but it has yet to be connected with the Madras line by an extension of about 80 miles, which will meet the South West line at a point about 250 miles from Madras. A branch from the Madras line, about 80 miles in length, leads to the military station of Bangalore: this is just completed. When the whole of these lines are finished there will be a complete chain of railway communication connecting the principal military stations in this Presidency with the great depôt at Madras; and this latter will communicate directly with Bombay.

Canals.—Of these there are but few. The irrigation channels in the deltas of the Kistnah and Godavery are used with great advantage for local traffic; and there is a coast canal, connecting the backwaters of some of the rivers to the north and south of Madras; while the Irrigation Company has on hand a project for completing a line of water communication between Kurnool on the Toombuddra, and the sea on the east coast.

As a general rule however, the country is altogether unfitted for this kind of communication, owing to the difficulty of securing, either at or below the summit levels, a sufficient supply of water to furnish the lockage and to meet the very large demand on account of evaporation.

I have given this short sketch of the Madras Presidency, and of the existing means of communication, in order to facilitate the comparison which it will be necessary to make between the result of the railway system here and elsewhere.

In England and Australia, the *indirect* benefits arising out of the railway system afford a full compensation to the country at large for the capital sunk in the railway. The holders of the railway shares are losers, of course, to the extent of the difference between the dividend paid and the ordinary interest upon the capital invested; but every man who travels by rail, and every man who has goods to send to market, saves a very large percentage of the amount he would have had to pay had his means of communication been limited to turnpike roads.

In India however, so far as the conveyance of goods is concerned, the *indirect* benefit is by no means so great as that which is enjoyed by English or Australian merchants. Here the cost of moving goods is about 2⅞*d.* per ton per mile on the road, while on the rail it may be put at 1½*d.*; that is, the cost per rail is to that per road as 2 to 5, while in New South Wales it is as 1 to 4, and in England 1 to 5.

The benefit to travellers in India is very great; the facilities afforded by the railway have made thousands travel, who in former times never dreamed of moving from their homes. Still however, the poverty of the people, the very low wages which they receive, taken in connection with the fact that a very large proportion of such wages is paid in kind, would seem to point to the conclusion that years must elapse before any very great extension of passenger traffic will take place, except in the vicinity of large towns. At the present low fare of ⅜ths of a penny per mile for 3rd-class passengers, the Madras cooly would only be able to travel 9⅓ miles for his daily wages; while an English laborer would earn enough in one day to carry him 30 miles. A reduction in the Madras rates would, I have no doubt, increase the number of passengers; but it is very questionable whether it would increase the net receipts. If, indeed, the cost of working the railway in India bore the same ratio to the cost of working in England, as the rate of wages in India does to that in England, the lowness of the Madras rate would not have much influence on its net receipts. But in India the cost of freight has to be added to that of the coal or coke used; the wages of skilled labour, as engine drivers, &c., are higher than in England, and though the ordinary labour employed about the stations, and on the maintenance of way, is cheaper than in England, it is not cheaper in proportion to the difference of wages, for one Englishman will probably do the work of *at least* three natives. On the whole it will, I think, hardly admit of a doubt that the amount of traffic required to pay the interest of the capital expended upon the construction of the railway, as well as to defray the costs and charges of maintenance of way and of locomotive power, must be far greater in India than in England and elsewhere.

Now the interest of capital is one of the heaviest charges against the proceeds of railway traffic, and when the traffic is comparatively light, and not likely to increase to any great extent, it may be more to the advantage of the Government, and of the country generally, that a description of road should be constructed which, involving a smaller outlay of capital, but requiring a somewhat more costly description of locomotive power, would, at a charge little if at all in excess of that of the railway, furnish a return sufficient to keep the road in thorough repair pay the interest of the capital expended upon its construction, and provide an amount of tractive power fully adequate to the wants of the people, though the time expended would, of course, be very much in excess of that required by the locomotive line.

I propose, then, in the remainder of this article to investigate carefully the relation between the outlay and the returns upon various kinds of roads in the Presidency of Madras; namely, the railway worked by the locomotive engines; the railway worked by animal power; and the macadamized road. The first step towards this comparison must be the determination of the amount of passenger and goods traffic which is to be taken as a standard quantity, and in order to simplify the calculations, and indeed, to substitute matter of fact for matter of inference, I propose to take the amount of traffic upon some given line or portion of a line of existing railway, as this standard.

The Madras or South West line of Railway, extending from Madras to Beypore, a distance of 406 miles, partakes too much of the character of a great trunk line to justify the adoption of the whole or any other portion of it as a standard of comparison, whether as to outlay or as to the amount of traffic; but the North West line, or the portion of it already completed, viz., 41 miles, may be fairly looked upon, at present, in the light of a branch; and an inquiry into the cost of moving the passengers and goods, stated to have passed over this line, by some more simple system of conveyance, will afford satisfactory data as to the relative advantages of railways or other roads.

I may observe that the Madras Railway, though it only paid, during the first half of 1863, interest to the amount of ·66 per cent. or 13*s.* 7*d.* per hundred pounds of capital expended upon the *whole line*, did, I have no doubt, pay the full interest of five per cent. upon the cost of the 40 or 50 miles nearest to Madras; but it would be difficult, if not impossible, to attempt to deal with the line in sections, and to attribute to each its fair share of expenditure and receipts. It is only necessary to say that, with an amount of traffic equal to 595,000 passengers, and 960,000 tons of goods in the half-year, the amount of interest was only, as stated above, ·66 per cent. for the half-year, so that 1,200,000 passengers and about 200,000 tons of goods would only pay the cost of traction, of maintenance of way, and 1½ per cent upon the outlay of capital.

The following is an abstract of the nature and amount of the traffic on the North West line, for the half-year ending 20th June, 1863; and the numbers given will, when doubled, form the standard amount of traffic upon which the calculation of the cost of conveyance on the different kinds of roads will be based; the actual cost of the working of the railway being taken.

	Passengers.	
1st-Class	194 × 2 =	388
2nd „	1,411 =	2,822
3rd „	75,999 =	151,998
	Goods.	
Tons	15,711 × 2 =	31,422

The first and second class passengers will be merged into one of, say 3220. The second class of passengers will consist of 152,000, and the goods will be taken as 32,000 tons. I will now proceed to enter upon a detailed examination of the cost of *Construction*, of *Maintenance of way*, and of *Locomotive power* upon the macadamized road, upon the railway for animal power, and upon the railway for locomotive power, with reference to the above amount of traffic.

CONSTRUCTION.

1*st.* *Macadamized Road.*—The data as to the cost of constructing such a road as this have been furnished by the Public Works Department, and the amount given below may be considered a fair average of the cost of such roads throughout the principal parts of the Presidency.

Width of road	30 feet.		
Width of metalling	24 „		
	£	*s.*	*d.*
Cost of earthwork	166	14	0
Do. of metalling	163	16	0
Bridges and Culverts	302	14	0
Sundries	40	0	0
	£673	4	0

If an addition be made to this sum for the cost of superintendence, &c., bringing it up to £750 per mile run, this will be an ample alllowance for any contingency.

2*nd.* *Railway for Horse-power.*—The cost of the earthwork, and of the bridges and culverts, would be rather less on the railroad than on the macadamized road; for, while it is not intended to modify the gradients in any way, or to add to the cuttings and embankments, except on very special occasions, the width of the road may be less. I do not, however, propose to make any deductions on this account, but shall assume the cost of the earthwork and bridges and ballasting at the same sum as given for the macadamized road, viz., £750 per mile; setting the metalling against the ballast of the railway. The cost therefore of a railroad will be found by adding to the cost of the macadamized road, that of the purchase of rails, chairs, and sleepers, and that of the labour of fixing them.

The weight of the rail used at first on the Manchester and Liverpool line, was 35 lb. to the yard, and it seems to me that for horse traction, a rail 28 lb. to the yard would be amply strong enough; and as 2000 yards, or an addition of 240 yards to the mile, will be sufficient to cover all sidings, &c., 2 × 28 × 2000 = 112,000 lb., or 50 tons per mile, will be the weight of the rails. These can be delivered at Madras at £8 10*s.* per ton, and an additional 30*s.* per ton, making a total of £10 per ton, will cover the charge for conveyance, so that £500 will be the cost per mile of the rails delivered upon the road. Timber sleepers have been found to decay rapidly in this climate; I should therefore be inclined to recommend the employment of stone blocks as supports for the rail: in many parts of this presidency, where the gneiss crops out on the surface, the stone block would be far cheaper in first cost, and far more durable than any other description of sleeper; but, as these may not be attainable generally, I propose to allow for the use of the iron pot sleepers, which have been employed on the railway. For the horse traction line these may be made lighter than for the locomotive line, but I propose to allow for the same weight and price, that is £1 per pair of sleepers with the connecting tie-rod. I shall allow, however, for a bearing of five, instead of four feet: the cost, under these conditions, of chairs and sleepers will be £1200 per mile.

The cost of laying the railway may be put as on the locomotive line, at 4½*d.* per yard run, the cost for 2000 yards would therefore be £37 10*s.*

In order to make the action of this railroad perfect, it should be provided with a line of telegraph; and the cost of this, judging from the amount expended upon that on the Madras line of railroad, will be £90 per mile.

The whole cost of this railroad for animal power per mile will then be as follows :—

Earthwork, including Ballast or Metal	330	10	0
Bridges, Culverts, &c.	302	10	0
Rails	500	0	0
Chairs and Sleepers	1200	0	0
Fixing Rails	37	10	0
Telegraph	90	0	0
Stables and Rest Houses	50	0	0
Sundries	40	0	0
Superintendence, &c.	76	0	0
	£2,627	0	0

Locomotive Railway.—The cost of this may fairly be put at the same rate, £12,000 per mile: this has been the cost of the South West line, and it will in this case include the cost of the rolling stock required to work the amount of traffic taken as the standard. The comparison therefore between the capital expended per mile upon the different kinds of roads, and the annual charge on account of interest at 5 per cent. will be as follows :—

	Cost per mile.			Interest.		
Macadamized road	£750	0	0 ...	£37	10	0
Railroad for Animal power ...	2,627	0	0 ...	131	7	0
Railroad for Steam power ...	12,000	0	0 ...	600	0	0

(*To be continued.*)

ARCHITECTURAL ASSOCIATION.

The fortnightly meeting of this society was held on the 6th ult., Mr. E. J. Tarver in the chair. The following gentlemen were elected members of the Association—Mr. Alfred Waterhouse, 8, New Cavendish-street; Mr. G. D. Mennie, Overton-lodge, Angel-town, Brixton; Mr. R. M. Marnock, 11, St. John's-terrace, Regent's-park; Mr. Frederick Dyer, 18, Bucklersbury; and Mr. G. Allan, 3, Westminster-chambers.

The Secretary read a letter from Mr. Papworth, requesting the Society to furnish the Voluntary Examination Committee of the Royal Institute of British Architects, with suggestions as to the mode of conducting the examinations. The Hon. Sec., Mr. Mathews, reminded the meeting that a schedule of suggestions was sent up to the Institute during last session, and it had been partially acted on, with considerable advantage. In connection with this subject, Mr. Riddett announced that the Voluntary Examination Class was about to re-commence its session, and invited the attendance of members. After some conversation a resolution to the following effect was proposed by Mr. Ridge, seconded by Mr. T. Roger Smith, and carried unanimously: "That this Association considers it highly desirable that a certificate should be given to each gentleman who passes the examination, stating the class in which he has passed; and that the certificate should bear the seal of the Institute and the signatures of the examiners."

Mr. Florence called attention to a scheme for the formation of a class to study water-colour drawing under an able master. The matter had been brought before the committee of the Association, who had expressed their approbation by granting the use of the rooms of the Association for the meetings of the class. Twelve gentlemen were requested to give their names to Mr. Florence, and thus form the first section of this class.

The Chairman then said that he regretted to announce that Mr. Cockerell, who had promised to read a paper on the "Works of the late Professor Cockerell," had been unable to attend this evening. It became necessary therefore to turn to some other subject, and it had been decided that a discussion should take place on "*Architectural Study*," with special reference to the paper which had been read some time ago by Mr. T. Roger Smith, and he called upon Mr. Ridge to open the discussion.

Mr. Ridge said he was afraid the committee, when they decided to have a discussion, did a very bold thing. Their reason for so doing was not simply that they could not get another paper to fill up the evening, for it was possible that some gentleman would have given a paper on this occasion, but it was thought that an Association like this ought to be able to entertain itself for at least one evening when circumstances required it. The subject of the education of architects was one of wide range and vast importance. So much had been said on this subject in the three papers which had been read to the Association by Mr. T. Roger Smith, that it was difficult to say anything new on it, but on the other hand, those papers had not been fully discussed at the time of reading, so that they might furnish matter for consideration this evening. For carrying on a discussion it was necessary that diversities of opinion should exist; but as a rule, members of the Association did not display very much difference of opinion; they had no gold medal to give away, and consequently did not even wage the Battle of the Styles. It would be found, however, that they looked upon the subject from different points of view, and this would doubtless furnish a discussion. Their chairman, for instance, would tell them with great nicety, the exact position which figure drawing should occupy in the architect's education. Mr. Florence would explain how water-colour drawing becomes a necessity of art-education; while our Treasurer (with an eye to the half-guineas) will insist that belonging to the Architectural Association is a matter of the utmost importance. Mr. Ridge observed that the most remarkable thing which struck one on looking at the Architectural profession, was the wonderful development it had undergone in recent years, and this necessitated a corresponding advance in the architectural course of study. The recognised education of architects, however, was at present much the same as that recognised in the old "five order" period: young men were articled now, as then, but beyond that nothing very definite was done as to their education; nevertheless, opportunities were now set before the young architects, which the older members of the profession were constantly telling them "did not exist in their time," but using these opportunities is purely voluntary, and forms no part of the system. One consequence of the greater development of the profession, was the larger number of men now rushing into it, which in some ways had caused a deterioration from the old system of education. For instance, much less time is now spent in study abroad than was formerly the case: this arose partly, no doubt, because Mediæval architecture could be studied at home; but still, it was a matter worthy of the attention of those who were considering the course of study which ought to be pursued by young architects. Mr. Ridge believed that many would feel conscious that much of the time of pupilage was often wasted in finding out what a student ought to learn, and the discussion of this evening would, he hoped, assist some of the younger members of the Association in this particular. Mr. Smith's paper, they would remember, ended with a paraphrase of Demosthenes' well known saying as to the most important requisites in oratory. Mr. Smith had said that drawing was the first, the second, and the third essential for an architect. He (Mr. Ridge) would, even at the risk of "finding aim the archer never meant," take the liberty of giving a separate meaning to each repetition of the word drawing. To the first, he would attach the meaning of "Geometrical drawing;" to the second, "Free-hand drawing;" and the third he would call "Drawing from the round." Making geometrical drawings of existing buildings, was a combination of "Geometrical drawing," with "Drawing from the round." In geometrical drawing they had sufficient practice, as they were of no use in an office if incapable of doing this species of drawing. On the question of free-hand drawing, Mr. Smith had hinted that the pupil ought to have some proficiency in it before he entered the profession. He (Mr. Ridge) quite agreed with this opinion. Writing a specification might be considered a fourth essential. It would be well, however, to bear in mind that the object was not so much to learn to write a specification, as to describe the work intended to be executed. We should, therefore, study the details of buildings on the works themselves, and on good detail drawings, and so describe what we understood, "and not crib phrases out of other specifications." Mr. Ridge illustrated the danger of putting the usual clauses into specifications without considering the effect they would have in individual cases, by an instance he had lately seen. Certain detached shafts of hard and dark coloured stone, such as are always obtained in as long lengths as possible, had been introduced in the interior of a church, in pieces of about a foot in height; on his remarking on the peculiarity to the clergyman, he replied that it arose from the insertion in the specification of the clause, "that all stones were to be laid on their natural beds," and this the masons had attended to in a manner never contemplated by the architect.

Referring to the voluntary examination scheme, Mr. Ridge observed that it was one of the great helps which the last few years had brought to young architects. He was sure that the very attentive study of the whole scheme of these examinations would be amply repaid. Not only was there a most excellent list of books, which divided into books which they read and books which they were advised to read; but the scheme also pointed out, by the mode of distributing the marks, what architects must know, and what they ought to know. The voluntary examination scheme was also calculated to warn young architects against one very obstinate sin of the profession. Most men were apt to study a few things exclusively, to the neglect of others. But the examinations directed attention to a very varied list of subjects, all of which it was requisite to study. Mr. Ridge observed that there was great diversity of practice as to the extent to which buildings both ancient and modern were studied. Some did little more than look at drawings of them in books or magazines. By the study of old buildings a knowledge of the different styles of architecture should be arrived at; and it seemed to him that one particular style must almost necessarily be preferred, and so selected for special attention. Thus a large school of architects at the present day looked upon the architecture of the thirteenth century as the purest and best for study, an opinion in which he agreed, believing it to be the period when Gothic architecture came to perfection without running into abuse. This period therefore ought to be thoroughly and completely studied, and in conjunction with it he believed it was necessary to study modern modes of execution. It might be very well to erect in a park, separate from all other houses, an archaic and Mediæval building, but the same style if used in a street would make people laugh. To his mind it was quite ridiculous to erect Mediæval buildings in the streets of a city like London. For this reason they ought to study modern buildings and modes of execution, and even such unpleasing subjects as the "Building Act." Combining these things with the particular style of architecture to which they were addicted, they would produce something appropriate for the present period. This process, Mr. Ridge maintained, differed from striving after a "Victorian Architecture," which its friends pronounced was to be as different as possible from any of the styles which had preceded it. Mr. Ridge remarked that many people seemed to think it not quite proper to sketch from modern buildings. He doubted whether this opinion was correct, as they were frequently well worthy of study, and moreover, the architects of the present day worked under the same disadvantages as the student would have to contend with.

Mr. Ridge said he would close his remarks with the observation—that in studying buildings, they must endeavour to arrive at the ideas of the architects who designed them. Unless they could perceive why certain forms were abandoned—why certain transitions took place, and why other styles were adopted, which were not now considered so good, their study would be but imperfect. M. Viollet-le-Duc's Dictionary adopted this mode of treating the subjects, and he thought it worth anyone's while to learn French, if only to study that work. The process of practical reasoning carried out in that book made an article on some point of military architecture, which was now necessarily obsolete, equally interesting and instructive with those on ecclesiastical or domestic subjects, which might arise at any time in ordinary practice. The whole spirit of our study of ancient architecture might be summed up in the words of Mr. Scott, in one of his lectures at the Royal Academy:—"That we should strive to do, not *what* they did in the middle ages, but *as* they did."

Mr. North thought it would be well if a man, before he entered the profession, studied free-hand drawing, and had a knowledge of perspective, and then obtain a practical insight of the leading principles in the art of building by working in a builder's yard or office for some time. He had been present some time ago at a discussion, at the Institute, at which it was stated that it formerly was considered advisable that anyone who entered the profession, ought previously to have passed a year in a builder's office or yard, learning the practical part of architecture. This was not done at the present day, and he thought that this defect lay at the root of the imperfect education of architects. The young men who entered the profession learn nothing for the first two years, except perhaps to draw up a few specifications, of which there were generally one or two dirty, well-thumbed, and grubby copies kept in the office, especially for the pupils to copy. He did not undervalue figure drawing, or the proper use of colours; these were very important; but first of all the pupil ought to have a thorough practical knowledge of the details of building. There were many books which professed to teach the student what he ought to know on these points, but they only led him into a fog; some gave sketches of specifications, which the pupil had to fill in, and these he thought were calculated to mislead. It often happened that the architect, knowing what would be wanted, but owing to the absence of an early practical training, not knowing how to express it, had to leave important details to the mechanic, who is generally prejudiced and wedded to old notions, and in this manner grave mistakes were committed. He thought the pupils should be trained to be engineers as well as architects, for he considered engineering to be the practical part of architecture. Partly owing to some architects (through the defects of the present system of architectural education) being unable to go minutely into the cost of labour and materials, and partly owing to unprincipled outsiders, whose strongest title to the name of architect was on the outside of their doors, there was a general, and oftentimes well founded complaint—that work which was estimated at, say £11,000, often came out at £15,000 when finished, a state of affairs very prejudicial to the working men of the profession. If architects paid more attention to good building, and less to pretty drawing, he thought the profession would make a style of its own, be more frequently employed by, and give more satisfaction to clients, than they sometimes did at the present time.

Mr. Koppers remarked that pupils, as a rule, did possess some skill in free-hand drawing, and many of them wasted their time in pen-and-ink sketches upon the office paper. A knowledge of geometrical drawing before entering an architect's office, might make them more useful in the office. Free-hand drawing was, however, he admitted very important, and ought to be recommended to all pupils who had not learnt it.

Mr. J. Douglass Mathews said, he thought study for the architectural profession might be divided into three parts: first, information gained by literary research; second, by association with others; and third, by actual observation. All these most important branches must be attended to by every man desirous of success; and the best way of accomplishing them was to make study as agreeable as possible. When a pupil entered an office, he should understand that he was expected to study out of office hours; formerly he had to study his lessons, and that study was still to continue; and when he had finished his office work for the day, his evenings were to be devoted to the mastership of such subjects as would advance him in the profession. It was, therefore, a question of some importance as to the way in which study could be made most interesting. The few remarks he had to make would be on the advantages of associated study, with special bearing on their own Association. For his own part, he felt strongly that study in conjunction with others was most interesting and desirable; while, at the same time, he could not be blind to the fact that many studied best and most thoroughly when alone. It therefore was an important point to discover as to the best mode to adopt individually. There was a certain amount of knowledge necessary before joining an association or class, with any benefit to the student himself or his fellows; and this must be obtained in private. The reason of this obviously was, that the subject brought forward would not be comprehended without some amount of previous study, without which, instead of gaining any benefit by attending such class, the results would be a loss of time and disappointment. On the other hand, he thought that the student who had given some little attention to the rudiments of the various subjects in home study would find that associated study was most profitable. As regarded the preliminary work, he considered the man who had mastered Weale's rudimentary treatises, or works of a similar character, was possessed of sufficient attainments to make his association with others advantageous. He begged to read an extract from Mr. T. Roger Smith's paper:—

"I believe it quite worth any student's while to join the Association for the Class of Design only, and I very strongly urge it upon the attention of you all; adding to my hearty recommendations that you should join it, the one caution, that you should in working out its subjects embrace every opportunity of showing the plans and some of the details as well as the general outline of your design, not contenting yourselves with a showy sketch, but working it more or less as though the drawing were to be built from."

He (Mr. Mathews) thought that one of the advantages in association was, that a man had opportunities afforded him of making friendships and securing associates of his own age. Another and important advantage was, that it kept a man up to his work, as young men were often inclined to "shuffle" their work. Another advantage was that by association they were mutually instructing each other. Each man ought to feel that he had a share in assisting the advance of the particular class to which he belonged. It was very easy to sit in a room with a number of others, and listen to a lecture; but the question was, did instruction simply by lectures produce the impression which was necessary? Doubtless attendance at lectures was very desirable but it must not be considered everything. It required to be followed up by private and associated study. He (Mr. Mathews thought it would be advantageous if members of classes were each to select a certain book on the subject to be studied, make extracts therefrom and read them to their fellow students, by which means they would have a collection of opinions, which while grounding each student in his work, would be advantageous to the other members of the class. He commended this idea specially to the members of the voluntary examination class. It was by this exchange of thought that ideas were formed in their minds, and the necessity of thus exchanging thoughts with others should be kept in view by everyone, from the beginning to the end of his life. One other advantage was, that a man could understand much better what he studied, seeing there were points that would appear difficult in private study which by the help of others would be made comparatively easy. Mr. Mathews remarked that great attention ought to be paid to minor points in the course of study. As they got older they would find that the things which now appeared trifling were the very ones which mastered them afterwards. Questions on trifling points were often asked by clients, and it was most embarrassing to have to confess that the little things had not been so closely studied as they required. Adverting to the necessity of association, Mr. Mathews said, every man must have companions. The greater number of the pupils in London architect's offices came from the country. They were frequently unacquainted with anyone in London. Perhaps their fellow pupils in the office were not of the kind they desired for companions. If such young men joined an association, such as our own, they met men of their own age and calibre with whom to form intimacies. Acquaintanceships were frequently formed under such circumstances which were lasting throughout their lives. If a man made a suitable choice of companions it had a beneficial influence upon the formation of his character for the remainder of his career. Again, a most important quality which association tended to educe was perseverance. In whatever line of life a man might determine to walk, perseverance was a most necessary quality. By contact with others in classes a spirit of emulation was awakened, which urged men on to persevering study. This spirit of perseverance would not be so active if the sudent were to study alone. He (Mr. Mathews) would not deny that there were some disadvantages incident to associated study. In so large a place as the Metropolis there was often a long distance between the student's residence and the place of meeting, and it might be said that the student could improve the time better at home in private study than by wasting it in taking a long journey. He admitted there was a loss of time, but still he thought that, all things considered, the advantage was on the side of class attendance, especially as there was a possibility that if the student stayed at home he would not study at all. Another point which, to those engaged in class study, required to be guarded against, was a tendency to have no decided opinions of their own, but to be content to follow those of the majority of students. This could only be obviated by independent thought. Every one must make up his mind, and decide for himself what was true and right, and ought not to allow himself to be swayed from his carefully formed opinions without very good reasons. Mr. Mathews concluded by urging upon students the necessity of perseverance, zeal, and love for their work, as without these it would be useless to follow out their profession. These qualities were especially desirable in the attendance at classes, which must not be fitful, but regular. If they were not zealous, and had not love for their work, they could not hope to succeed, and in expressing this opinion he was sure he should be backed up by members who were older and had far more experience than himself.

A Member referred to what Mr. Ridge had said, regarding the benefit to be obtained from studying modern buildings, and said he thought such a practice would be considered "prigging:" nobody, of course, would appropriate the entire design of a building, but architects might accuse students of stealing their details.

Mr. T. R. Smith said it was gratifying to find that the Association had determined to fill up a vacant evening, by discussing such an important subject as they were considering, and gratifying to himself because his paper had been made a sort of groundwork for the discussion. He did not propose to say much on points that had been dwelt upon by other speakers, but would point out that the range which the discussion had taken showed how very much they had to learn. There were many things with which students of architecture ought to make themselves acquainted, as an absolute necessity, and many things which without being essential would yet be very advantageous to know. There were, in truth, but few kinds of knowledge or attainment which the architect would not find of advantage. If this was the case, it was clear they ought to work constantly, beginning early in life, and neglecting no kind of study which would be beneficial to them in their career. He advised that they should never miss any chance which might offer of learning anything which affected their profession. They should bear in mind, moreover, that their time was limited, and if they wish to make their studies successful they ought to classify the objects of study, and pay most attention to those subjects which were of most moment. Mr. North had well pointed out the importance of a thorough practical knowledge of the constructive part of the profession. To those who could do it, nothing was better than passing some time in a workshop or on the scaffold. But the most important and chief part of their duty was the study of architecture *as an art*—as a fine art, as a constructive art, and as a science. They ought to know architecture as a skill—as a trade, as a business; but above all that, they ought to know it as a fine art, a mastery over which, was the highest point to attain. It was impossible to know the art, unless they understood the structure and materials, and the purposes for which they were intended; but they might know all that, and still fall short of practising architecture to the best purpose, fall short of the power necessary to make themselves a great name, and to produce buildings which should be a credit to the country and to themselves. He should therefore be very glad if the students would set before them the duty of studying earnestly those things which bore upon the artistic part of their profession. They should no doubt study buildings both ancient and modern; but if they studied modern buildings, he advised them to study only good ones. There were only a few good, and very many bad, among modern buildings. But whether ancient or modern buildings were studied, students should ever keep their hand and their eye constantly alive to all that bore upon architecture as a fine art; for this reason, that he urged the importance of early attaining great excellence in drawing. There were some things which could be learned late in life, such perhaps as the power of fluent talking. But whatever required much study, required to be learnt in the first twenty or twenty-five years of a man's life. Few learnt languages after that age, and few had much skill in draughtsmanship who had not attained that skill by the time they had reached that age. It was therefore most important to study early, in order to gain skill with the pencil, and they should make this a very prominent aim. Notwithstanding what one gentleman had said to the contrary, he was himself convinced that entering an office with some skill in free-hand drawing was a great advantage. When they got into an office, their time was of course taken up by technical matters, and the opportunity of there learning the higher parts of draughtsmanship was rarely great. Their preliminary knowledge would therefore to a great extent fix the amount which they could afterwards attain. At the same time he did not consider that fine draughtsmanship would of itself alone make a young man a good architect. The architect's business was not to draw fine buildings, but to build them, and the reason he (Mr. Smith) laid so much stress upon drawing was, that they might be able to draught their own designs, and to shape and communicate to others their own ideas. Then they required to be well acquainted with the constructive part of the profession. They ought to know the effect which the features introduced into their designs would have when erected. Unless they understood a great portion of the technical knowledge which the workmen had, they would not be able to get satisfactorily executed. For this reason a structural knowledge of buildings was indispensable. But if it could be said that of two equal things one was greater than the other, and if structural knowledge and artistic knowledge were the two things of equal importance, he would say that artistic knowledge was greater than structural knowledge. It was of great importance to students that they should avail themselves of any machinery which was set in motion to assist them. They would find the machinery of classes of great help. The reason why, with only moderate ability, men who had passed through a good school and college often succeeded remarkably well, was that there was such an admirable system of machinery to assist in developing their powers. The systematic arrangements for the study of architecture in the present day were few and imperfect, and he thought this in one respect an advantage. Self-reliance was thus developed in the young architect. There was a disadvantage in a perfect system of machinery for education. It tended to produce a large number of architects of the same pattern. He (Mr. Smith) had been struck with the uniformity of the most recent architectural work in Paris. One cause of this was, no doubt, the very complete academic system of architectural education there, one natural result of which was that the architects all designed very much in the same style. He was sure that the buildings designed by architects in the reign of Napoleon III. could be recognised as of this era, and dated to within a year or two, two or three hundred years hence, by future archæologists, if the buildings remained till that time. This uniformity was greater than would suit the genuis of the British nation, or of British architects, and showed the bad results of too much machinery. But still some sort of educational machinery was requisite, and he thought the students owed a vast deal to this valuable Association, for the efforts which it had made to supply this want.

The Chairman had found Mr. Smith's paper so exhaustive, that he was glad his position did not require him to say much on that occasion; he would only venture on one general remark, namely, that the young architects must not be in too great a hurry to make their studies remunerative. There was so much to learn, and so much to be thought of, that one felt quite overwhelmed, until the requirements of business recalled one to a practical state of mind. He considered the discussion had been very good, and hoped that the evening's debate would lead to the earnest study of professional duties.

At the meeting on the 20th ult., the following notices of alteration in the rules of the Association were given. The alterations to be considered at the special business meeting, on the 4th. inst.

Proposed by Mr. T. R. Smith, and seconded by Mr. Lewis, that in the rule No. 4, the words "two vice-presidents" be substituted for the words "vice-president" and that in rule 5, the words "more than" be inserted next before the words "two successive years."

Proposed by Mr. Ridge and seconded by Mr. Florence, as an amendment on the proposed alteration of rule 5, that that rule should stand thus, "The office of president cannot be held by any member for two successive years, or that of vice-president for more than two successive years.

LONDON STREETS.*

The difficulties and dangers of our streets, about which so much has, during a century and a half, been said and sung, are again the theme of many voices. If we were not the grave and deliberate people that we are, if our constitutional immobility did not at inconvenient moments still betray the eastern origin of our race, we might trust that the reformation in our thoroughfares, which has so long been demanded by sage and satirist, would set in with a swift and steady tide. We have in *Trivia* a lively treatise on the Art of Walking in the Streets of London, much of which might be given in sober earnest now. Many of the old evils, often too in the old spots, may yet be found surviving Gay's satire, and terribly vital still. In spite of all that has been done of late years tending to the improvement of our streets, we are driven to ask whether our works of public utility are keeping pace with our advancement in intelligence, in numbers, and in wealth. One of these powers has indeed been steadily demanding for itself a larger measure of regard. Numbers have an inexorable logic, and now that we are proved to have packed ourselves so closely that there is not alone the certainty of interruption in our business, but a very appreciable risk of making an end of our business and ourselves once for all, it is likely that reform may be thought about in earnest. For if we are to believe that increase of population, of business, and of intelligence, must produce a proportionable decrease of comfort, convenience, and safety, it may be worth considering whether the attraction of the people towards towns is not a mistake. If the increase of wealth upon a given area renders the people less able to provide for themselves that facility of intercourse which is one of the great advantages of wealth, it may seem that a little more repulsion amongst the atoms of population would be wholesome permanently, as we know it to be temporarily agreeable.

We know however that there is no necessary connexion between commercial prosperity and public inconvenience. That to keep the thoroughfares of London in a state of cleanliness and convenience very much in advance of their present condition, is a matter quite within the reach of its wealth, and the skill of its public officers. Will those who represent the tax-payers have the courage to say that this necessary work shall be done, or must we wait till some wise and strong government shall take the management of their affairs out of their hesitating hands? The evils of our present condition are too patent, and have been recognised too often in Parliament and in public, to need formal proof here, but it is not often that we have from competent authority a clear analysis of the processes by which people proceed to elbow each other out of comfortable existence, and a plain statement of the results and the needful remedies.

Mr. W. Haywood the engineer to the Commissioners of City Sewers has in his report to the Commission given such a treatise on the state of the city and its wants in respect of highways. It is one of those reports which during several years have occasionally come from the same hand, and treating of various questions pertaining to the health and comfort of the community. We have here the views of the responsible officer of a governing body which has interests of unequalled magnitude under its charge, and the value of those views is not diminished when it is seen that they are given without that reserve and circumlocution which are erroneously supposed to be peculiarly official.

London City is only the core of the Metropolis, and Mr. Haywood does not sever it entirely from that of which it is but a part, though in many respects the most important part. He treats first of the Metropolis and its great centres of traffic. Then of the City proper, and the great streams of traffic which set in towards it. Lastly, of the improvements that are needed to meet its necessities. The extracts which follow will show how he deals with these matters.

"In order to take the broad and comprehensive view which the subject demands, I must refer to the whole Metropolis, for I shall be enabled to show that a large portion of its inhabitants have the most direct interest in the City, going to and from it daily, spending within its limits the largest portion of their active life, earning therein their livelihood, and forming the bulk of the traffic which encumbers its streets. It is, indeed, for the convenience of this vast multitude, which resides in the Metropolis solely because of its contiguity to the City,

* Report upon the Traffic and Improvements in the Public Ways of the City of London. By William Haywood, M. Inst. C.E., F.R.I.B.A., Engineer and Surveyor to the Honourable Commission of City Sewers. March 23rd, 1866.

and selects its residences mainly with the view to the facility with which the City can be reached, that improvements in the thoroughfares are principally needed.

The population of the Metropolis was, in 1801, 958,863; 1811, 1,138,815; 1821, 1,378,947; 1831, 1,654,994; 1841, 1,948,417; 1851, 2,362,236; 1861, 2,803,989.

From these figures it will be seen that the total population in 1861 was three times that of 1801, it having trebled itself in 60 years.

By the same figures it may be calculated that the metropolitan population doubles itself in about forty years, and this has been the rate of increase since the beginning of the present century—those sixty years cover periods of commercial distress, political disaffection, long exhausting wars, famine and pestilence, and all those agencies which might have been expected to retard its growth, and this may therefore be fairly assumed as the rate of increase at the present day.

The question of population may, however, raise much speculation, leading to views adverse to those herein set forth, for such adverse views have been frequently expressed during the last thirty years (and probably at all times), but experience has hitherto been uniform in its contradiction of them. It is possible, no doubt, that they may at length be true, and that all other views as to the future of the Metropolis may prove to have been false, but the practical method of dealing with a matter of this kind is to use the experience which is clearly before us, rather than depend upon theories which, however plausible, have hitherto proved fallacious.

Now the population in 1865 was computed to be 2,993,513, which in round numbers I will call 3,000,000, therefore in forty years hence it may be expected to be 6,000,000, and it is for the wants of this future, as well as for those of the present community, in respect of highways, that provision must now be made. . . . . .

Now should the population double itself in the next forty years, the mean annual rate of increase during that period will be about 75,000, and at the expiration of the forty years, perhaps forty or fifty square miles of open country will be covered, more or less closely, with homes for the additional three millions of inhabitants which will then exist.

But there are other causes which have arisen of late years, tending largely to disperse and radiate that part of the existing population which is above the operative classes, the principal agency being the facilities for transit offered by railways. The tendency of that class undoubtedly is to seek cheaper residences and a purer atmosphere, and, consequently, to encroach still farther upon the open area now round the Metropolis, so that, probably, sixty square miles of open country, if not a considerably larger area, will be covered and occupied forty years hence, or by the time the population reaches 6,000,000.

For facility of access to the City, a large portion of that population will settle down as near to it as possible. It has been seen that the districts in the centre are already densely inhabited (and indeed the suburbs within a radius of 2½ miles from Blackfriars-bridge are now closely populated), therefore the thickly populated area will annually extend farther and farther from the commercial centre, and the means of transit, unless ample provision be made at once, will be more and more difficult to obtain. As economy in time is of the highest importance in a commercial community, this difficulty must be obviated as far as possible, and should be well considered and arranged for at the present day. This is a subject requiring the immediate attention of the rulers of the Metropolis.

Had the metropolitan authorities foreseen in past years this vast augmentation of population, they might have provided, at but small comparative cost, larger and more convenient highways to meet the exigencies which have already arisen or must soon arise. As matters stand, it is probable that relief must be sought mainly in the construction of lines of railway to carry the suburban traffic. These railways have been termed, not inaptly, omnibus lines, as they carry that class of traffic which previously to their introduction had been carried mainly by omnibus; and these lines must be at least co-extensive with all the main lines of highway out of London, and should be laid out upon a more complete and comprehensive system than has hitherto been attempted.

But although railway conveyance must soon be used to a large extent by all classes of society in the Metropolis, and will no doubt supply in a greater degree the means of transit as the distance of the inhabited portion extends farther from the City, it will never obviate the usage of other vehicles. For, as the wealth of the Metropolis increases, indifference to expenditure increases also, and the employment of cabs and carriages of other descriptions, which give a convenience and luxury that a railway cannot afford, will be still greater than at the present day. Although, therefore, railways must prevent the vast and rapid increase in public vehicles which otherwise would be an absolute necessity, still the vehicular traffic will increase, and it is for this that provision must be made in the highways and thoroughfares of the Metropolis, ande specially in those which lead to or are within the City, or such as may relieve the City from traffic needlessly passing through it.

Indeed, highways and railways should be considered together as one question, for they are now concurrent necessities which may be made to assist each other greatly. It is a subject so pressing, that not a day should be lost in entering upon the consideration; to delay is to ignore the teaching of the last half century, and to diminish the chance of remedying the insufficiency in the thoroughfares, which is greater than in any metropolis or town in Europe.

It is not, however, needful to enter into the question in its fulness here. It is sought only in these preliminary remarks to draw attention to broad indisputable facts, which, in their future effect upon the metropolitan traffic, have never yet been sufficiently appreciated; to show the vast population which is in the advent; the large area of ground it must cover with its habitations; the increasing distance those habitations must be from the centre; the traffic the population will generate; and the necessity which therefore exists for well-designed lines of highway to meet its requirements.

I now proceed to show how the City in respect of traffic will be affected by this population. . . . . .

The Great Centres of Traffic.

There may be said to be two centres of traffic in the Metropolis the governmental centre, and the commercial centre; the one being at Westminster, the other within the City.

The governmental centre comprises also what may be termed the centre of pleasure. It comprehends the quarters inhabited by the nobility, gentry, and wealthy classes of England, and those attracted to the Metropolis during the London season by parliamentary business or for amusement; and is thus localised by the position of the royal palaces and the Houses of Parliament. It has its own special traffic at all times, but its more important traffic has but a season, and that season is determined by the sitting of the legislature.

The commercial centre of the Metropolis is the City, and the spot of most importance within its limits is the Bank of England, which is usually, but erroneously, thought to be the point to which all the traffic of the City gravitates; it is, doubtless, the point to which all commercial transactions must tend, and to which, periodically, most of the business men of the Metropolis and City wend their way; but much of the daily traffic either does not go to the Bank, or, if so, only because there are at present no other main lines which public vehicles can take excepting those which approach it, and these therefore still present, with all their encumbrances, the best route to and from the various places of business.

I now proceed to the consideration of the elements which contribute to the traffic of the City, and the conditions under which it moves within the City.

Area, Population, Thoroughfares, and Traffic of the City.

Area.—The area of the City, within the muncipal limits, is 631 acres, or nearly one square mile. According to the divisions of the Superintendent Registrar of Births and Deaths, the area is 725 acres; deducting the water, 67, there remains of land 658 acres. This is 27 acres in excess of the true area of the City, and the population returns here used refer to the larger area; the areas and statistics of the thoroughfares must, however, necessarily refer to the true City area of 631 acres.

Population.—The population of the City was as follows at the periods given:—In 1801 the number of inhabitants was 128,833; in 1811, 121,124; in 1821, 125,065; in 1831, 123,608; in 1841, 124,717; in 1851, 129,128: in 1861, 113,387.

It was, therefore, nearly stationary for a period of fifty years, but at the last decennial period was manifestly decreasing, and was, perhaps, lower than it had been for centuries.

The population of 1861 was lodged in 13,431 houses, which is at the rate of 8½ inhabitants to each house.

For the purpose of this population, and of all the traffic which belongs to it, the thoroughfares of the City would be more than sufficient. It is obvious that it is not for their accommodation that improvements are needed, and yet the smallness of the area of the City, and the smallness of its sleeping population in comparison with the whole Metropolis, are not unfrequently dwelt upon by those who find it convenient to estimate the City's importance according to the space it fills in the Census Tables, and the number of square yards of ground it covers.

Nor will the sleeping population increase, inasmuch as the demand for space for commercial purposes, and the construction of new streets, markets, and public buildings, will gradually and fortunately sweep away the houses which are now so densely inhabited. In their place will arise vast warehouses and structures full of human life in the day, and all but tenantless at night, and each succeeding census for many years to come may be expected to show a diminution in the City population. The traffic in the City is, therefore, not materially caused by, nor is it likely to be augmented by its sleeping population.

The present sleeping population, therefore, neither represents the actual population, nor the vastness of the City in any respect; for it is mainly composed of the poorer classes, or of those left in charge of the various premises, and year by year it will be less a representative of the City in any way, although its diminution will indicate the security the merchants and traders of the City enjoy in being able so to leave their vast property to the protection of the City police.

The public ways may be divided approximately, as follows:—7 miles of main thoroughfare, 28 miles of collateral thoroughfare, 15 miles of minor streets and courts, alleys, passages, &c. There were in 1860 altogether 48 points of inlet to the City, the total traffic of which was, on certain days, taken by the police. Of these inlets, 3 were bridges, 33 had carriageways and footways, 3 had footways only, 6 were steamboat piers, 2 were waterside stairs, 1 was a railway station; total, 48. At the present time there are four additional railway stations which are inlets, but, as no general enumeration of the traffic of all classes has been made since 1860, I must herein refer to the traffic, and the conditions affecting it, as they existed in that year.

The total number of persons entering the City upon a day in May 1848, between 8 a.m. and 5 p.m. (a period of nine hours), was 315,099. The metropolitan population in 1850 was 2,240,289, and may be assumed in 1848 to have been, in round numbers, 2,200,000, thus there entered the City, during a period of nine of the busiest hours of a day, in 1848, a number equal to one-seventh of the whole metropolitan population. In May 1860 (twelve years afterwards), the traffic was again taken, and it was found that, during twenty-four hours, the total number of persons entering the City was 706,621. No means now exist of separating this return, so as to arrive at the number which entered the City between 9 a.m. and 5 p.m., and an exact comparison with the return of 1848 cannot be made. I take, therefore, the return between the hours of 7 a.m. and 7 p.m., in 1860 (twelve hours), when there entered the City 527,636 people.

Now, in 1860, the metropolitan population was estimated at 2,829,130; therefore, during twelve of the busy hours of a day in that year, there entered the City a number of human beings equal to nearly one-fifth of the whole metropolitan population. And as the total number which entered during the twenty-four hours was 706,621, it was equal to one-fourth part of the whole metropolitan population.

As the traffic has increased since 1860, it may be computed that there now passes into the City daily three quarters of a million of human beings, and that the same number passes out at night, leaving but its residential or sleeping population of 113,387; and this vast daily influx is equal to one-fourth part of the whole metropolitan population, and equal to the combined population of the parishes of St. Marylebone, St. Pancras, St. George's, Hanover-square, Islington, and Lambeth, as they existed in 1861.

Comparing it also with the population on the registration districts of some of the largest towns in the United Kingdom in 1861, it was equal to nearly three times the entire population of Liverpool, more than three times that of Birmingham, four times that of Manchester, and added to the sleeping population, to more than the total population of Dublin, Edinburgh, and Glasgow combined. And this is the true population of the City, for although not residential, most of its waking existence is spent within the City limits, and it comprises mainly the owners of the City property, and the creators of its wealth, importance, and traffic.

Vehicular Traffic.—The great impediment in the streets is owing to the vehicles, therefore consideration must now be specially given to that branch of the subject; and as a general opinion upon this point may be best formed by bringing to your notice the large increase which has taken place upon the thoroughfares of the City, despite the relief which has been given by the construction of new lines of street and railways, I append a table showing the traffic at important points at periods fifteen years apart:—

Situation.	Width of Carriage-way at point of observation.		Total in 12 hours.		Increase since 1850, per cent.
	ft.	in.	In 1850.	In 1865.	
Aldgate High-street	57	6	4·754	8·376	76·18
Aldersgate-street, by Fan-street	30	8	2·590	3·936	51·96
Bishopsgate-street Without ..	22	2	4·110	7·366	79·22
Blackfriars-bridge	28	0	5·262	9·660	83·58
Finsbury-pavement, by South-pl.	41	7	4·460	6·715	50·56
Fleet-street, by Temple Bar ...	23	8	7·741	11·972	54·65
Holborn-hill, by St. Andrew's Church	35	3	6·906	9·134	32·26
London-bridge	35	0	13·099	19·405	48·14*
			48·922	76·564	56·50

The total number of vehicles which passed over the bridges in twenty-four hours, according to the latest observations in my possession, was as follows:—London-bridge, 25,960 vehicles, in June 1863; Southwark-bridge, 1094; Blackfriars-bridge, 10,653.

By the foregoing table it seems that the mean increase of vehicular traffic at the eight principal City inlets was 56·50 per cent. in fifteen years; whereas, during the same period, the metropolitan population had but increased 33·62 per cent.: the rate of increase in vehicular traffic was, therefore, far greater than the rate of increase in the population of the Metropolis. . . . . .

* Since Southwark bridge was opened toll free.

Pedestrian Traffic.—The question of the accommodation for the carriage traffic must always take priority in such considerations as the present, because it is that which suffers most from the want of space, not having, from its very character, the power of adapting itself to circumstances, which the pedestrian traffic has; yet travellers in vehicles in the City are as but one to every three on foot, and almost everyone is at some period a pedestrian in the City; their comfort and convenience when on foot should therefore not be forgotten. . . . . .

The circulation of pedestrian traffic when within the City may be seen by reference to observations made in other places in 1863, when between 8 a.m. and 5 p.m. the following number crossed over the carriageways of some of the principal thoroughfares:—At the junction of Mansion House-street, Princes-street, Threadneedle-street, Cornhill, and King William-street, there crossed over in various directions 56,235 persons. At the junction of King William-street, Cannon-street, and Gracechurch-street, by the King William Statue, there crossed over in various directions, 42,395; at the junction of Ludgate-hill, Fleet-street, Farringdon-street, and New Bridge-street, there crossed over in various directions, 37,075; at the junction of Cornhill, Leadenhall-street, Gracechurch-street, and Bishopsgate, there crossed over in various directions, 28,080.

The foot traffic is therefore more vast numerically than the carriage traffic, and its activity and circulation in all parts is more surprising: and although stoppages do not actually take place through the aggregation of the foot traffic, nevertheless the discomfort in some places is upon ordinary occasions considerable, and on wet days (there are 157 days annually upon which rain falls more or less in London) the discomfort is very great.

In most of the streets in the centre of the City the footways might be widened with advantage, whilst in others a widening is essential for celerity of movement as well as for safety; and of some few thoroughfares it may be said, that if the whole of the carriageway was turned into footway, it would not more than comfortably accommodate the pedestrians.

Composition of Traffic.—Of the traffic generally, some passes through the City on its route to other parts of the Metropolis; another portion stops but for a short time within it; but the largest number of persons are some hours therein transacting their business, or pass the whole day within its limits.

On consideration of the foregoing figures, the vastness of the City traffic, both pedestrian and vehicular, will be seen and appreciated; the conditions under which it moves within the restricted thoroughfares of the City will be understood; and the necessity for extensive improvements will be admitted.

It will also be clearly seen that the traffic for which increased convenience in the public-ways is needed, is not due alone to the residential population of the City, but is generated mainly by that large section of the metropolitan inhabitants to which the City is a place of daily resort.

It is not, however, confined to those, but varies in its constituents, and comprises all classes of society, from the highest to the very humblest in the social scale. Thus there are 68 Members of Parliament who have offices within the City, and are to be found there daily throughout a large portion of the year, and many other Members of Parliament have business interests in the City, even although they nominally have no occupation there. And of that large class who are directors of the commercial undertakings which must have a home in the commercial centre, there are 56 Peers of the Realm, 132 Members of Parliament, and altogether as many as 589 titled and distinguished personages, whose directorial duties bring them frequently within its precincts.

It may be said, then, that the City is the scene of the daily labour of hundreds of thousands whose homes are in the Metropolis, or even far beyond its broad area, and that within the City are the centres of the industry and commerce of almost the whole country. For although there are other places in England which are the homes of special industries, and of a special commerce, there is scarcely a manufacturer of note, or merchant of celebrity, in the whole nation, who has not his office or his agent in the City, and does not at times visit it personally, and it is this combination of interests that causes the vast traffic which daily fills it.

Yearly this traffic has increased, and yearly it may be expected to increase, for the same influences are operating which have created it; and if it should continue to augment only in the same ratio as the metropolitan population (and it has hitherto exceeded it), then in twenty years hence the daily influx to the City will be more than a million, and in forty years a million and a half of human beings; and, therefore, if for the wants of the present traffic alone improved thoroughfares are needed, how much provision should be made for the future? The whole Metropolis, and in a degree the whole of England, is, indeed, interested in this provision being made.

The Great Streams of Traffic.

There are various currents of traffic in the City, but the whole may be said to move chiefly upon two lines—first, that passing between the north and south; second, that passing between the east and west.

These may be subdivided into several smaller streams of traffic, but, however many the inlets to the City, the traffic entering by them, before it reaches its destination, is nearly certain to mix with one or other of the larger streams. The direction and composition of the several streams of traffic and the conditions under which they are formed, must therefore be inquired into.

The north and south traffic is divided into three principal streams—that which passes over London-bridge; that over Southwark-bridge, and that over Blackfriars-bridge.

London-bridge with its approaches is the most important, and constitutes a line which, next to the east and west line, is more inadequate to the public wants than any thoroughfare in the Metropolis. London-bridge is the only roadway across the Thames, for the population of a great area stretching far away into Essex on the north side, and Kent on the south side of the river; it is true that part of this population might go to the river banks and cross over in boats, but the vehicular traffic must pass by the way of London-bridge.

East of a straight line drawn five miles to the north and five miles to the south of London-bridge, are comprised the following metropolitan districts:—On the north side—Bethnal-green, Blackwall, Bromley, Bow, Dalston, Hackney, Haggerstone, Homerton, Hoxton, Kingsland, Limehouse, Mile-end, Plaistow, Poplar, Ratcliff, St. George-in-the-East, Shadwell, Shoreditch, Stamford-hill, Stepney, Stoke Newington, Stratford, Upper and Lower Clapton, West Ham, Whitechapel. These districts in 1861 had a population of 667,000. On the south side—Bermondsey, Camberwell, Deptford, Dulwich, Greenwich, Lee, Lewisham, New Cross, Peckham, Rotherhithe, St. Olave, Southwark, Sydenham. These districts in 1861 had a population of 282,000.

The combined population north and south was, therefore, 949,000; and is now probably fully a million, or equal in numbers to one-third of the metropolitan population; and to this must be added districts to the west of the line, and others further to the north, south, and east, for which London-bridge is the only highway over the Thames. In all of these the population is fast increasing, and in some of them faster than in any other districts of the Metropolis.

The north-east and east will indeed probably be the home of much of the future industrial population, and the south and south-east will be equally occupied by those who form the great body of the commercial community of London. These will generate a vast traffic of pedestrians and quick moving vehicles, whilst for miles down the river on either bank, docks, warehouses, and manufactories are multiplying and creating traffic of a cumbersome and slow character.

For the traffic of this great community, already equal to four of the largest towns of England, there is but one bridge or highway over the river, having a width of carriage-way of 35 feet, and a total width of but 54 feet.

In the year 1850, the vehicular traffic passing over London-bridge between the hours of eight a.m. and eight p.m. was about 13,000, in 1860 it was 16,000, showing an increase of about 23 per cent. in ten years.

Now in September 1860, the Brighton Railway Company opened its line to Pimlico, and much traffic which at that time passed over the bridge was diverted, and to this day it continues largely to prevent traffic from passing through the City.

In the year 1864, the South-Eastern Railway Company's extension to Charing-cross was opened; that also effected a diversion of traffic from London-bridge, and has continued to do so, inasmuch as at the present time three-fourths of the whole of the continental and Hastings traffic of that railway is booked at the Charing-cross terminus.

New Southwark-street was opened from the Borough to Southwark-bridge-road early in 1862, and to the Blackfriars-road early in January 1864; it gave a shorter and unimpeded route to the west and north-west of London, and immediately developed a large traffic. This traffic in November 1865, had reached 5700 vehicles, which comprised many that would have passed over London-bridge had this new street not been formed.

On the 8th of November, 1864, Southwark-bridge was opened toll free; previously to that date its traffic had scarcely ever reached 1000 vehicles daily (8 a.m. to 8 p.m.), but it almost immediately rose to 3000, and in November 1865, had reached 4700 during the same hours; this is an increase of 3700 vehicles daily, a very large portion of which was, doubtless, taken away from London-bridge.

Thus we have had the Brighton Railway extended to Pimlico, and the South-Eastern extended to Charing-cross; Southwark-street opened in 1864, and Southwark-bridge made free of toll at the end of the same year; all four causing the diversion of a very large amount of traffic from London-bridge; but, nevertheless, in July 1865, the traffic upon London-bridge was 19,400 vehicles, which was a larger number by 3000 than passed over it during the same hours in the year 1860, before either the railways, the new street, or the bridge had been opened. . . . .

At the present time, the whole line from St. George's Church, in the Borough, to beyond Norton Folgate, is, with the exception of the wide part of Bishopsgate-street, so encumbered with vehicles during the busy hours of the day, that it is impossible to proceed along it at a rate of more than four to five miles per hour; whilst between Liverpool-street and Southwark-street, the rate rarely exceeds three-and-a-half miles per hour, and as the population increases, and the traffic gets greater, even this rate of progress will not be obtained.

New Bridge and Approaches.—There is but one complete remedy for this, which is the formation of a new bridge or a tunnel, with suitable approaches, lower down the river than London-bridge.

A bridge so situated, with approaches opening for a sufficient distance, both north and south, would not only relieve London-bridge, but would relieve effectually the whole line of street from the Elephant and Castle to Shoreditch Church, as it would also ease Eastcheap, Fenchurch-street, Leadenhall-street, and many other thoroughfares of the City, and would prevent, in a large degree, the conflict which arises between the east and west traffic whenever they cross each other, afford great facilities for business, and an immense convenience to a vast and increasing population.

I am aware of the great interests which would be interfered with by the construction of this bridge,—I am aware of the large sum of money which would be required, although I believe that the cost is exaggerated in the minds of most; but whatever the interests may be, and whatever the cost may be, sooner or later a bridge or tunnel must be built lower down the river. Nothing else will effectually relieve London-bridge at the present day, and nothing else will satisfy the requirements of the vast population which will, within the next forty years, exist east of London-bridge, and it is to be hoped this necessity will be boldly faced at once, and not be postponed until the period when it will cost double the outlay now needed, however great that outlay might be.

The widening of London-bridge by throwing out footways on either side should be adverted to. This is physically practicable, although it could only be carried out to the utter destruction of the architecture of one of the finest bridges of Europe; it would not, however, help the difficulty of the traffic, as it is upon the approaches to the bridge on each side where the obstructions mainly take place. At both of those spots there is the confluence of several streams of traffic: the carriage-ways it is true are there not quite as narrow as the bridge itself, but they are subject to carts standing to load and unload, which the bridge is not; and, therefore, widening the bridge would be useless unless the approaches were made wider also.

The approaches include, on the south side of the river, the whole line from St. George's Church in the Borough to the bridge; and on the north side, the southern branch of King William-street, and the whole of Gracechurch-street and Bishopsgate-street Within; the cost of widening these thoroughfares alone would probably go far towards constructing a new bridge with proper approaches.

It is, however, fundamentally an error to make streets and bridges of very great width; large streets are more costly, they are also in one respect inconvenient, they lead to concentration of traffic, and if stopped or impeded (as at times they must be), the public inconvenience is very great—diffusion and not concentration of traffic should be the object in devising the thoroughfares of large towns—alternative lines give the most convenience—and as a principle it may be said that it is far better to have two bridges, each of 50 feet in width, than one of 100 feet in width, even if the cost were greater for the two than the one.

Mr. Haywood examines into the utility of Southwark-bridge, and gives his conclusions:

"It is not probable, therefore, that it ever will be so great a relief to London-bridge as some have anticipated, unless by the agency of police regulations enforcing its usage. Nevertheless, situated as it is in the midst of so dense a population, with its ever-increasing traffic, and forming as it does the only highway over the river between Blackfriars and London Bridges, Southwark-bridge should be purchased, and the toll be removed from it for ever.

Indeed, as a principle there ought to be no toll bridge in the Metropolis; directly the necessities are so great that another bridge is needful, it should be built out of the public funds; and with regard to the existing toll bridges, as far as to and including Vauxhall-bridge, they should be purchased, and the toll be taken off as speedily as possible.

It may be desirable to add a few words, specially with regard to the purchase of Southwark-bridge.

If the Corporation should be unable to agree with its proprietors as to price, application should be made to Parliament for power to take it compulsorily, and determine the basis of compensation, or the process by which it should be determined. The commercial value to its proprietors is not a difficult matter to arrive at, for it has been opened forty-seven years, yet has never paid one farthing interest upon its original capital, and but one-and-a-half per cent. upon its preference capital of £150,000, nor is there the remotest probability of its ever paying more, for the traffic that naturally accrues to it cannot be great; its gradients are bad, its width is small, and as years roll on the expenses of its maintenance may be expected to increase. On the other hand, eighteen months of freedom from toll leaves its present vehicular traffic under 5000 daily (its traffic previously being about 1000), and its footway traffic 12,300 in the same time (it previously being about 1400 per day); and the toll which might have been due from these would represent an extravagant estimate of its value to the public, inasmuch as it is clear that none of the additional traffic thought it worth while to pay 1*d*. or 2*d*. toll for the privilege of passing over it. With these conditions before us, and having due regard to its strength and permanency as a structure, it appears to me that a tribunal might be found to determine closely a just compensation to its proprietary. And if all measures fail by which the purchase can be effected at its true value, a new bridge, nearer to London-bridge, with good approaches, with good gradients, and ample width, should be built; and whether the proprietors of Southwark-bridge would then be entitled to compensation for what to them is almost a useless structure, is a point upon which I need not enter now.

THE EAST AND WEST TRAFFIC.—The traffic which passes into and through the City from the west may be divided into two streams, which ultimately lead it to and past the Bank. These may be termed generally the north-west and south-west lines of traffic.

The traffic of the north and north-west is collected by the line of Oxford-street and Holborn, and includes that from the districts which lie upon and beyond Bayswater, Edgware, Tottenham-court, and Gray's-inn Roads, and a large district lying to the south of the line of Oxford-street. Those districts comprise a vast area of residential property of the better class, inhabited mainly by those whose business brings them to the City frequently, if not daily. This traffic enters the City at Holborn, passes through Skinner-street and Newgate-street, and meets the traffic of Islington and Clerkenwell at the western end of Cheapside.

The purely western traffic is collected mainly by Piccadilly, and is joined at Charing-cross by the south-western traffic coming from Westminster and the districts which lie beyond the line of Victoria-street. The united streams of western and south-western traffic pass along the Strand, enter the City at Temple-bar, and pass through Fleet-street, Ludgate-hill, and St. Paul's-churchyard; then, with the exception of that portion which leaves the stream at Cannon-street, this traffic also arrives at the western end of Cheapside.

Now the whole line from Temple-bar to Cheapside is insufficient for its vehicular traffic; the line from Holborn-hill to Newgate-street is less so; but Newgate-street itself is so overcharged that it is already evident it should have been widened to seventy feet instead of fifty feet.

These two streams of western traffic, each of which is too great for the channel through which it passes, then meet, and are compressed at the western end of Cheapside into the one channel not very much wider than either of them separately, and thence the united stream struggles through the Poultry towards the Bank, throwing off or receiving, mixing, and clashing with the collateral and local traffic which meets it at right angles from the streets north and south of Cheapside. At the Bank a diversion takes place, one portion going by way of Leadenhall-street and Fenchurch-street, the other turning off by King William-st., to Eastcheap and London-bridge. Although somewhat relieved by this, yet, eastward of the Bank, the line of streets is barely sufficient, and the extreme difficulty and confusion recommences at the eastern ends of Cornhill and Fenchurch-street, and also of Cannon-street, where the concentrated north and south traffic of London-bridge meets the east and west traffic at right angles; and from thence to the City boundary, both on the Leadenhall-street, the Fenchurch-street, and Eastcheap lines, the carriage traffic through the busy hours of the day is frequently congested.

The traffic coming from the east enters the City at Aldgate, and proceeds by Leadenhall-street, Fenchurch-street, or Eastcheap (but principally by the first of these thoroughfares), across the City towards the west, by the lines of thoroughfare just described, mixing with the western traffic, and with it constituting what is denominated the east and west traffic, for which it may be said the whole of the lines of thoroughfare from Temple-bar to Aldgate Pump are inadequate.

Until within the last ten or twelve years, Cheapside and the Poultry were the only thoroughfares which were generally encumbered; they still retain their pre-eminence in this respect, but the whole way from Temple-bar to St. Paul's is now frequently in little better condition, yet Cheapside and the Poultry have had a large and special relief afforded to them by the widening of Cannon-street and the opening of Cannon-street West.

Cannon-street West was opened throughout in 1854. In 1863 it had, during twelve hours daily, a traffic of 5200 vehicles, and in 1865 close upon 6000 vehicles. This line of thoroughfare must, therefore, be a great relief to Cheapside and the Poultry.

Now, the railway extensions and the street improvements which have before been referred to as having kept down the increase of traffic on London-bridge, must also have relieved the east and west lines through the City, and therefore many sources of relief have been opened to them within the last few years. Nevertheless, in 1865, the vehicular traffic had since 1850 (15 years) increased at Temple-bar 54 per cent., at Holborn 32 per cent., and at Aldgate 76 per cent., nor is there any probability that it will not continue to increase.

The improvements which are needed to meet these exigencies are two new broad lines of thoroughfare between the east and west of the City.

The new street from the Thames Embankment may be considered as one of those lines of thoroughfare, and it will suffice as a relief for the western and south-western traffic to a certain point; but the north-western traffic will not be affected by it, nor will any of the thoroughfares east of the Bank be relieved by it.

A NEW STREET NEEDED.—Complete relief can only be afforded by the formation of an additional arterial line of thoroughfare through the City. Nothing else will permanently relieve Cheapside, the Poultry, and the eastern lines of public way. The formation of such a street, although in itself costly, would render needless many minor improvements, which otherwise must be carried out; would open up and render valuable property in districts now comparatively valueless, afford additional facilities for reaching the railway-stations in the City, reduce the inconvenience when other thoroughfares are stopped, enable the agency of the police in the direction of traffic to be largely dispensed with, and would be the best, the most permanent, and certainly, in the long run, the cheapest improvement which could be effected.

MINOR STREETS.—Having dealt with the two fundamental wants of the City traffic, which are a new bridge and north and south line, and a new east and west line, the minor requirements must be referred to. So numerous are they, that it is difficult to select the most pressing; for, indeed, it may be almost said, there is scarcely a thoroughfare in the heart of the City, which might not be widened and improved with both local and public advantage.

Of the subordinate lines lying east and west, Lower Thames-street is gorged for sixteen hours out of the twenty-four, and the same may be said of a large portion of Upper Thames-street during some part of the day; that line of street accommodates, however, but its own traffic. The Commission has already laid down a line of improvement for it, and is gradually widening its thoroughfare; a new eastern bridge would relieve Lower Thames-street.

The remaining through line east and west is that of Long-lane, Barbican, and Chiswell-street—barely sufficient at present, and yearly becoming less so; the large influx of traffic to the new market in Smithfield will render an improvement more speedily needful, and the whole line should therefore be made fifty or sixty feet wide forthwith.

Turning to collateral streets, such as Chancery-lane, Fetter-lane, the Old Bailey, Queen-street, Gresham-street, Houndsditch, and others, leading between the main east and west lines; the whole are more or less obstructed daily.

The same may be said of that large class in the centre of the City, which lie on both sides of the main line running east and west, such as Wood-street, Bread-street, and others. Within the last ten or fifteen years, some of these occasionally afforded relief to the main thoroughfare when encumbered with vehicular traffic; but they are now impeded with that which is due alone to the business carried on in them. Many of them are only wide enough for a single carriage, and this alone renders them comparatively useless to the general public.

With regard to the improvements in these streets, but little need be said, as they will, I believe, mostly be admitted as needful, when I refer to them—and I shall, therefore, simply place them in their proper order, in a subsequent section of the report."

The report then proceeds to treat of the new streets, railways, and other public works now in progress and likely to influence City traffic. The Thames Embankment and its continuation by a new street from Blackfriars-bridge to the Mansion House will ease the traffic of Fleet-street, Ludgate-hill, and St. Paul's-churchyard. Its effect upon Cheapside and the Poultry will be less decided, and it will tend to throw a large amount of traffic into the vortex at the Bank, and in a way that will increase the present confusion. The Holborn Valley Improvement will provide a level thoroughfare in the place of the dangerous hills about which the City authorities were becoming excited so far back as the times which preceded the old Reform Bill. The new Markets in Smithfield will eventually draw all smaller markets of similar character to that spot, and alter the direction of trade and traffic. The City Sewers Commission proceeds gradually with the widening of narrow thoroughfares so far as its powers will permit, and by setting back the frontage of buildings that are pulled down for commercial purposes. Newgate-street, Upper Thames-street, Great Tower-street, Ludgate-hill, and Fenchurch-street are some of the best known instances of works now in progress. The new railways will effect the most important alterations in the direction of City traffic. Of these there are eight which propose to open several new stations within the City, and considering that the area of the City is less than a mile, the possession of thirteen passenger stations, which will exist when these lines are completed, will be a great public convenience. Although several of these stations are rather objectionably near to each other in Liverpool-street, there will be no part of the City more than one third of a mile, and very few parts more than a quarter of a mile, from a station.

"The intercommunication between the lines will enable passengers to reach most parts of the Metropolis from any one station; the trains will be so frequent, that no one will think of consulting time tables, and although the speed may not be great, when compared with average railway speed, it will be double that of ordinary omnibuses within a radius of two or three miles of the City. The consequence will be that each station will become the centre which will attract most of the passengers within its radius. The approaches to each of those stations should, therefore, be made adequate, if not already so; but, in most cases, the approaches, when all the stations are opened, will be found sufficient, provided adequate main lines of thoroughfare are made within the City. Therefore, with regard to the authorised and existing lines generally, it may be said that they will be of the utmost value to the City; they have already supplied a public want, which must have been severely felt, and is manifest from the fact that the railway stations within the City have from 60.000 to 70,000 passengers daily; but the present convenience is but slight, when compared with that which will be given when the whole of the lines are complete, and every great trunk railway which radiates from the Metropolis has the means of bringing passengers into the heart of the City. And it must be observed that the railway companies, becoming by experience convinced that the great want of the Metropolis was communication with the City, gradually approached it, and at length projected railways within it; and the benefit of those already opened has been so fully appreciated, that no company can rest until it has the same facilities to offer its passengers as other lines—it is a necessity which they cannot avoid—and which can never be resisted ultimately. But, nevertheless, with all this convenience, and much as it will distribute traffic, the formation of new streets, and the widening of others, will undoubtedly be necessary. For facility of locomotion stimulates and augments traffic of itself: and thus, without reference to that due to the increase in the metropolitan population, an increased traffic to and from the City may be anticipated, whilst the rapid augmentation of the population, creating its own business necessities and a corresponding increase in traffic, will also add to this mighty influx to and circulation within the City; and it is this increase, never yet sufficiently appreciated, for which improvements in the City thoroughfares are still more needed.

There is some corroboration of this view in the fact, that although so much through traffic has been taken away from the City, and at the present time the City railway stations have, as before stated, between 60,000 and 70,000 passengers daily, yet the traffic in the streets has since increased, and vast as the usage of the metropolitan railways generally was during last year, yet the London General Omnibus Company carried 1,357,645 more passengers in 1865 than it did in 1864."

The Report then indicates the improvements which seem to be demanded to meet existing and probable requirements. These are of three kinds, viz., the formation of new lines of thoroughfare, the widening of existing lines, and improvements of a minor character.

For the relief of London Bridge and its approaches, a new bridge over the Thames is recommended This should be to the east of the Tower, and would need to be connected by suitable approaches with the great thoroughfares on the north and south of the river.

"By these roads an almost direct line would be formed between Shoreditch and the Old Kent-road, and the whole of the traffic which lies directly to the north-east and south-east of the City would cross the river by that road; this would include nearly the whole of the heavy dock traffic. There will be no difficulty in forming this bridge with good gradients. The cost of this work would doubtless be very great, principally on account of the compensation to the wharfingers. The wharf property would however not be valueless, even if vacated by its present occupants, and the removal of the special trades now carried on in the wharves and adjacent premises, even if needful at all, would leave room for the expansion of other business for which the site is adapted, and this would of course greatly reduce the ultimate cost. Billingsgate Market might be transferred to another site if that were found to be needful, and the question is worthy of consideration, whether, in the present day, the site for a metropolitan fish-market need be on the banks of the river at all? The sea-going steamers would not be able to come further up the river than the St. Katherine Docks; but, looking at the facilities which will shortly be afforded by metropolitan railroads, the inconvenience to passengers will not be made very great by such alteration. I however am quite aware that formidable trade interests would have to be disturbed, and that a section of the public must thereby suffer some inconvenience; but sooner or later such disturbance is inevitable, and after all it resolves itself into a question of compensation, and nothing more. A bridge might be constructed with a central compartment, to open so as to admit the passage of vessels up and down the river at certain stages of the tide; or it might be open to the public only from 7 in the morning to 7 at night, which are the hours when the great pressure is felt upon London-bridge.

A Tunnel.—Another mode would be to construct a tunnel at one of the spots named, but I apprehend that, if really convenient approaches were made to it, it would be more costly than a bridge, nor could it afford the complete convenience which a bridge would give. But the formation either of a bridge which could only be periodically used, or of a tunnel in lieu of a bridge, can only be regarded as half measures—such as have been too frequently carried out in the Metropolis, and which are unworthy of its vast population and of its vast wealth.

Steam Ferries might be useful lower down the river, but could hardly be used as a means of relief to the traffic of London-bridge. For at the spot where a bridge is needful, the river is so crowded with shipping, and with quick-moving steamboats, that the management of the large pontoons which would be necessary could only be attended with very great inconvenience, difficulty, and danger. Steam ferries are, indeed, but the expedients of a poor traffic and a small population.

This subject has been to me a matter of consideration for many years, and I am convinced that the construction of a bridge for ordinary communication across the Thames at or about the spot indicated, will alone materially and permanently relieve London-bridge and its approaches both north and south, and that sooner or later such a communication must be given."

The relief of the City thoroughfares as respects the east and west traffic is proposed to be effected by means of a new street extending from St. Sepulchre's church, by Newgate, to Whitechapel. This would go to the north of Guildhall and the Bank, and would be a continuation of the line of Holborn, leading in a straight course to the Whitechapel-road. It would also enter this road at the point where the Metropolitan Board of Works proposes by its Bill now in Parliament to make a new street to communicate with the Commercial-road. A glance at the map will show that this would form a direct route between the eastern part of London and the north and west.

"It would relieve Cheapside, and thus render any extensive improvement in that thoroughfare needless, and that which relieves Cheapside will also in a degree relieve Queen-street, Bread-street, Wood-street, and all the collateral streets running north and south from that thoroughfare. And although the Poultry should be widened, it would doubtless relieve that thoroughfare of a large part of its traffic. It would convert the narrow part of London-wall and Wormwood-street (which must otherwise be widened) into a broad thoroughfare, and thus in connexion with police regulation it would free Bishopsgate-street Within and Threadneedle-street of part of the traffic which now encumbers them, and would aid in dispersing the eastern traffic which may arise owing to the terminus of the Eastern Counties Railway being brought to Liverpool-street, as it would be but about 110 yards from that street, where at a future day there will be the stations or termini of four different railways. It would also relieve Houndsditch, and Aldgate High-street by opening up a new thoroughfare between the docks and the warehouses in the neighbourhood of Houndsditch. It would ease the traffic to and from all the railway stations lying to the north of it. In respect of distance, therefore, the new route would be superior to the existing one; in respect of gradient it would be as good as the present route; in respect of line it would be, for all practical purposes, straight; and upon the whole, therefore, it would be superior to the existing line from Newgate to Whitechapel; being broader, straighter, and shorter in distance. In laying out this line of thoroughfare, I tried to avoid public buildings as well as buildings of large commercial importance, but it was found impossible to do so entirely. Its formation would involve the destruction of Christ's Hospital, the Money Order Office in St. Martin's-le-Grand, and several large commercial buildings, and it would cut through a large quantity of miserable property at the extreme east of the City."

Many other improvements are recommended, such as new streets from the southern end of Farringdon-street to Holborn, near Hatton-garden, and to the end of Newgate-street. From near the western end of Upper Thames-street to Ludgate Hill, opposite the Old Bailey, which street should be widened. Many other streets are proposed to be widened, and lay-byes or standing places for vehicles, to be made on the sites of disused churchyards. As to the setting back of projecting buildings which are so inconvenient to traffic, we are told that—

"There is scarcely a street in the City which is not very irregular in its lines of frontage, in most of them also there are projections beyond the general line, which are more or less obstructive to the traffic. To remedy this, plans to a large scale should at once be made of all such streets. Lines of improvement should then be laid down upon them, and whenever a building is removed, the new line only should be built up to. This system should be adhered to strictly, and the plans be worked to without deviation. By such means, in the course of twenty years, with the large changes which must during that period take place in the condition of City property, a very appreciable improvement might be effected at a comparatively small cost. But to be effectual, I repeat, it must be carried out unhesitatingly."

In conclusion, Mr. Haywood alludes to other matters bearing on the question of street improvements, and of general interest to the inhabitants of the Metropolis. He says—

"I have endeavoured to suggest improvements commensurate, not only with the present wants, but also with the necessities of a future population, as, undoubtedly, a portion of the expense of present improvements will be cast upon a future generation. To plan and execute half measures, or such as are merely palliative, the results of which may perhaps be scarcely felt a dozen years hence, would not be sufficient, nor would it be just to those who may hereafter have to pay largely for them, and therefore I have suggested improvements of a comprehensive character, and, in two cases, such as will go far to meet the requirements of a great augmentation of the metropolitan population; and especially in the interest of the future population these improvements should be carried out at once, *for fifteen or twenty years hence they will cost double what they now would cost, great as the outlay might be.*

Exigencies in respect of highways will soon also arise in parts of the Metropolis far off from the City, and the formation of lines of thoroughfare leading from the centre of the Metropolis to the country, and of those subsidiary lines by which the fast growing suburbs communicate with each other, should no longer be left to chance arrangement, or to the caprice of individual landowners. And I must again repeat here a fact that cannot be too fully impressed upon you, that the population of the Metropolis doubles itself in forty years, and that the traffic towards the centre appears to increase in a greater ratio; so much so, indeed, that I firmly believe that the improvements I have herein suggested, large as they may seem to be, will not be adequate to the wants of the City by the time the metropolitan population is doubled.

In drawing up this report, many incidental subjects have naturally suggested themselves to me, upon which I beg to make a few remarks.

River Steamboat Traffic.—Considering the advantages which the river route between the east and west of the Metropolis possesses, in respect of celerity of transit, and of attractiveness, it is surprising that no successful effort has yet been made so to regulate the steamboat traffic as to obtain from it the full measure of benefit which it is capable of affording. Improvements have certainly been made in the City steamboat piers, yet there is scarcely one approach to them that is sufficiently public and sufficiently convenient, and this is the first thing in which improvement should be effected. The boats themselves are not of the handsome, cleanly, and convenient kind which should be made compulsory, and which would render them attractive to passengers and an ornament to the river, as well as more remunerative to their proprietors than they can be in their present unsatisfactory condition. There is no doubt that if these two conditions were improved, a larger steam-boat traffic might be developed, with advantage to the public, and benefit to the proprietors.

As to the Formation of New Streets.—The formation of a new line of street is frequently opposed by those owning property or business in the existing main lines, upon the supposition that the diversion of the traffic will be injurious to their interests. Should this even be the case, it must be observed that no individual has a right in the public traffic; and, moreover, when the traffic reaches such an extent as to create public inconvenience and loss, diversion is inevitable, and is generally foreseen and calculated upon many years before it takes place. In the majority of cases, however, no fear need be entertained of injurious consequences, for it is rarely that any street improvement is carried out in London, until business is actually suffering for want of such improvement; and at the present time the impeded condition of the main lines of City street, is undoubtedly a hindrance and impediment to the business within them, and the diversion of some of the traffic could not therefore be otherwise than a benefit to all; for every facility of intercourse with the City which is afforded to the metropolitan population. has a tendency to increase the traffic and increase the business. And the actual business in the streets so relieved in all probability will be greater after the relief, than it is at the present time.

When new lines of street are planned in the Metropolis, it has frequently happened that they are spoiled at some point by obstacles which should not be allowed to interfere with them; the impediments are usually the existence upon the proposed lines of public buildings, or the estates of great public bodies, or of men of great parliamentary influence, or they are the result of some small economy practised in the midst of a large expenditure. Such influences it is believed brought the northern end of Regent-street to its ugly junction with Portland-place; nearly spoiled the line of the Thames Embankment at its western end; now prevents the formation of the very best line of access from Trafalgar-square to that noble thoroughfare, and will leave in the middle of the new street from Blackfriars-bridge to the Mansion House, which is to be 70 feet in width, a length of 170 feet with a width of but 50 feet. In the City, the chief obstacles formerly were the Churches, which, being numerous, were in the way of every line of street which was projected. In some cases they were removed, as for the formation of London-bridge and its approaches, and the streets in the vicinity of the Bank of England, and the result was that good satisfactory lines of thoroughfare were formed. But where they were allowed to remain, and the streets were planned so as to avoid touching them, the thoroughfares have been utterly spoiled, of which an example is Gresham-street. The churches are still almost as numerous as ever, and are so situated that in every direction they prevent local improvement, and it is almost impossible to plan a new street or to improve an existing one so as to avoid them. But for a large and important improvement there would be perhaps less difficulty in effecting their removal than formerly was the case, for it has been shown that the residential population is decreasing, and the congregations in most of them will become less and less; and therefore new lines of thoroughfare in the City should not in the present day be injured for fear of interference with churches. Nevertheless, in laying down the line of the new east and west street, I have carefully avoided churches; but must again state that it would be very advantageous if four, which are immediately upon the line, were removed.

Police Regulations in Respect of Traffic.—In all the large capitals of Europe there are regulations for the guidance of traffic. In our own country they have hitherto been but slight, and it may be said, that when such strict police regulations are needed here that the free selection of route is denied to the driver of a vehicle, it is in itself a proof that the thoroughfares are inadequate. The enforcement of such regulations is always difficult, and is much resented by the public; it requires also the special attention of a police force, and is therefore expensive. It usually also implies a condition of traffic which is eminently destructive to the pavements, and therefore expensive; it involves the more frequent relaying and stopping up of the streets, and thus periodically increases the public inconvenience, and it moreover hinders effective surface cleansing. Thus inadequate thoroughfares are not only inconvenient, but are expensive to the public—lead to police regulations, which impede the free and natural course of the traffic and business of a commmunity, and are repugnant to the spirit of the age. I, however, anticipate that police regulations, more stringent than those now enforced, must be exercised in the Metropolis; but it is wisdom to make such improvements in the streets as shall diminish as far as possible the necessity for police interference."

These are the views of the engineer to the City Sewers Commission, as to the state of the City streets, and the needful remedies. That these will be costly he clearly sees, but though he does not take the responsibility of indicating the source from whence the funds are to be derived, he refuses to believe that the wealth of the City can be very greivously burdened by the cost of works, which its unprecedented and still increasing prosperity have rendered needful. He sees, moreover, that the cost will rapidly be increased if action be delayed, and looking to the rapid manner in which the reconstruction of the city by the rebuilding of its business premises is progressing, it does seem not only that a waste of money, but a great and needless waste of thought and labour, will be caused if the execution of such works as are necessary is delayed until the ground has been covered with new and costly buildings, when important businesses, scarcely settled, will have to be broken up or driven away.

ON ARCHED ROOFS.*

By C. Von Wessely.

(With Engravings).

Amsterdam Crystal Palace Roof.

The area covered by this roof is 130 ft. 8⅝ in. long, and 64 ft. 1¼ in. wide, on each side of an oval dome—the entire length of the nave being 329 ft. 1 in. The roof is supported on each side of this dome by seven pairs of ribs, 2 ft. 1 3-16 in. apart, leaving a clear space between them of 19 ft. 8½ in. The ribs of principals are true arches. The intrados and extrados are concentric curves, being struck from the same centre with a radius of 31 ft. 6 in. and 33 ft. 1¼ in. They were so constructed that in being fixed they were made to spring 2⅝ inches outwards, making the distance from centre of building to face of column 31 ft. 7 5-16 inches. They each consist of a top and bottom flange of one T iron, 4¾ inches × 1¾ inch × 5-16 inch × ⅜ inch, and a plate 4¾ inches wide 5-16 inch thick, rivetted to it by 7-16 rivets of about 4 inch pitch. These two flanges are connected by two web plates, No. 9 B.W.G., 1 ft. 6 in. wide, one on each side of the T irons rivetted to them also with 7-16 inch rivets. The entire available sectional area of this rib is 10·56 square inches. The web plates are joined alternately in lengths of about 23 ft. 4 in. by one ⅜ joint plate placed between the two web plates. It is 4 inches wide, and for the sake of architectural appearance rivetted to them with 7-16 inch flush rivets.

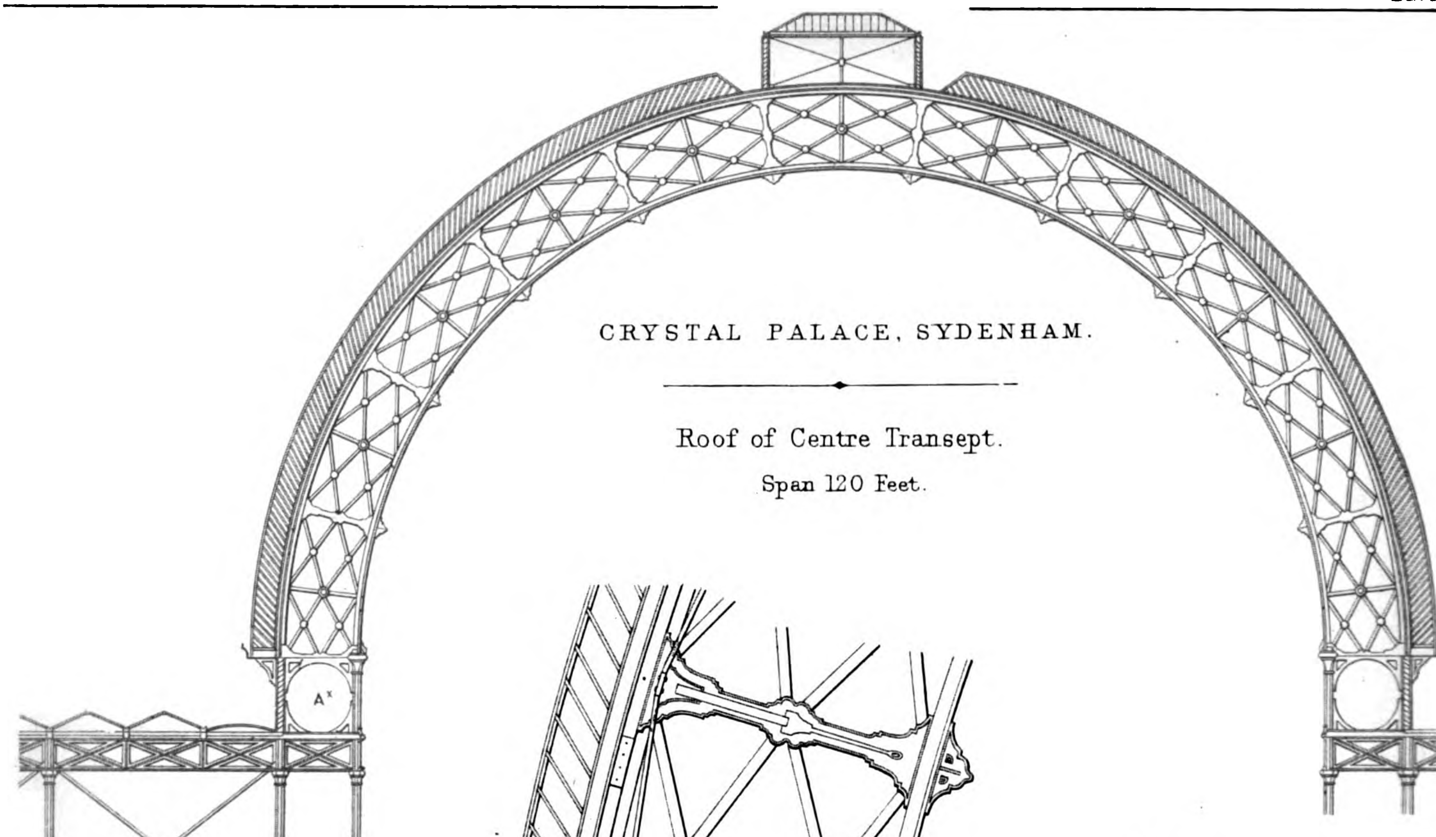
The rib is divided on its outer side, between a point 10 ft. 2 in. above the springing line, and its centre, into seven equal parts.

* Concluded from p. 110.

CRYSTAL PALACE, SYDENHAM.

Roof of Centre Transept.

Span 120 Feet.



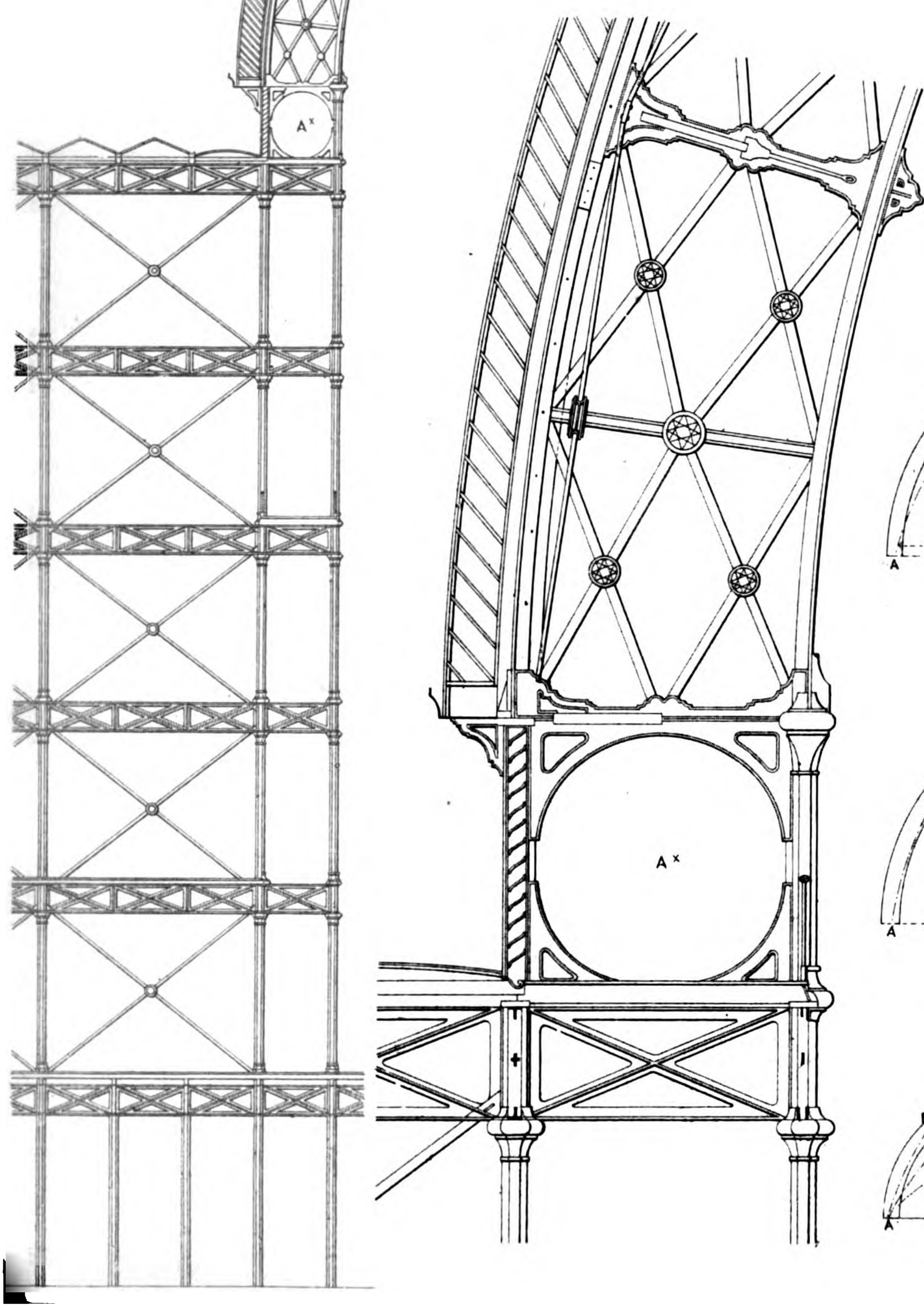


Fig. 1.

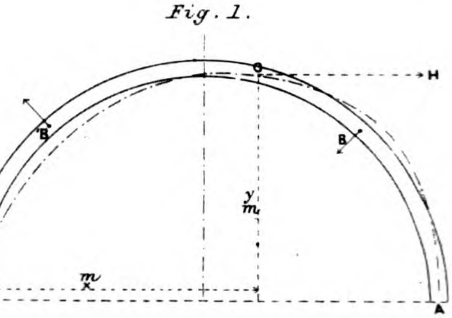


Fig. 2.

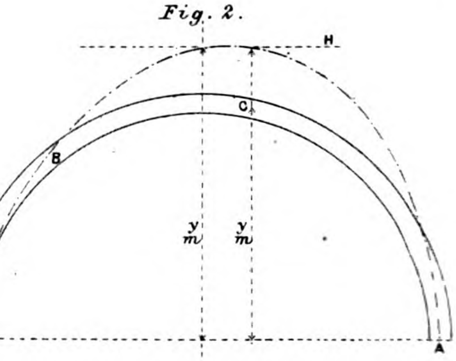
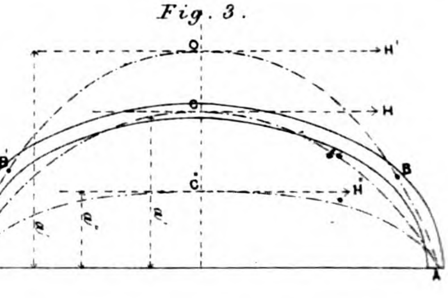
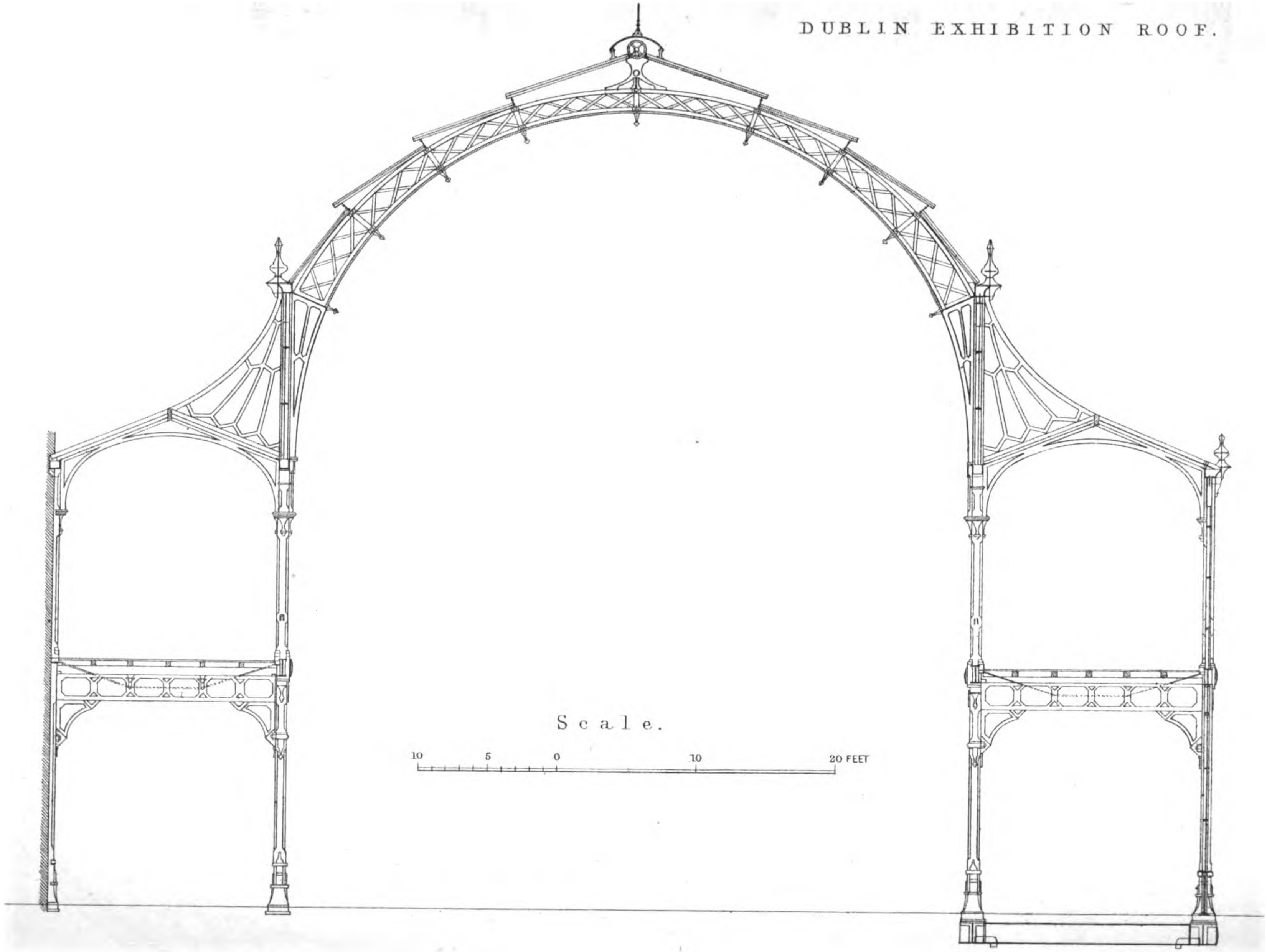


Fig. 3.



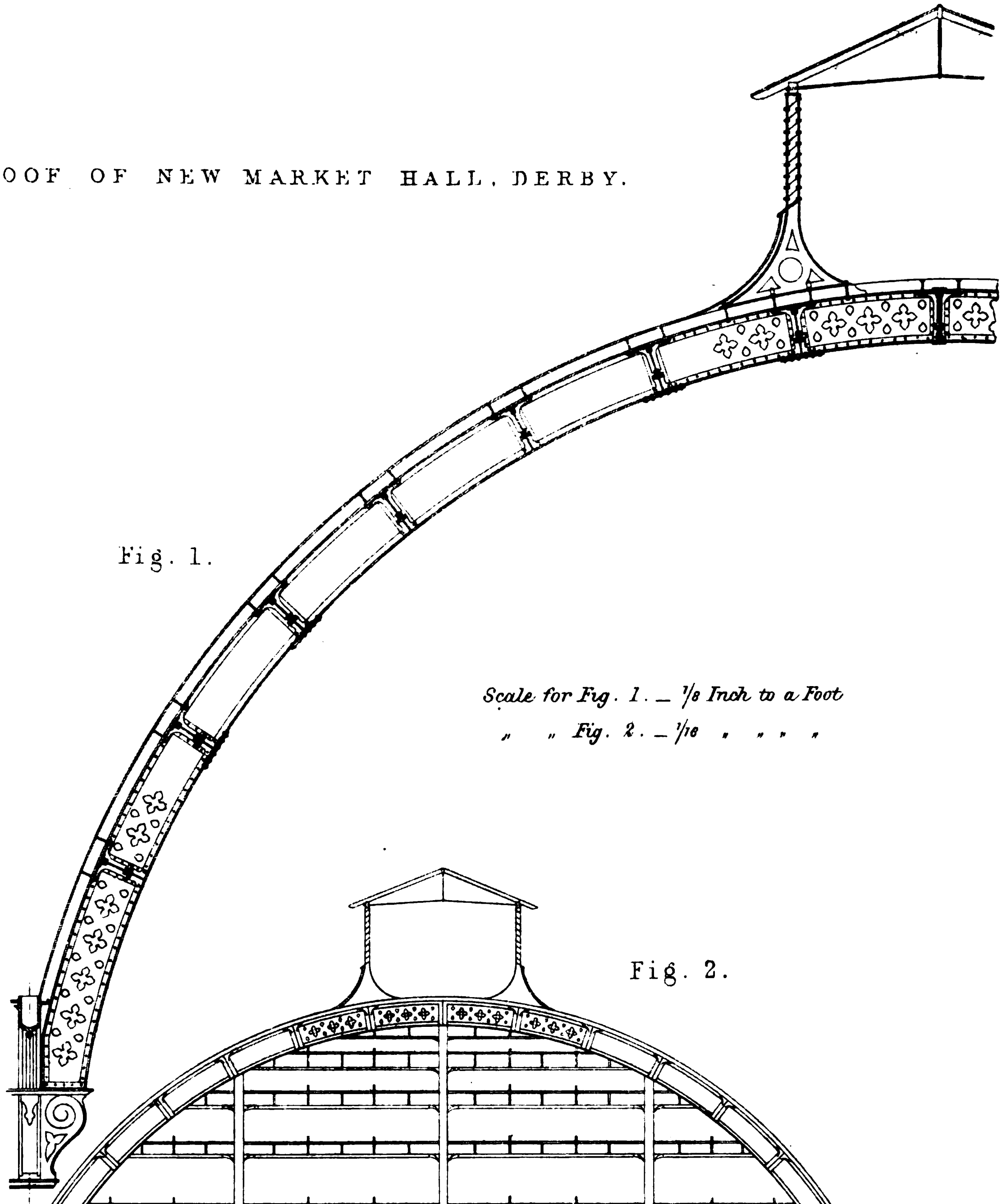
DUBLIN EXHIBITION ROOF.



J. Jobbins

ROOF OF NEW MARKET HALL, DERBY.

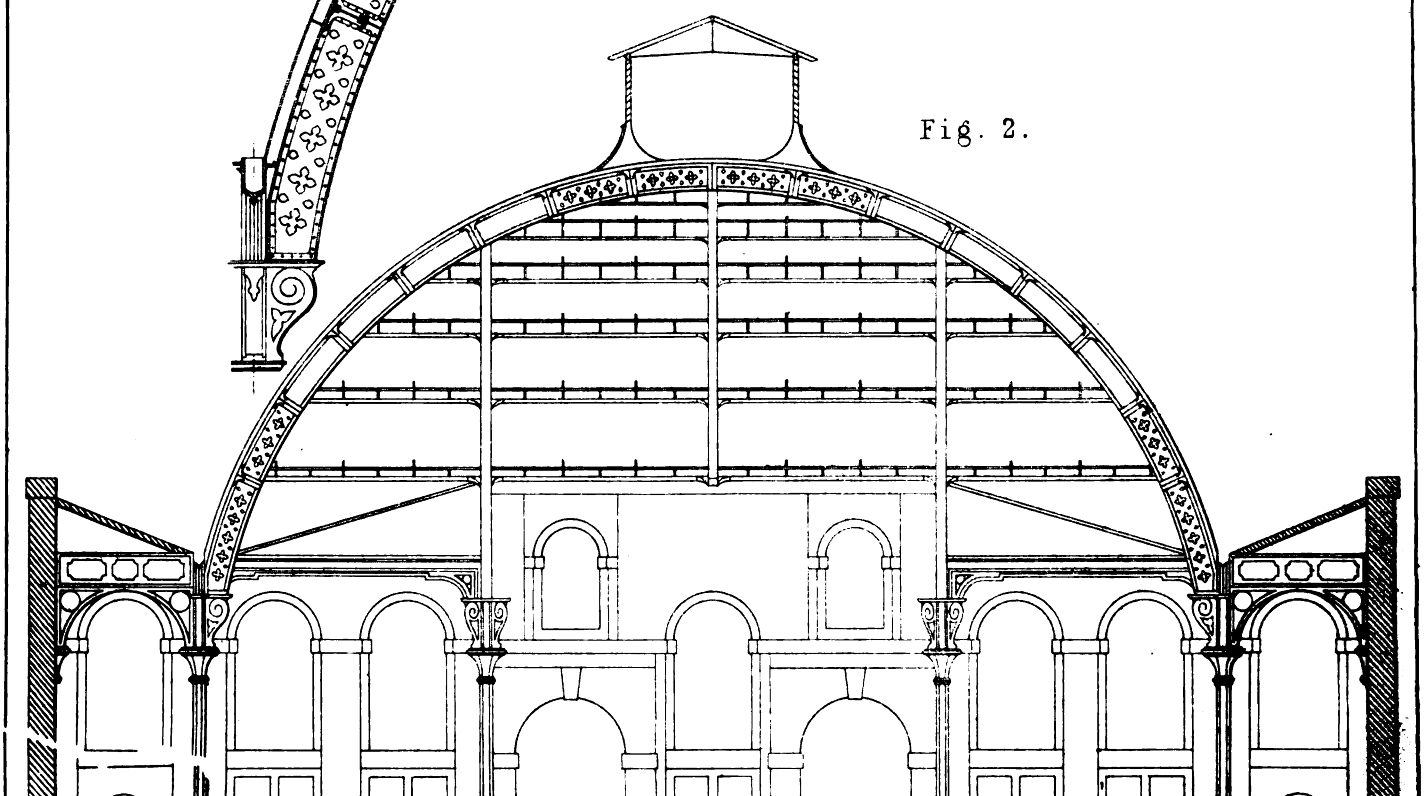
Fig. 1.



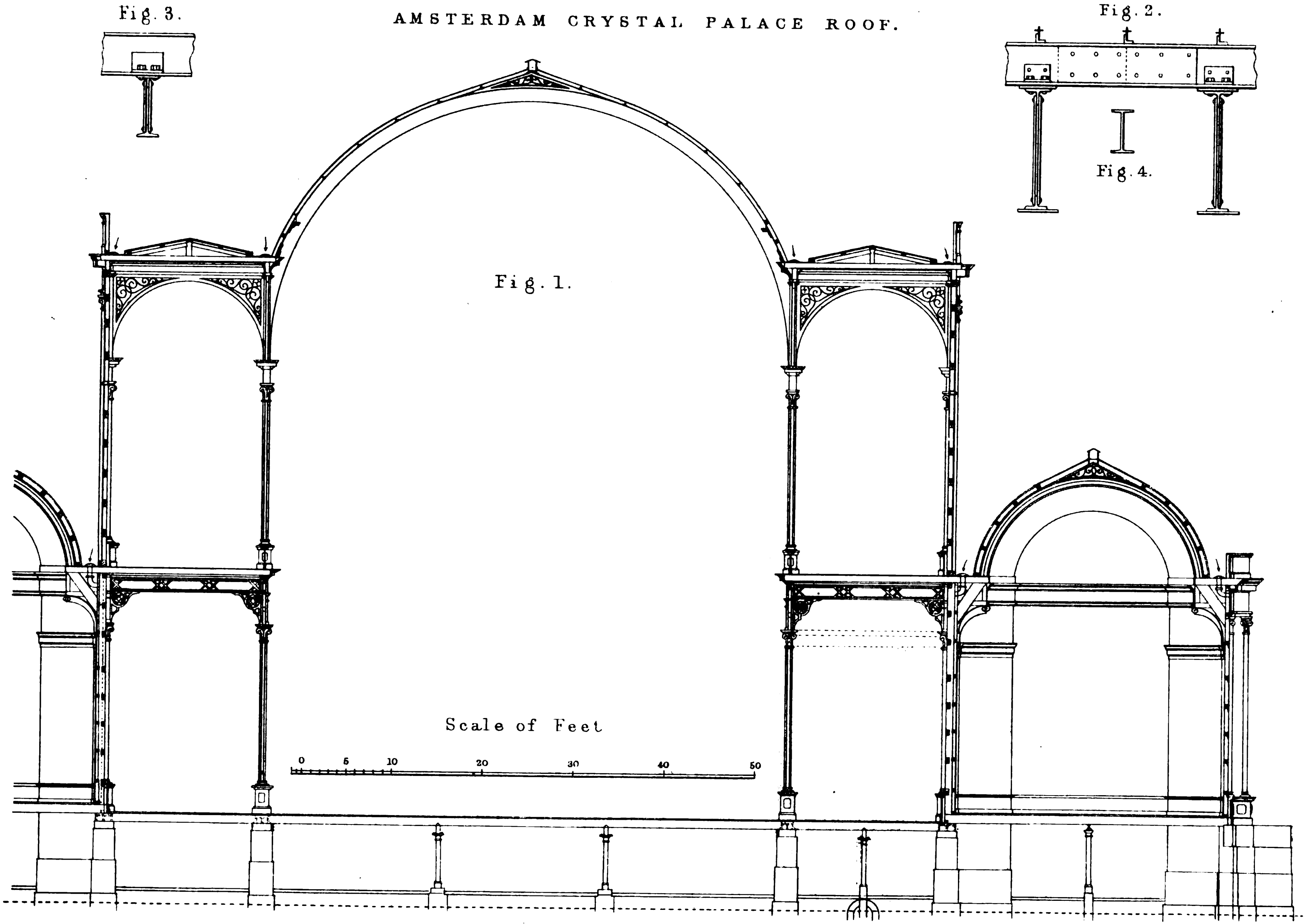
Scale for Fig. 1. — 1/8 Inch to a Foot

" " Fig. 2. — 1/16 " " " "

Fig. 2.



AMSTERDAM CRYSTAL PALACE ROOF.



J. Jobbins

The purlins are carried by it in these intervals. They consist of simple ⊢⊣ irons 6 inch × 3 inch × ⅜ inch with an available sectional area of 1·08 square inches in the top and bottom flanges. They are joined in lengths of 21 ft. 9 7-16 in. between each pair of main ribs by two joint plates 20½ inches long, 5½ inches wide, and ⅜ inch thick, and twelve ⅝ inch rivets. These purlins carry the W. I. skylight bars, one length of the former divided into twenty spaces gives the distance of each skylight bar about 13 inches pitch. The skylight bars are fixed to purlins by L iron brackets 1½ inch × 1½ inch × ¼ inch—3 inches long. The purlins are fixed to main and intermediate ribs by two L iron brackets 3 inches × 3 inches × ⅜ inch, 4 inches long, with four ½ inch bolts, with two ⅜ inch washers, and two ⅝ inch rivets. Between each pair of main ribs are two intermediate ones. They have the same extrados as main ribs, but are only 10 inches deep. They consist of a top and bottom flange of one T iron 3½ inch × 1¾ inch × 5-16 inch × ⅜ inch, connected by two web plates, like those in main ribs, No. 9, B.W.G., rivetted to them with 7-16 inch rivets of about 4 inch pitch. The web plates are connected in length of about 23 ft. 5 in. by one joint plate placed between them, ⅜ inch thick, 4 inches wide, and six 7-16 inch countersunk rivets. The entire available sectional area of this rib is 7·11 square inches. Each of the ribs is supported by one column, so that the upper half of it is widened out to a sort of bracket, at a height of 11 ft. 7½ in. above its springing line. This bracket is strengthened by ⅜ inch plates placed between the two web plates, and two L irons 4 inches × 4 inches × ½ inch rivetted to each side of webs, and to a base plate ⅞ inch thick, which is bolted to top of column with five 1 inch bolts.

The intermediate ribs are supported at their ends by a timber beam. The inner T irons are bent round, and the flange of the upper one, and both are rivetted to ⅜ inch base plate with eight 7-16 inch rivets, which plate is screwed to timber with three ⅝ inch coach screws. Each of the main and intermediate ribs carry in centre a triangular frame of cast-iron, with ornamental filling in, bolted to them by ½ inch bolts 2 feet pitch. It is in centre 1 ft. 7 in. high, and extends on each side about 5 feet over ribs, and supports, in the middle, the cast-iron ventilator. The ventilator is formed by two ridge purlins of a proper cross section, covered by a small ridge roof. It consists of a simple plate of a very flat angle, with proper water-tight joints and a pocket for fixing ridge ornament along the roof.

The weights of this structure are as follows: Main rib, 1 ton 10½ cwt., intermediate rib, 13 cwt., purlins for one bay, 1 ton 17 cwt., skylight bars for one bay, 1 ton 18 cwt. 2 qrs. 11 lb. Total weight of wrought and cast iron in one bay of roof, 9 tons 15 cwt. The appearance of all the columns from inside the building is similar. The first tier columns support the gallery girders, and form an ornamental framework with brackets at joint with column. The columns rest on a stone foundation.

Although this structure forms a sort of stiff frame for resisting the horizontal thrust of principal, still a strong wood structure is made of the roof of the gallery acting along the whole nave as a horizontal girder of great resistance against side pressure.

Proposed Roof of the St. Pancras Station, Midland Railway.

Although the particulars of this roof have been already published it was still thought advisable to repeat them here again for the sake of comparison. The area covered by this roof is 690 feet by 240 feet. The main ribs are 29 ft. 4 in. centre to centre, and have three intermediate ribs between them at equal distances apart, carried at every 18 ft. 6 in. by trussed purlins between the main ribs. The form of the ribs is entirely novel. They spring directly from the ground, and are firmly connected to massive brick piers below floor level. The curve of the ribs is of two radii of 160 feet and 57 feet, meeting at an angle in the centre 100 feet above the level of rails. The ribs are 6 feet deep, and formed with open box flanges 10½ inches deep; the flanges being braced together by diagonal channel irons and radial struts forming the ends of the purlins. The feet or springing of the ribs, to a height of about 25 feet from platform level, are constructed of plates and angle irons rivetted together. The intermediate ribs are 10½ inches deep, and will be made most probably of angle irons braced with diagonal bars. The purlins are braced beams 18 ft. 6 in. apart. They are so constructed that they stiffen the main ribs laterally. The bracing is so arranged as to carry the proper proportion of each of the three intermediate ribs, besides assisting to keep the bottom flanges of the main ribs in place. The whole of the roof is braced horizontally, to resist any strains that may be caused by the pressure of the wind either on the gable or on the side.

Ventilation will be amply provided for by open spaces in the skylights, along the whole length of the ridges, and also along the eaves where the glass overhangs the gutters. The lower sides of the roof are to be covered with glass ridge-and-furrow skylight, at right angles to the ridge, 152 feet wide, extending nearly the entire length of the roof, there will be a gangway at the foot of each skylight along the whole length of roof, and each gutter of skylight will have a snow grating along its whole length, with cross stripes to enable the workmen to repair and paint any portion of the skylight. The horizontal thrust is partly taken by the heavy brick piers, which act as abutments, and partly by a wrought-iron tie running below level of rails across the platform, forming one of the wrought-iron girders supporting the latter one.

Referring to the various roofs described, we find that in the Dublin Crystal Palace Roof, with a clear span of 49 feet, one square of area covered with glass requires 9¼ cwt. of wrought and cast iron. The smaller roof of the Crystal Palace, with a clear span of 56 feet, a square of covered area with glass requires 13 cwt. of wrought and cast iron. The Derby Market Hall roof, of 81 ft. 5 in. clear span, one square covered over partly with slates and partly with glass, requires 15 cwt. of wrought and cast iron. In the large roof of the Crystal Palace, which has a span of 104 feet, a square covered with glass requires 12¼ cwt. of wrought and cast iron. In the Amsterdam Crystal Palace Roof, which has a clear span of 63 ft. 2⅜ in., an area of one square covered with glass requires 15 cwt. of wrought and cast iron; and, lastly, in the Midland Roof, of 240 feet span, one square of area, covered partly with glass and partly with slate, requires 17 cwt. of wrought and cast iron.

In each of the buildings covered by these roofs we find a new principle employed in the construction of ribs and in the arrangements for taking the horizontal thrust.

In erecting true arched ribs, it will be often the case that the feet of them must be made to spring out a little to fit the supporting structure; but it must be considered then, on the other hand, that in all cases the flanges are constructed stronger than minute calculation would require, and so the pressure may be increased a little in the top flange at or near centre, getting lessened at the same time in the bottom one, and that without any bad effect upon the structure itself. The Amsterdam ribs were, in fact, manufactured so as to spring out in erection 2⅜ inches, as already mentioned in the description.

The most rigid of the various roofs treated of, no doubt will be the Midland Roof, as the stability or rigidity of an arched roof increases with its size, the same, for instance, as in bridges. The great weight, therefore, of the Midland Roof is a guarantee for its stability. This is shown to a certain extent by constructing the curves of equilibrium for the equal load and the unequal moving load, the vertex in the latter case not moving as much as it would in the case of a smaller, and consequently lighter, roof.

No apparent provision has been made in any of these roofs for expansion of the structure by temperature, as is commonly done in large roofs where trussed principals are employed. As the abutments are not allowed to give way, the ribs will simply rise and fall at the crown like the iron arch of a bridge.

THE LATE GEORGE RENNIE, F.R.S., C.E., &c., &c.

It is our painful duty this month to record the decease of the above named eminent engineer. Mr. Rennie had been comparatively an invalid for some years prior to his death, which event took place on Good Friday last, March 30th, at his residence in Wilton-crescent, London. It would be difficult, if not impossible, to mention a name connected with the civil and mechanical engineering professions of this country more distinguished than that of Rennie. Monuments exist on all hands which will testify to posterity of the indomitable industry and the genius of the founder of the house—John Rennie—whilst his descendants have proved themselves worthy of their sire, and achieved also an enduring reputation. Our present object however is not to trace out and chronicle the numerous works which made the life of the first Rennie remarkable, but to indicate rather some of those which have tended to make famous that of his eldest son—the subject of the present memoir.

George Rennie was born at the village of Christchurch, in Surrey, on the 3rd of December, 1791. His father had then been established as an engineer in the Metropolis for about seven years, and in friendly union with Messrs. Boulton and Watt, who had early discovered his great ability, he had achieved considerable fame. The education of young Rennie was commenced at the classical school of Dr. Greenlaw at Isleworth, and continued at St. Paul's school, London. At the age of sixteen years he may be said to have received his first lessons in engineering, for he then accompanied his father in one of his annual professional tours through England, Ireland, and Scotland. The advantage of this first insight into the mode of conducting works such as those under the management of the elder Rennie was great, but it was supplemented by introductions to men of eminence—scientific, scholastic, and practical; and it is known that the journey was productive in all ways of excellent results to the youth.

Soon after this memorable tour it was determined that George Rennie should be entered as a student at the College of Edinburgh, and this was speedily accomplished. The Rev. Dr. Roberts was his first tutor in the Scottish capital, and with that gentleman he remained for two years, having also the privilege of daily communication with Professor Dunbar, and Dr. Henery, the celebrated chemist of Manchester. At the end of the period named the embryo engineer was transferred to the charge of Professor John Playfair, in whose house he resided for other two years, and under whose guidance he profited greatly. Professor Playfair was admirably qualified to be the guide and friend of youth, and in the present instance he found an apt and intelligent pupil. The latter was most assiduous in the pursuit of information, whilst the former possessed in a remarkable degree the valuable faculty of pleasantly imparting it. During the time that young Rennie was thus happily situated he attended classes for the study of all those branches of knowledge an acquaintanceship with which was considered likely to be of most value to him in the future, mathematics, natural and moral philosophy, Greek and Latin, chemistry, &c.

By the year 1811, it was considered that he had acquired sufficient book knowledge to fit him for more practical labours, and he then returned to London. In the drawing office, and the workshops of his father's establishment at Blackfriars, we next find the subject of this notice. In both departments his diligence, talent, and amiability of disposition were conspicuously displayed. He is reported to have made at this early period of his life the working drawings for a small steam engine, and afterwards to have fitted up the engine unaided by other assistance. Unhappily, this specimen of his youthful ability and perseverance was destroyed, many years afterwards, in a fire which occurred at the manufactory of George and Sir John Rennie, in Holland-street.

In 1818, he was appointed Inspector of Machinery, and Clerk of the Irons (dies) at the Royal Mint, London, in succession to Mr. James Lawson, deceased. The office demanded that its possessor should have a practical knowledge of machinery, and of the character of steel, and was otherwise of an arduous nature. The appointment, on the strong recommendation of Sir Joseph Banks and James Watt, was confirmed by the Treasury, and for eight years subsequently Mr. George Rennie was a Government Officer. It does not appear that the occupation was a congenial one, for in the year 1824 he resigned the appointment, and returned to his old quarters at Blackfriars. During what may be termed the official portion of his career, it was the misfortune of Mr. George Rennie to lose the counsels of his father. In 1821, and in the 60th year of his age, John Rennie died, and then it was that a partnership was entered into between the two sons, George and John (now Sir John): possibly too his father's death, may have conduced to the abandonment by the former of his post in the Mint. Very speedily the heads of the new firm imported a considerable amount of energy into the conduct of the business which had thus been committed to their charge. Their father had left many designs for projected architectural and engineering works, and conspicuously among these were the bridges of London, Southwark, Staines, and that for spanning the serpentine in Hyde Park. All these were afterwards realised by the younger Rennies, as well as many other structures of a similar but less important character in various parts of the kingdom. They took care to associate with themselves talented assistants to conduct, and skilful workmen to execute the various undertakings for which they were responsible, and hence another source of the invariable success which attended their labours.

In the construction of the vast Docks of London, Leith, Sheerness, Dublin, Deptford, Chatham, Woolwich, and Pembroke, and in the formation of the harbours of Plymouth, Howth, Kingstown, Portpatrick, Ramsgate, and Whitehaven, they earned great fame. The Plymouth Breakwater, and the magnificent Victualling establishments at Gosport, Plymouth, and Deptford, are also among the works demanding honourable mention.

The drainage of the fens of Lincolnshire, Cambridgeshire, Bedfordshire, and Norfolk, though less prominent as engineering works than those referred to, were productive of great advantage, and the results attest the skill and energy of the Rennies.

In the department of Civil engineering the late George Rennie distinguished himself greatly. To him was entrusted the first survey of the present Liverpool and Manchester railway. He had prepared himself for it, by numerous investigations into the working of the railways in the northern and western parts of the kingdom, and notably of that between Stockton and Darlington. In the years 1825-26, he had also made a vast number of experiments on the gliding and rolling friction of metals and other substances.* Briefly it may be said that the act for constructing the "line of the Liverpool and Manchester railway, as laid out under the direction of Messrs. George and John Rennie," was carried through Parliament in the year 1826.

Mr. George Rennie also made the survey of the London and Birmingham, the Great Northern, and many other accomplished or projected English railways; the Namur and Liège and the Mons and Manege lines in Belgium were surveyed and partially constructed by him, and the remarkably beautiful stone bridge spanning the river Meuse, and consisting of five segmental arches, was designed by the same gentleman. The present bridge at Chester, originally designed by the late Mr. Harrison, was completed by Mr. Rennie, who exhibited great ability in the construction of the centreing employed in its construction. It was the fortune of Mr. Rennie to be frequently called upon by foreign governments to construct machinery for almost every conceivable purpose. We can scarcely enumerate the number of mints which owe their existence to his mechanical skill. Those of Calcutta, Bombay, Lisbon, Mexico, Peru, and France may be cited. In the formation of the machinery for these he found the knowledge of coining, which he had acquired in the Royal Mint, of great service, and in company, as his father was of old, with the firm of Messrs. Boulton and Watt, he has certainly rendered the places named famous for their money manufactories.

As a complete and perfect specimen of mechanical work, for a totally different purpose, the Turkish Small Arms Factory, situated on the Sweet Waters, near Constantinople, may be referred to. It was designed by Mr. Rennie, for the manufacture of 100,000 muskets per annum, and comprises the whole of the appliances necessary for forging, rolling, rough and fine boring, adjusting, and proving the barrels, the forging and fitting of the different parts of the locks; cutting and shaping the stocks, &c. During the progress of the Crimean war the establishment was in full work, and produced the maximum number of muskets for which it was originally designed, it thus proved of great service to the Turkish Government. Similar machinery was afterwards completed for the arsenals of France, at Chatelbeaux, Toulon, and Rochfort. By the Russian government Mr. Rennie was highly esteemed and constantly employed. He constructed for it, numerous mechanical appliances for every variety of purpose. They included coining, biscuit, and block-making machinery, dredging barges, &c. Several steam frigates of great power were also furnished to Russia. These comprised the "Smâlè" of 400 horsepower; the celebrated "Wladimar," also of 400 horsepower, and which was employed at Sebastopol during the siege of that gigantic fortress and stronghold. The latter was indeed the first screw steam-ship introduced into the Russian service, and she was followed by the "Peterhof" and "Alexandria," used as yachts by the late Emperor Nicholas. Other steam ships of lesser note were fitted out for service in the Black and Caspian seas. Mr. G. Rennie designed the Great Steam

* Vide Transactions of the Royal Society, 1828

Factory at Cronstadt, and one on a reduced scale at Astracan. The large dock gates of Sebastopol, ten pairs in number, owed their existence also to the same source.

For Her Majesty's Navy the Messrs. Rennie constructed many marine engines, and among them those for the "Sampson," "Bulldog," "Vulcan," "Megœra," "Reynard," "Cruiser," "Oberon," &c. When these and other works of a similar nature were completed, Sir John Rennie quitted the firm, and Mr. George Rennie formed a partnership with his two sons. The new firm, it may be mentioned, have since designed and constructed marine engines for the Peninsular and Oriental, the French and Sardinian, Transatlantic and other companies, besides greatly extending the general mechanical department of the establishment.

Mr. George Rennie was elected a Fellow of the Royal Society in 1822, and he subsequently held the offices of treasurer and vice-president for more than five years. He was also a fellow, or member of the Astronomical, Geological, Civil Engineers, and Philosophical societies, and an honorary member of the Royal Academies of Dublin, Turin, and Rotterdam. He served in the Royal Commission for investigating and experimenting upon the strength of iron, and, jointly with Mr. Hodgkinson, conducted a series of exhaustive experiments elucidatory of the subject. The results of this inquiry have since proved of great value to the practical engineers and architects of this and other countries. Mr. Rennie was one of the jurors named by the Government for the Crystal Palace of 1851, and was also appointed to a similar office at the Paris Exposition of 1855.

He was chosen as Referee by the House of Commons at a later period, relative to the printing of their proceedings. Many valuable papers were contributed by him to the Royal Society, and they are permanently preserved in its volumes of "Transactions." Some of these may here be enumerated, as their titles will serve to show the wide range of subjects he had considered and the versatility of his talent. Among them were treatises on "The Strength of Materials," the "Friction and Resistance of Fluids," the "London, Metropolitan, and other Bridges;" on the "History and Present State of Hydraulics," and on the "Advancement of Science." The general literary works of Mr. Rennie include volumes or pamphlets on "the Heat produced by Agitating Water," on "the Resistance of Screw Propellers when driven at High Velocities and at Different Depths."* On the "Expansion of Arches of Stone and Iron;" on the "Aqueduct Bridge of Roque Favore," &c. He brought out a new edition of Tredgold on the Steam Engine, and enriched it with considerable additional matter culled from his own experience. The same may be said of Buchanan's admirable treatise on mill-work and machinery, which he re-edited and supplemented by an extensive and entirely new series of chapters on tools.

In the year 1857, Mr. Rennie designed a plan of a breakwater for improving the port and harbour of Liverpool. It was intended that this work should project from the Black Rock point; at the mouth of the Mersey, on the Cheshire shore, and advance in a line nearly parallel to the Lancashire shore, to a distance of *three miles*, where it should terminate by a lighthouse. Among the advantages which Mr. Rennie calculated would arise from the existence of such a structure here, the prevention of many shipwrecks, and of the loss of many lives annually; the reclamation of forty thousand acres of sand-banks; and the reduction to a minimum of the great expenses now incurred in maintaining the lights, buoys, steam tugs, dredgers, &c., employed in preserving the direction and depth of the sea channels, and which heavily tax the forty thousand ships and four millions of tons carried by them annually. This gigantic proposition was not realised, but undoubtedly honour is due to Mr. Rennie for making it: some day we may witness its resuscitation and possibly its acomplishment.

Mr. Rennie's reports on civil engineering works are numerous and we hope that they will be eventually collected and printed, as they deserve to be.

We have thus endeavoured to enumerate some of the principal works in which Mr. George Rennie was engaged; but his history will remain to be written at a subsequent period. During a long life he was constantly engaged in the promotion of mechanical and engineering science, and in the realisation of designs having for their object the material and moral welfare of mankind. His mind was never idle, and in this respect especially his example may be cited for the advantage of others who desire to ascend the pathway leading to the Temple of Fame. Those who were most intimately associated with Mr. Rennie best know of his high moral characteristics.

The funeral of Mr. George Rennie took place in the pretty churchyard of Holmwood, near Dorking, Surrey, on the 6th ult., just a week after his death; it was conducted in that unostentatious manner which was consonant with his character, and befitting the last scene of all in the career of a great and a good man.

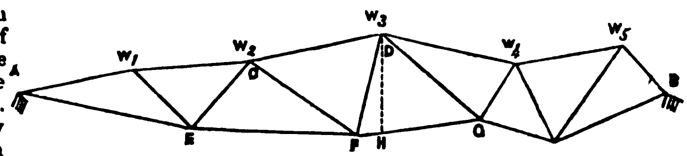
If it be not finally determined to remove his ashes from their present resting-place, and to deposit them beside those of his father in the vaults of St. Paul's Cathedral, we would suggest that a monument be erected over Mr. Rennie's grave at Holmwood, and that the necessary funds for the purpose be furnished by subscription among the host of friends and admirers who sincerely mourn his loss.

* It is proper to mention in connection with this part of our subject that to Mr. Rennie's exertions after his construction of the well-known steam-vessel the Archimedes, is due, largely, the introduction of screw propulsion into the Royal Navy. Mr. Rennie was a strenuous advocate of the screw propeller when many other engineers declined to entertain the idea of employing it at all, and when Mr. F. P. Smith, like other ingenious men, stood in need of supporters.

FORMULÆ FOR OBTAINING THE STRAINS ON THE SEVERAL PARTS OF GIRDERS AND ROOFS.

By Alfred A. Langley, C.E.

Let any triangular combination of bars, such as is shown in the annexed figure, be loaded with weights w_1 w_2 w_3, &c., at the point of junction of the intermediate and upper bars. Find the weight or reaction at the support A, owing to these weights, which call R. Let S equal the strain on any of the lower bars in



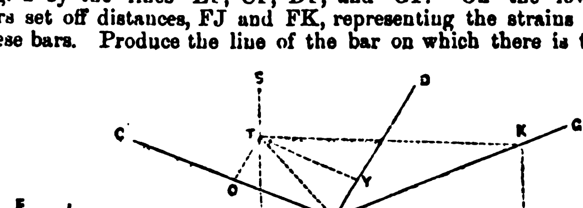
the direction of its length, which strain we shall now proceed to find on the bar FG. Draw the line HD perpendicular to FG, and through the point D. Let the sum of the weights between D and the support A be called W, and let the horizontal distance of its centre of gravity from D be called g, also let d equal the horizontal distance between A and D. Then taking the moments about the point D we have

$$S = R \frac{d}{DH} - W \frac{g}{DH}$$

By the above process the strains on each of the lower and upper bars may be obtained; the upper bars will be in compression, and the lower ones will be subject to a tensile strain.

Intermediate Bars.—There are four bars meeting at each of the points E,F,G, &c., their directions are known, and after obtaining the strains on the two lower bars by the preceding formula, the forces acting on the remaining two intermediate bars can be calculated by properly resolving the forces so that they may be in equilibrium.

The forces can readily be arrived at by construction as follows:—Let the inclination of the four bars meeting in F be shown in Fig. 2 by the lines EF, CF, DF, and GF. On the lower bars set off distances, FJ and FK, representing the strains on these bars. Produce the line of the bar on which there is the



greatest strain, which we will suppose to be JF, draw a line from K perpendicular to EF, and intersecting it in I. Set off JN = FI. Draw LS through the point N, perpendicular to JF, and draw a line parallel to EI from K, intersecting LS in T; then will TF be the resultant of the forces acting on the intermediate bars; from T draw lines parallel to FD and FC, intersecting them in O and V, then will FO and FV represent the strains on FC and FD respectively. When T lies between the intermediate bars they will both be in compression, and when between the lines of the intermediate bars produced below F, both in tension; but if the resultant is not in either position, then the bar nearest T will be in compression, and the other in tension. Let the strain on EF and FK = H and h respectively; also let the angles CFE, CFD, and DFG = α, β, and ψ respectively, and the required strain on CF=x and on DF=y; we can then at once write down

$$x = \pm H \frac{\sin(\alpha+\beta)}{\sin \beta} \pm h \frac{\sin \psi}{\sin \beta}$$

$$y = \pm h \frac{\sin(\psi+\beta)}{\sin \beta} \pm H \frac{\sin \alpha}{\sin \beta}$$

BELFAST WESLEYAN COLLEGE.

The foundation stone of this college was laid in the autumn of last year. The building, which has now made considerable progress, will be in the Gothic style, of the usual academic type —the details Early English in character. It comprises a longitudinal main building, 190 ft. long, with two transverse wings, each 130 ft. in length, projecting both to front and rear. In the centre a massive tower projects boldly from the main building. A plateau or terrace in front will be laid out in ornamental beds and walks. There is also a central rear building, containing the refectory, kitchen, laundry, and offices. The college is to serve for two distinct purposes, namely, a theological college and a preparatory school. The left side of the building is devoted to the collegiate department, the right to the school, the departments common to both occupying the centre.

The principal entrance and the president's house occupy the centre of the front; the theological tutor, on the left, and the head-master, on the right, have their residences in the main building, each having a separate entrance. At one side of the principal entrance are the waiting-room and board-room; and at the other the president's hall and staircase, also his study and dressing-room. The rest of the president's, tutors', and head-master's apartments are in the basement and on the first-floor of the front building. Each house is perfectly distinct and self-contained. Behind the entrance-hall a corridor or cloister leads right and left to the school-room and lecture-hall, which form the front projecting wing, each about 55 ft. by 27 ft. in the clear. The lecture-hall has a partially open roof, with semicircular ribs to the principals, and ornamental pierced boarding filling the spandrels. The school-room is 20 ft. high, and has a dormitory over.

The total number of students to be accommodated is 20; of boarders, 80; and of day pupils, a little over 100. A separate entrance is provided for the students, and one for the boys, in their relative staircase towers. These latter form a good feature in the designs. To the lecture-hall a distinct entrance is provided for the admission of the public, on the occasion of lectures, distribution of prizes, &c.

The rear projecting wings contain the class-rooms and the library of each department, with dormitories over. The rear central building is connected with the main building by a central staircase, with two side passages to the dining-room, which measures 50 feet by 25 feet in the clear, and has an open roof In one corner is a recess containing a lift communicating with the kitchen, which is immediatedly beneath. To the rear of the dining-hall are placed the butler's pantry, matron's rooms, stores, &c., with a back entrance. The main kitchen, sculleries, servants' rooms, and minor offices, are in the basement. The rear projecting wings are so planned as to be capable of further extension.

Extending over the residences, the students' bedrooms occupy a portion of the second-floor of the front, a separate room being given to each. Large dormitories, extending over residences and schoolroom, are provided for the boys, in some of which the system of division into cubicles is adopted. Separate bedrooms for the under-masters are placed in immediate connection with the boys' dormitories. Water-closets, lavatories, and bath-rooms, in proportion to the number to be accommodated, are provided in suitable places.

At the lateral entrances, stone staircases in the side towers give access to the upper floor. The first-floor of the building, at the rear of the dining-hall, at one side contains an hospital; at the other, apartments for the matron and female servants, each side approached by a separate staircase. The building is intended to be of Belfast red brick, with dressings of freestone from Glasgow; the rubble walling in the basement is of the freestone of the locality.

It is intended for the present to omit a portion of the wings. The cost of the building, as now contracted for, will be £11,000. The architect whose design, selected in a limited competition, is being carried out, is Mr. William Fogerty, of Dublin. The builder is Mr. James Henry, of Belfast.

Ipswich New Town Hall.—The foundation stone of this building has at last been laid. The works are being carried out under the direction of Messrs. Bellamy and Hardy, architects, the contract amounting to £11,750, being taken by Mr. E. Gibbons, of Ipswich, and the masonry is being executed by Mr. R. Ireland, of Ipswich. Mr. W. P. Ribbans, the borough surveyor, and Mr. E. Catchpole, act as clerks of the works. The building has now so far progressed as to be in some places considerably above the level of the ground. The style is Venetian. The principal front towards the Cornhill is divided into centre and side wings. The centre is composed of three canopied openings surmounted by a tower and clock turret, with illuminated dials. Balconies are provided in the first or principal story, from which public meetings held on the Cornhill may be addressed. The wings on either sides are divided by vermiculated pilasters, forming arched and deeply recessed bays for windows. Red Mansfield stone will be used for the plinth of the building, and the columns and the pilasters throughout. The grand staircase will also be of red Mansfield stone. The height of the building from the ground to the top of the balustrade will be 55 feet, and to the top of the tower will be 100 feet.

Statue of James Watt.—A statue of Watt is about to be erected in Birmingham. It will be in marble, and 8 feet high. Mr. A. Munro is the sculptor.

New Dock Works, Sunderland.—The bridge across the junction entrance, being the first portion of the work in connection with the new Hindon Dock, was opened on the 25th ult., by the chairman of the Commissioners of the River Wear. The bridge, which is of iron, is lifted off its supports by means of a hydraulic press, it works on a water centre beneath the pivot of the bridge, after being lifted about 2 inches, it is swung round by means of handles attached to each wheel work. The total weight is about 100 tons, its length 110 feet, span 60 feet, its breadth 12 feet 6 inches, depth of outside girders in centre 5 feet. The bridge on being swung round worked admirably. These dock works, which have progressed most favourably since commencement, two years ago, are expected to be ready for opening throughout on the 1st October next. They are from the designs and under the direction of Thomas Meik, the Commissioners' engineer; Messrs. Sir W. Armstrong and Co., Newcastle, being the contractors for the machinery.

A new Church at Fawley, Oxon, was consecrated on the 12th ult. The style of building is early mediæval, and it consists of nave, aisles, chancel, and circular apse. The roof of the chancel is composed of groined stone. The roof of the church is open timbered, and the walls are of stone from Bisley-common, near Cirencester, hammer dressed. The pillars are of highly-polished Devonshire marble, with carved Bath stone capitals. The reredos is by Earp, of Lambeth, from a design by Mr. G. E. Street, the architect; it consists of three compartments, the centre panel containing the Crucifixion, and filled in with mosaics. The font is of Bath stone richly carved, and the pulpit of the same kind of marble as the pillars. The floor is laid with encaustic tiles by Godwin. The seats are open and of carved oak, and offer accommodation for about 200. On the north side of the chancel stands the organ, which was built by Hunter, of Kennington-green. The whole of the works were carried out by Messrs. Rogers and Booth, of Gosport, the duties of clerk of the works being carried out by Mr. Cloutman. The cost of the structure, independent of the site, was about £3000.

THE ARCHITECTURAL EXHIBITION.

The Architectural Exhibition opens this year under somewhat different auspices to formerly. It is now denominated a Society, having a president, four vice-presidents, and the ordinary council or working committee, with the usual officers. The president is Mr. Beresford Hope, who is also the president of the Royal Institute of British Architects; among the vice-presidents are the late two secretaries, Messrs. Fergusson and Edmeston, whose places in the latter capacity are now filled by Messrs. R. W. Edis and Rowland Plumbe; while Mr. Ashpitel has resigned his honorary treasurership, and been succeeded by Mr. E. B. Lamb.

In addition to the president's opening address at the inauguration conversazione, on the 1st of May, lectures have been delivered during the past month, on Tuesday evenings, viz.: May 15th, by Mr. Digby Wyatt, on "The advantage of travel in the study of architecture;" 22nd, by the Rev. J. L. Petit, "Remarks on Egyptian architecture;" 29th, by Thomas Wells, Esq., "On the influence of Eastern on Western art, and more especially on that influence as exerted through the medium of Constantinople." There yet remain three lectures to be delivered in the course of the present month, viz.: June 5th, by J. P. Seddon, Esq., "New lamps for old ones;" 12th, by Professor Lewis, on "Byzantine architecture;" 19th, by T. Roger Smith, Esq., "On the influence of site upon the design of some celebrated buildings." The usual privilege is accorded to season ticket holders, of admission to these lectures, as well as to the exhibition at all times when it is open; and this is a great boon to all who can avail themselves of its full advantages, the charge being the almost nominal one of half-a-crown.

It may be also premised that some alterations have been made in the arrangements of the galleries themselves; the two principal apartments being now confined, as originally, to architectural drawings and architectural photographs only, while the eastern gallery has been reconstructed internally, and is now filled with a useful collection of practical works in connection with the general subject of "Building Materials and Appliances," under the management of Mr. D. O. Boyd. The north gallery is still retained for sundry general features of the same kind.

The absence of one familiar face will not fail to be regretted by all who were acquainted with the genuine worth of the late curator to this as well as to the other societies, Mr. Henry Moody; so obliging, courteous, and painstaking in all that related to the interests or comforts of those whom it was evidently as much his pleasure as his duty to serve, and whose sudden removal by death, a few months since, is a loss consequently felt far beyond the circle of his immediate family and friends. It was, however, with satisfaction that we learnt that the post had been offered to, and accepted by, his nephew, Mr. W. Farthing, a gentleman whose business qualifications in every way fitted him for the work.

Mr. I'Anson (1) exhibits his new building in New Southwark-street for the Hop Planters' Company, a plain red brick edifice, of the warehouse type, rather less ornate and characteristic than the majority of that gentleman's works. Mr. C. E. Giles has some excellent drawings of buildings in progress, carefully given, though perhaps to rather too small a scale. However, as each is shown by more than one view, there is less left to be imagined than there otherwise would be. Of the half-dozen groups thus exhibited, the most noteworthy are (8) "a church and curate's house at Nordelph, Norfolk; (12) a small new "church and schools at Froome Selwood," which are designed with much true feeling, though the bell-turret to the former is rather too pretentious for the general character of the rest. Mr. Giles evidently studies—and properly too—the effect of skylines, and the forms of his roofs. Foremost among the sketches of old buildings must be mentioned those by Mr. T. H. Watson, of which several made by him during his travelling-studentship of the Royal Academy are distributed on the walls. His rapid and effective style of pencilling is heightened by his facile water-colouring, rendering these sketches (for such they in truth are) every way expressive and satisfactory to the beholder. In this category may be particularised the exquisite porch to "S. Paolo, Ferrara," (2), and S. Matthias, near Treves (4). A brother traveller in the same school, Mr. Phéné Spiers, has eight contributions of this class, more delicately handled, but scarcely less effective than those to which we have just referred. His sketch of the "Cathedral of Palermo" (23), and the "House of the Painted Capitals, Pompeii" (23), will be especially examined with interest. As a specimen of patient labour, in illustrating a subject of interest which we do not remember to have ever seen before adequately treated, we may point to (5), Mr. R. Groom's elaborate drawing of the "Old Choir Gates of St. Paul's Cathedral." In (6) and (7) Mr. Plumbe exhibits an interior and exterior of a proposed "Congregational Mission Church, North Bow," the former of which has some very good features, particularly in the construction of its roof, which for a wide span is contrived on an excellent principle, consisting of ornamental curved ribs and braces, connected by a tie beam, not at the usual wall-plate level, but at about one-third of the space above.

Passing by Mr. Whichcord's "Offices in the Old Jewry" (16), which are very feeble in design, we come to the smartly coloured "Parsonage Houses" adjoining (20), which completely kill everything near them. Yet this is no undesirable attainment in these competition days, and Mr. Hooker may deem himself very fortunate in having at command so skilful an artist, whose abilities have undoubtedly been also exercised in tinting Mr. Sorby's beautiful drawings (141, 148). Mr. W. White is to be commended, year by year, for the plain, unvarnished, architectural drawings which he invariably sends; crude to a degree in finish, and scarcely less quaint in design. Nevertheless, under their somewhat unattractive garb there is sure to be found a vein of real good sense and meaning, which is generally wanting in more showy productions. Mr. G. L. Beetholme's drawings exhibit more of the picturesque artist than the genuine architect, nevertheless there are in both of them many good points of composition as well as detail. Mr. W. Peachey is a conspicuous exhibitor, not only of his architectural productions, but of his personal features, which are duly set forth in a carte-de-visite portrait, in an illuminated border, as a centre to a "Sheet of Photographs" (179), which would otherwise be probably overlooked altogether. Nor are the drawings (39, 65) of his competition design for the "Exchange at Middlesborough" more commendable, betraying as they do but little appreciation of the real secret of true art. Thoroughly contrasted with such attempts (and their name is legion) are the really clever and artistic conceptions of Mr. E. B. Lamb, who, as heretofore, is a liberal contributor to the exhibition. We must still, however, except the peculiar style in which he continues to invest his churches, which savours more of the domestic of a late age than the orthodox ecclesiastical character. His "mansions" and "residences" are picturesque in the extreme, and show the well-trained hand of a master mind. See the photographs of Nuneappleton, Yorkshire (42), and of the Manor House, Aldwork, near York (191), also Parkfield Place, Fawkham, Kent (78).

The additions to "Richmond Grammar School," by Messrs. Austin and Johnson (46) are in character with the old building, a good example of plain domestic Gothic of the Perpendicular age. In their new church, too, of St. Stephen, Newcastle-on-Tyne, shown in an exterior and an interior view (76, 82), there is the same correct appreciation of style, plainly but sensibly treated, especially externally, as evidenced in the skilful pen-and-ink view before us. Another bold pen-and-ink drawing is of an interesting and difficult subject,—the old staircase (17th century work) at Cromwell House, Highgate, as it existed before the fire of 1865, and to which Mr. T. Harris in his delineation (77) has done full justice—it is a complete study in its way; (80 and 81) are two large frames of photographs, the former, by Mr. Phipps, of Bath, exhibits the Militia Stores, Gateway, Guard House, &c., erected by him in that city for the 2nd Somerset Militia, and also portions of some semi-detached villas of careful design; the latter consists of no less than fifteen reductions from drawings of buildings designed by J. P. Jones, whose extensive and apparently expensive commissions are further displayed in (204 and 224), besides a series (217-220) of "Madrid Improvements," gigantic in scale, and satisfactory in appearance, provided they meet the requirements of the climate, which is perhaps open to question. There is too much prettiness about Mr. J. P. Pritchett's Gothic designs to render them quite satisfactory, as is evidenced in (47, 48); while the extravagant attempts at quaint originality in which Mr. Bassett Keeling delights to indulge are far less tolerable. Of late there have been symptoms of a subdued tone in this gentleman's works; and his Wesleyan Chapel at Dalston (50), which seats 1200 persons, and has schools, class-room, and chapel-keeper's house under, costing inclusively, as stated, only £4200, has really considerable merit; but the best of Mr. Keeling's executed works, so far as we know, is his "Church of

St. Philip, Camberwell," of which a complete series of plans, sections, and elevations, is given in (175—178); though the overhanging of the complete belfry stage is not altogether judicious.

Mr. Mocatta, in his Italian sketches, has supplied an interesting study; those from Milan Cathedral (91) especially. Nor should his "View at Amiens" (242) be overlooked. The greater part of the church of St. Cuthbert, Darlington, has been restored, we believe, by Mr. Scott; but Mr. J. P. Pritchett shows (93) the east end, as recently restored by himself. This church is well known as one of the finest examples of early work in the north of England; and it is gratifying to know that, from a very threatening condition, it has been made thoroughly sound, and restored, as far as possible, to its original design.

In a clever allegorical panel in the proscenium of the theatre at Nottingham, Mr. Holliday has depicted Shakespeare, with the principal characters from his comedies and tragedies, forming part of an architectural composition designed by Mr. C. J. Phipps, and here shown in a coloured photograph (98); the same frame containing views of the interiors of the theatres at South Shields and Nottingham. (101) Contains five photographs of recently-erected buildings by Mr. Thomas Harris; the originality in which partakes quite as much of blemish as is displayed in most things of the kind, too often wildly novel and proportionably unsatisfactory. "The Vicar's House, Lowestoft," in this series, is a case in point.

In the large gallery, the first subject is "the building designed for the International Exhibition, Bombay," by Messrs. Imbshaw and T. Roger Smith, shown in a cleverly coloured interior view (118), while (249) gives an exterior view of the same building. In both of these drawings, though there is much to remind one of the ordinarily received type of such edifices, particularly in the application of iron and glass, the modifications necessary to suit local exigencies have not been overlooked, and consequently there is an air of truthful novelty in the general aspect, which is very satisfactory. But by far the most important drawings in the room, and indeed in the whole collection, are those contributed from the recent competition for the New St. Pancras Station and Hotel for the Midland Railway Company, in the Euston Road. The designs which received the first and second premiums are exhibited at the Royal Academy, but there are here before us (taking them in the order of the catalogue) portions of the designs of Messrs. F. P. Cockerell, Owen Jones, and T. C. Sorby. That of Mr. Cockerell includes the general plan, but as it is hung above the eye, it cannot well be adequately examined. Considering, however, the magnitude of the scheme, the general arrangement seems dictated by the site, and one which, probably, most of the other competitors have more or less followed. Not so, however, the character of their respective elevations, which are widely dissimilar; the first-mentioned being gloomy, tame, and unpicturesque in the extreme. It is therefore the more to be regretted that this design is the most completely illustrated by the geometrical drawings also; while Mr. Owen Jones has none at all, and Mr. Sorby only a section of the passenger shed, and some beautifully-studied and coloured portions at large. Mr. Owen Jones's design is not intrinsically very striking, except in boldness, but it is made so by the masterly skill of the artist, who, in the interior view (128), has overcome with consummate ability a very difficult task.

Mr. Sorby's principal elevation differs from the others in its being more symmetrical, and planned on one continuous curve, whereas the others appear to follow more rigidly the precise outline of the ground. The style of the elevation is Italian—so far agreeing with the others by its side,—but there is a tinge of French detail about the windows and other parts, which is by no means unpleasing. In place of being able to examine the direct plan, we must content ourselves with portions of the author's description of his design, which he states to have resulted from a personal inspection of the principal metropolitan stations and hotels, in company with the managing officials of the various departments. The scheme of the plan of the railway office is based upon that of the Great Northern, containing a booking office 88 feet long, 55 feet wide, and 55 feet high, with an office for ticket clerks 40 feet by 30 feet.

"By placing the clerk's office central, first-class passengers have the great advantage of quietness, and being 'select,' an arrangement highly appreciated, and adopted in effect at Charing Cross and the new High Level Station at Sydenham, &c., with the most marked satisfaction. Contiguous are the branch telegraph, the station superintendent's office, and the first-class general and ladies' waiting rooms, both with direct access to the platform. Convenient lavatories and W. C. are provided for the use of both ladies and gentlemen.

On the second-class side are two waiting rooms communicating, and with direct access to the platform; also an easily accessible departure cloak room, with spacious entrance lobby communicating with platform and booking office. A conveniently placed cloak room is also provided on the arrival platform, with 'lost property' office adjoining.

The excursion or secondary booking office is 55 feet long, 25 feet wide, and 25 feet high, placed opposite the central platform; the ticket clerks' office being taken out of the adjoining rooms, leaves the space unencumbered (see drawing No. 1). A general waiting room, 30 feet by 25 feet, with ladies' waiting and retiring rooms, with the usual convenience, is attached.

An office, 32 feet by 22 feet, approached from the end platform, is provided for the divisional superintendent, within easy distance from the staircase to the company's offices.

An office 22 feet by 18 feet, is placed near the excursion booking-office for the G.E. agent; if requisite at any time, a staircase and another office of the same size might be constructed over, as there is ample height for the purpose.

Contiguous to the exit gateway, the exit staircase, and the arrival cloak room, is a convenient gentlemen's waiting room, with lavatory and dressing room attached, for the benefit of gentlemen arriving early from a long journey; similar accommodation is provided for ladies. W. C. and urinals are avoided in the gentlemen's room, as they are to be found close by. . . . . . .

"Experience at the Great Northern Railway proves that a long narrow lamp room is a great error, and the smell of oil a nuisance on the platform. I therefore propose a large square room, 32 feet by 30 feet, with a 10 feet passage way to the platform, placed in a central position, equally convenient for the lamping and unlamping of trains; this room would be floored with zinc on boards, and fitted up with stove shelves, brackets, sinks and counters, for every convenience of trimming, filling and repairing the lamps.

The principal 'outwards parcel office' is placed on the departure platform, similar to that at the Great Northern Railway and Great Western Railway, with this extra advantage, that a door at the end will enable large batches of parcels of private property, requiring special care, to be placed in a van on the outside rails before being attached to the train. A branch outwards parcel office is placed at the street level, at the corner of the Euston and Old St. Pancras roads, adjoining the 'inwards parcels office.' By this means, I should obtain parcels from the rapid passing traffic and light carts, offering the same advantages as the various 'town receiving offices,' and also helping to catch and divert parcels at present sent per Great Northern Railway or London and North-Western Railway by means of offering more conveniences to those passing that way than these lines possess. Parcels received here would be hoisted to the inwards office above on platform, and conveyed to their proper vans.

The principal inwards parcels office would be on the platform level, S.E. corner, where the parcels would pass through the books, then be sent down the hoist or sliding shoot to the office below for delivery into the carts. A similar inwards parcels office is placed at the north end of the platform, with hoists and shoots to the delivery office below; but this office I regard as more for the reception of fish, poultry, cheese, butter, eggs, meat, and articles of that description, and the trains from the north might be made up accordingly. The shops which I have indicated in the elevation drawing No. 3, are prepared for the sale of produce off the line, both wholesale and retail.

An entrance hall, approached from the carriage exit gateway, leads to a spacious and handsome staircase, lighted from above, for the directors ascending to the board room. A staircase for the public and company's employées is placed close by, with entrance from the platform.

At the head of the board room staircase is placed a room for board messengers, and ante-room to board room, with general waiting room for parties attending on appointment and dismissal days, and three or four private waiting rooms. The board room would be a handsome apartment, 37 feet long, with alcove end, 27 feet wide, and 17 feet high, adjoining which would be the committee room, 27 feet by 18 feet, and the partition between these two rooms would be made to slide bodily up, so as to throw the two rooms into one room, 56 feet by 27 feet, if requisite for a larger meeting. . . . . .

The structure throughout would be fire-proof, the floors being constructed with Dennett's patent arch on rolled iron joists, &c., with board floors over same in the rooms, and tiles or stone landings in corridors, &c. A lift near the public staircase brings coals from the basement to a small store on this and the other floors, and a shoot carries away the dust to a proper receptacle in the basement. The main transverse walls would be so arranged (and the intervening walls carried on girders, and so be removable) in this and the upper floors, that the directors could either add to their office accommodation by taking in rooms now set apart for the hotel, or alter the size of the rooms, or give up certain rooms and add them to the area of the hotel at various times, as circumstances might indicate, without interfering with the stability of the structure.

On the second floor offices are provided fer the company, subject to the last clause. . . . . . .

Entering the hall from the archway leads you at once to the bar and the grand staircase, and the groom of the chambers and hall-porter; opposite the bar is the entrance to the smoke and billiard rooms. Close by the foot of the staircase and the bar is the ascending room, and the lifts for luggage. Connected with the bar is the bar parlour, the manager's room, and a small private stair to the cellars, and lifts for wine, &c. Over the kitchen is placed the coffee room, a handsome apartment, 55 feet by 35 feet, by 21 feet high, adjoining which is a serving room, (with lifts from the kitchen,) and the still room. Opening out from the coffee room is a small library and reading room for gentlemen to retire to after breakfast. The remainder of this floor is devoted to dining rooms, a waiters' room, lavatory, W. C., and a bath room. The grand staircase and ascending room are taken up to the third floor, and the secondary staircase is planned to run the whole height of the house for hotel servants. Between the ground and first floors, along the frontage next Brewer-street, and towards the yard, I have provided for twelve bed rooms, 9 feet high, approached from the hotel staircase. These rooms are not shown on plan. A second bar is provided at the landing of the first floor, a feature that has been recently added at the Charing Cross hotel. Speaking tubes, small lifts, and a private stair communicates with the bar on the ground floor, and a small closet is added to the bar parlour. The ladies' coffee room with library adjoining same, for the use of families staying in the hotel but not having private sitting rooms, is placed over the principal coffee room, and has the serving room, with lifts from the kitchen and still room as below. Four private sitting rooms, 12 bed rooms, 1 dressing room, bath room and W. C., and housemaid's closet, are also provided on this floor in this section of the hotel.

I have proposed a feature in connexion with the hotel and terminal and 'head-quarter' station that has not, I believe, before been adopted, but the idea has in this plan met the cordial approval of the managers of the Grosvenor and Charing Cross hotels, and others interested in the development of similar matters.

There are a large number of gentlemen who run up to London for a few hours for business, who have no office where they can give a *rendezvous* or make an appointment; they therefore go to some hotel, transact their business, and spend their money. I propose to make special provision for this valuable class of custom, for the benefit of both railway and hotel. I have, therefore, reserved a certain section of the hotel, adjoining the railway station and offices on the first floor, where gentlemen entering from the platform or the railway offices, can have their private room, and make their appointments; where they can enjoy the luxury of a bath or lavatory after a long journey, finding every convenience close by; can lounge in the news room overlooking the platform, join the *table d'hote*, and while away an hour till the train starts, in the billiard room or smoke room. The railway would appeal to them as offering a great advantage, the hotel has good customers, and the man of business enjoys great convenience and comfort, saving his time and money in running about London. A ladies' or private dining room, on the same plan, with dressing closets, is also provided, and a staircase leads to a mezzanine below, where accommodation may be found for visitors' servants, and for the bar department. I also regard this arrangement as a matter of great convenience to the board of directors and superior officers, who thus have all the advantage of a first-class hotel at hand, and can take a friend in to dine, and wait their return trains, &c. The plan provides for extension of the scheme at any future time. The staircase and hoist leading to and from the platform are also continued up to the top of the house, and would be the ordinary means of exit from the hotel to the station, and entrance from the platforms to the hotel. . . . . . .

The second floor provides for 9 sitting rooms, 37 bed rooms, 4 dressing rooms, 2 housemaids' rooms, 3 bath rooms, and 6 W. C. On this and other floors there are suites of rooms, comprising sitting room, bed room, and dressing room, with option of a second bed room. These rooms all open upon a small inner lobby with outer door and bell, with the number in the fanlight over the door, as at Charing Cross hotel. The third floor provides for 5 sitting rooms, 45 bed rooms, 5 dressing rooms, 2 housemaids' rooms, 3 bath rooms, and 6 W. C. The fourth floor provides for 22 bed rooms, 1 dressing room, 1 bath room, 1 housemaids' room, and 2 W. C. 10 servants' bed rooms are provided in the pavilion roof. The total number of private lettable room is:—22 sitting rooms; 152 bed rooms; 12 dressing rooms or small bed rooms. In addition to which there are 8 bath rooms, and 38 W.C. All these rooms are exclusive of the special railway hotel accommodation."

The approximate estimate of the total cost is £245,000. We have ventured to transcribe thus largely, in order to show not merely the questions to be considered, and the difficulties to be contended with, but also the painstaking way in which they have, in this particular instance, been met—a labour recognised by the award of the third premium.

Mr. G. R. Green's "Keighley Town Hall" (150) is a bad adaptation of the New Town Halls of Northampton and Congleton, and not much can be said in favour of his two "District Churches" (234, 239). Mr. Petit's characteristic colour-sketches are as powerful and unmistakeable as ever, and he has done good service to the Exhibition from year to year in sending so many of the productions of his facile brush. "The Great Mosque at Damascus," and the "Tomb of the Mamelukes at Cairo," are especially noticeable. Of sketches in pencil, also the result of foreign tours, there are not a few, including a liberal sprinkling from Mr. Digby Wyatt (163, 188). There are also (to dismiss this subject) some very good contributions from Mr. Nattress (152, 153, 181); and Mr. R. W. Edis (160, 162).

Mr. Truefitt exhibits but one drawing (158), containing a sheet of illustrations of the bank buildings now in course of erection, from his designs, at Manchester. It is needless to remark that these, like everything of the kind proceeding from the same source, are at once original and satisfactory. In the case before us the chief feature is the treatment of an otherwise blank wall by a row of columns, and by masonry squared and dressed to pattern, in a simple but effective manner. The font for Llandaff Cathedral (166), by Mr. J. P. Seddon, is a vigorous conception, and quite in keeping with the character of the venerable edifice for which it is destined. A decided attempt at novelty, and, unfortunately, not a very successful one, has been made by Mr. W. White in his new District Church, now being erected in Aberdeen Park, Islington. The general outline is clumsy, and the dwarf central tower to such a building unmeaning; while the fanciful brick patterns on the interior surfaces are greatly exaggerated. In this building much has apparently been aimed at; and, as an almost necessary consequence, the result is less satisfactory than usual.

There are four drawings contributed to this exhibition by Mr. J. Drayton Wyatt: (85) being views of "the new church and parsonage lately drected at Weaste, near Eccles, Manchester," by Mr. Scott; (115) "St. Andrew's College, Bradfield, near Reading," showing the new "half-timbered" library, with studies and school-room, as proposed; to which is added a complete general ground plan; (131) an interior view of the "New Swimming Bath, now in progress of erection for Brill's Brighton Bath Company (Limited); and (229) an elaborate lithograph of the "Interior of Copley Church, near Halifax."

The Architectural Publication Society, and the Class of Design belonging to the Architectural Association, are both represented as usual on the walls. The latter are this year particularly good, and some so highly finished as to deserve a better title than mere "sketches;" proving the interest taken in the questions to be solved from time to time, and the degree of emulation evoked among the members who are wont to assemble.

Mr. Goldie and Mr. Pugin are exhibitors of sundry clever Gothic designs, each marked by the peculiarities of their respective authors, but each well worthy of examination. The "Augustinian Church, John-street, Dublin" (231), by the latter, is, in particular, a noble conception, well worked out. In four highly finished outline drawings by Mr. A. M. Ridge (206, 209), we are presented with the "Design for a Hall of Science and Art,' which received the Royal Academy gold medal, scholarship, and books, 1865,—an English Gothic composition, rather Venetianised in its details, which, beyond its careful delineation throughout, has not much to recommend it. Mr. Charles Barry reappears, in his "Dulwich College Estate Railway Bridges" (225); and Messrs. Banks and Barry, in their new "Westminster Chambers, Victoria-street;" and the extensive buildings now being altered by them in the "Piazza Statuto, Turin."

The Exhibition will finally close on the 30th instant.

MECHANICS APPLIED TO ARCHITECTURE.

By R. O. Harris, M.R.I.B.A.

(With an Engraving).

The object of this paper is to invite attention to the leading facts of science which guide to the economical and efficient modes of employing the various materials we have to deal with in construction. The nature of those most commonly used, the different strains to which they are subjected, and the forces producing them, in the parts of a building,—the force or weight applied, and the resistance, not only in framework but among the parts of the material, will have attention. This we will call the balance of forces, which leads to the consideration of its effect on framed beams, roofs, &c., or the balance of framework. The consideration of arches and walls, with the thrusts upon them, will also have some attention.

Force and the Balance of Forces.—Statics, or the science of balanced forces, may be simplified into weight and force, and a structure may be said to consist of an arrangement of material or weight to preserve a definite form, either by framing or the natural combination of the material within itself; and the investigation of the forces that are distributed so as to balance them, form the subject of this division.

The attraction towards the earth of a body, and the intensity with which it is attracted, is as its specific gravity or weight acting in a line to the centre of the earth; not only does the entire mass act, but also the parts of which the weight consists, as in the case of a beam spanning an opening. Imagine a line in the centre of it being composed of an indefinite quantity of points or centres of attraction equally heavy, and acting in the same downward direction, and considered as acting in lines parallel to each other; each of these centres are connected to each other by the natural cohesion of the material, and are collected at the centre, which becomes the centre of gravity of the line, and is always in the middle of its length. A rectangular beam (fig. 1, plate 21) then, being considered as made up of an infinite number of lines, has also its centre of gravity there. This system of finding the gravity of a beam by the action on its points applies equally to irregular shaped beams as well as regular, for example: if a beam be of this shape (fig. 2), or has more to carry at one end than another, where will be found its centre of gravity, or the position a column should be placed under it to make the best use of the material. It is evident upon referring to the diagram that the masses on each side of the centre line A must be equal, therefore a point that has the parts all around it balanced must be its centre of gravity; the proof of this is simple, for if the mass be suspended longways from B, its vertical line will be found in the direction of B C; if suspended at D, in the direction of D E; and a line drawn through the centre thus found will divide the beam into two equal quantities; a glance at the diagram will shew the correctness of this, and from whatever point the mass be suspended the vertical will cross the same centre. In triangular forms the centre is found by bisecting the sides, and drawing lines to the opposite angles, as in fig. 3, the intersection will be the centre and position of the vertical line A, if the mass or beam were supported at each end. The centre of gravity of a regular curved line is found by multiplying the chord of the segment by the radius, and dividing by the length of the arc, the fourth term giving the distance of the centre of gravity from the centre of the circle, for example, fig. 4 takes an angle of 90° A, whose radii, AB, AC, form the sides of a square each equal to 1, therefore the chord C B is the diagonal, and equal to 1·414, and the arc is equal to one fourth the circumference of the circle or 1·572; the formulæ algebraically stand thus:—

$$\frac{\overline{CB} \times \overline{AC}}{CBD} = 0{\cdot}9 \quad \frac{1{\cdot}414 \times 1}{1{\cdot}572} = 0{\cdot}9$$

giving the distance of the centre of gravity E $\frac{9}{10}$ from the centre of the circle, showing clearly that a circular line is not equally balanced in quantity about the centre of gravity line, except when suspended from D. The application of these results will be further spoken of when referring to arches, curved ribs, &c. &c.

The whole of the assumed parts into which we have imagined the beam divided are rigidly connected together, and act with equal downward force in the middle or centre line of gravity, and is considered equal to the whole load of the beam: this collection of the separate forces into one at the centre is called the resultant of the load, and must be necessarily equal to it—and a measure or a result of the combined forces acting on the beam in a vertical downward direction and for distinction is called the vertical force. The two supports also, dormant as they appear, exert forces in the exact proportion of the load they bear, and are called the resisting or supporting forces, being always equal to the applied or vertical force. The power of resistance in a body is said to be somewhat analogous to gravity, and wonderfully accommodates itself to the force it has to resist, exerting so much force as is required only. The exact balance of these two forces maintain the body in a state of forced rest or equilibrium, and are distributed throughout the beam in equal proportions.

We have considered as yet, forces acting vertically only, and irrespective of their intensity and direction. The laws of oblique forces, or forces acting at an angle with the horizon, differ essentially from the former, for their direction and intensity being given, we have to find a third that shall balance them, or one being given and the other two in direction only, the amount of force each requires to balance the given one. Let two forces be inclined to a vertical, and represented by two lines, AB, AC, Fig. 5, whose position indicate the direction and whose length show the amount of force in units of a given weight. By drawing the lines CD, BD, parallel to the two given lines, a parallelogram will be formed whose diagonal AD will represent in direction and length the force required to balance the two given ones, and is their resultant.

A very practical and simple experiment will demonstrate the correctness of this law, upon which depends the whole system of the parallelogram of pressures, so particularly applicable to construction.* If a vessel of water be filled to the brim, and a flat board be floated on its surface, with three strings attached to it in any position by the pins 1, 2, 3, fig. 6, now fasten three strings to them adjusted so as to pass over pullies at the side, at A, B, C, and attach different weights at the end of each. The first thing to be observed is, that if the three lines are produced they will meet at a common centre at O, and if A be extended to represent inches in length the lbs. weight at A, and DO at B; complete the parallelogram of which these are the sides, when it will be found that the two lines will intersect at F, and the diagonal FO will be equal to the third force.

The foregoing rules given refer to forces in a horizontal plane, and are difficult of application to building, where the neutralisation of gravity is the chief consideration. I have not been able to apply to my satisfaction the rules generally given for the parallelogram of forces, but I think the following a practical one, and easy of application, if not original. In the first place, the horizontal beam of a given weight, say 2 cwt., rests upon two supports with a force of one cwt. each, this we will call its horizontal thrust or pressure, AB, fig. 7, while its vertical pressure will be represented by AC, which is the entire weight of the beam, or 2 cwt. It is evident that in passing through all the angles of the quadrant half the weight of the beam is gradually increased from the other half, until it merges into the total weight of the beam in the vertical position upon the support A, and at every angle a portion of the weight acts with a force tending to turn the support A. over at a loss of downward pressure on B. It will be seen on reference to the diagram, that when at an angle of 45° with the horizon, the two lines, DE, EF, perpendicular to the vertical and horizontal lines AB, AC, are equal, but the pressures are not equal, for half the weight of the beam is still upon the support (A) but increased in the proportion of the sine of the angle DE, taking half the beam as a radius. The amount it requires to make up the two cwt. being its pressure on the support B; for example, the angle of 45° whose radius equals one cwt. or half the length of the beam, the sine of that angle is the line DE, and equals ·707, therefore the pressure on the support (A) equals 1·707, and on B if it were raised to it would be the difference or ·293, and the outward thrust on (A) ·707. The application of this rule to a pair of rafters will be in precisely the same manner, of course considering the two pressures that meet at the junction of the rafters as vertical pressures, and equal to each other. Should each side not be the same angle, the method of proceeding would be still the same, but the different downward pressures at the apex require to be neutralised, which may be done by diverting the pressure there at another angle, which will be treated of more fully in its place on the balance of framework.

Another very important force, of which we are continually seeing the effects, claims a large share of our attention, that is the principles of leverage or the theory of couples. I regret not being able to treat of this branch more fully, having limited myself more particularly to the application of practical rules to construction, giving just so much theory only as is required to show the means by which the conclusions are arrived at, and to render the subject traceable to more detailed works. Two equal forces acting in opposite directions, but not in the same line of action are called a couple. The two forces in a beam, for instance, the vertical and supporting pressures as before described acting in the direction of the arrows AB, fig. 1, while the distance between them is called the arm or leverage of the couple. You will readily perceive that if the beam were extended along to D, the

* Moseley's Mechanics.

force at D, would tend to turn it on the base or fulcrum C, and the distance BC, multiplied by the force applied, is called the moment of that force, hence a beam fixed at the ends is doubly as strong as one merely supported, because the leverage is equally balanced. Suppose a mass of stone or any other material, fig. 8, were required to be moved, say on a centre at (*a*), and require forces to move it 40 lb. each applied in the direction of the arrows b b_1, the leverage will be equal; but if, instead of applying the force at b, it is exerted at c, it will require 70 lb. to produce the same effect as b_1 does, and a corresponding alteration in the upper force c, to produce only a force of 10 lb. Taking then each of the divisions as representing 10 lb., multiply the weight on one side by the divisions on the other; the result is the moments of the forces.

Before applying the foregoing rules to construction, I have to ask your attention to a few remarks on the strength of materials. There is no part of my subject of greater importance than investigations connected with the strength of materials; the resistance to forces variably applied is first ascertained by practical experiment, and upon it depends the most satisfactory demonstration of the rules deduced therefrom—and what are called the *measures* or *moduli* of strength to resist force in a given direction. Whatever be the position of the force or load with respect to the material to be acted upon, the resistance or tendency it has to recover its original state is called its elasticity. When the force applied is not so great as the direct elasticity of the material, the body is said to be elastic (to a certain degree) if the load is increased beyond this fracture ensues. I may here mention that the laws of elasticity applied to a sphere equally apply to a beam, for if it is compressed transversely it lengthens longitudinally—and *vice versâ*. The load applied to cause fracture is called the breaking load; and the load that may be applied with safety, without injury to the material, is called the proof load.

The different ways a material may be injured or broken we may reduce to two: that where the force is applied longitudinally, and transversely. By the first we may have tension—tenacity or resistance to tearing,—and compression or crushing by a direct thrust. The force applied transversely produces three principal kinds of fractures:—1, distortion or shearing (that is the sliding of one part on another); 2, twisting or wrenching; and 3, bending or breaking across. The following table* will give the moduli of strength or the force under which a given material begins to yield or fracture. The experiments being made or reduced to the application of the force in pounds on the square inch, in the case of breaking across they are reduced to bars one inch square and one foot between the supports.

	Extension Tension, Tearing or Tenacity.	Compression or Crushing engthways	Cross-breaking.	Shearing.	Modulus of Elasticity. Stretching.	Modulus of Elasticity transversely Distortion.
Red Fir	13,000	5700	472	650	1,600,000	
Oak	15,000	10,000	700	2300	1,400,000	
Cast Iron......	16,000	112,000	2222	27,700	17,000,000	2,850,000
Wrought Iron	60,000	38,000	2333	50,000	29,000,000	9,000,000
Sandstone ...	...	4400	83			
Slate	10,000	...	280	...	15,000,000	
Brick	290	900				
Limestone ...	...	4000				
Mortar	50					

There are three principal forces which are generally comprehended under the word *stress*:—1st, thrust or compression, when each pushes the other towards the centre; 2nd, tension or pull, when each draws the other; and 3rd, shear, when each draws the other on itself.

* This table has been generalised from Telford, Tredgold, Rankine, and Moseley's works on practical mechanics.

The strength of timber depends on the adhesion of the two tissues, the fibrous and cellular, arranged in alternate rings. The fir woods are those mostly that contain turpentine, the fibres are straight, and their resistance to tension is considerable, being nearly that of oak; but the adhesion of the fibres to each other is very small, their consequent resisting power to shearing is but 650 lb.; whereas in oak it is 2300 lb.: a fact to be borne in mind when the force at the end of a tie beam is great. The tenacity of the fibres to each other of oak, and its durability, give it an advantage over fir, particularly for columns; but its proportion for bearing a transverse load is not sufficient to compensate for its extra cost over fir.

The strength of cast-iron is remarkable, as having its resistance to tension so small (16,500 lb.) as compared to crushing (40,000 lb.) Also the greater tenacity of the skin or exterior of the beam than the interior. Wrought-iron, like other fibrous substances, has more tenacity along than across, and its resistance to tension (60,000 lb.) is greater than to crushing (38,000 lb.)

On Beams and Girders.—In a former paragraph has been described the weight or load of a beam, and its resisting pressures. We have now to deal with the action of a transverse load upon it. The gross load is transmitted by the beam to the piers, in the proportion of its distance from the walls; the force of gravity acts upon it, drawing it down in the centre, causing a compressive stress in the upper part and a tensive stress in the lower, acting against each other, and at the division of these two actions is a neutral plane or neutral axis, as it is generally called, which will be situate in the depth of the beam proportionate to the tensive and compressive strength of the material; or in other words, reduced from the formula, the sum of the tensive and compressive moduli of strength is to each of them as the entire depth to each of the depths. For example, a beam of fir, 10 ft. long, 4 inches × 4 inches, calling T the tensive force of the material, and C compression, Dt tension depth, and Dc compression depth: then,

$$(T + C) : T : C :: D : Dt : Dc$$
$$18{,}700 : 5{,}700 : 13{,}000 :: 4 : 2{,}219 : 2{,}775$$

and the neutral axis of the beam will be nearly $2\frac{3}{4}$ in. from the bottom and $1\frac{1}{4}$ in. from the top; this may be taken as a fixed rule for fir—that the neutral axis is in proportion to the depth as 11 to 5, the greater depth being at the bottom. The two strains in a beam on each side of the neutral axis are found to be equal but vary in intensity, and are called into action by the load on the beam, which, if supported at both ends, will cause a strain equal to half the weight, multiplied by half the length or leverage, thus: $S = \frac{1}{2} W \frac{\frac{1}{2}L}{D}$ or $\frac{WL}{4D}$ will give the greatest strain on a beam with a load in the centre. Example: In the former beam 10′×4″×4″, what transverse strain will 100 lb., placed in the centre, cause? 50 lb. or half the weight of the beam by 60 in., half its length or leverage, divided by 4 in., the depth of the beam ($50\frac{60}{4} = 755$ lb.), will be equal to 755 lb., the strain acting upon the fibres of the material in the centre; the breaking load of the beam is 2,560 lb.; therefore, the working load should not be more than 643 lb. or $\frac{1}{4}$. It must be noted that this is the central strain, and that it gradually diminishes towards the supports, where it disappears.

It is clear then that a beam will be equally strong for a central load if its depth be regularly diminished from the centre to the ends, as diagram fig. 9.

If the load upon the beam should not be in the centre, the entire load will be distributed on the two walls, in the proportion to the distance from them, inversely; for instance, 100 lb. placed at one fourth the span will give 75 lb. pressure to its nearest wall, and 25 lb. to the opposite one. The strain at the various points will be given by multiplying the proportion of the weight transmitted, by the distance of the weight from the wall, and dividing by the depth of the beam, thus: $\frac{75 \times 30}{4} = 562$, and $\frac{90 \times 25}{4} = 562$ lb. the strain on the beam at the point with the weight there. With regard to beams with the load uniformly distributed (which we have generally to consider in practice) it is a law in mechanics that an equally distributed load on a lever is equal to the same load collected midway upon the length of the lever, as at A, fig. 10; therefore the strain induced on a beam equally loaded with the same weight is only half of that concentrated at the centre, and the value of the previous formula becomes doubled, thus, $\frac{WL}{8D}$ equals the strain on the centre; this also diminishes towards the ends, but not in the same regular proportion as the central loaded one, but in exact proportion to the verticals from an ordinate of a parabola, which gives the shape of the top, when the material is so distributed to counteract the strains induced. We have the strain in the centre given in the expression $\frac{WL}{8D} = 1$, (Fig. 11), the ratio at the other points is found by dividing the product of the two lengths l_1, l_2, into which we divide the beam by the square of half the length, and this expression will give the height of any vertical required, $\frac{\frac{1}{2}L^2}{l_1\ l_2} = S$, or the strain at that part; thus, dividing a 10 ft. beam into 10 equal lengths, and start with the strain in the centre as 1; the following give the height of each of the verticals:

$$\frac{24}{25} = \cdot 96,\ \frac{21}{25} = \cdot 84,\ \frac{16}{25} = \cdot 64,\ \text{and}\ \frac{9}{25} = \cdot 36$$

thus forming a parabolic curve at the top. Not only showing, but perfectly demonstrating, this truly scientific and useful law.

The principles of leverage are closely connected with the strains on beams. A plain beam fixed in the wall in the position of a cantilever breaks with x lb. applied at the ends; and $2x$ lb. with the weight equally distributed. In a beam twice the length of the cantilever, and twice the load, $2x$ would break it applied in the centre, and $4x$ if it were distributed, and $8x$ if the ends were rigidly fixed; this is sometimes given as $6x$, making allowance for the impossibility of almost rigidly fixing the beam.

So far then as we have gone it will be seen that the few rules given are really self evident, and not so perplexing as some practical men would lead us to infer when fully acquainted with the causes that produce the different results in experiments on the same material. So entirely are we dependent on the skill and accuracy of the experimenter, as well as the state of the material at the time, that it becomes a matter of the greatest consideration whose experiments we adopt. They certainly should be those whose means of application and accurate skill have born the test of many years. Telford, the engineer, in his memorandum book collected many useful data on the strength of materials, particularly oak and fir; Fairbairn and Hodgkinson being the chief authorities on ironwork. The table given above is made up from Professor Rankine's work on Applied Mechanics, and is well considered. The method of arriving at these measures or moduli of strength, is to find the breaking weight in pounds of a bar one inch square and one foot between the supports for cross breaking, giving the result in foot-pounds, and for crushing and dragging in pounds on the square inch or inch-pounds, as strains are generally calculated. Oak and fir being the principal timber used in building, will have attention now, iron being deferred until speaking of iron structures, bearing in mind that the same general rules apply to all materials. Telford gives the cross-breaking weight for oak as ranging from 160 lb. to 584 lb., and later Rankine gives 700 lb. (see table). So if we take 600 lb. for oak and 450 lb. for fir as constants of strength, we have a fair average on the safe side of the breaking weight. The causes of the difference of the constants varying first, are condition or quality, which is as the specific gravity when seasoned or free from sap, next that the heart of wood is stronger than the outside, and lastly, that even the outside of a tree differs in strength, that portion exposed to the sun having its fibres and tissues stronger.

We have seen the number of fibres in a square inch of section that will break or fracture with a known weight a bar one foot long. We have now to consider the effect on a longer bar and of larger sectional area. Telford gives a bar of oak 8 feet long and 5 inches square as breaking with 9787 lb., against which theory sets at 650 lb. to the inch section, 9797 lb. for 16 feet long, 4350 lb., against theory 4461 lb., and for 24 feet long 2162 lb., against theory 2400 lb.; which proves sufficiently near for all practical purposes that the strength of a square or rectangular beam to resist cross-breaking is as the breadth by the square of the depth inversely as its length. Thus a beam twice the width of another, all other circumstances being equal, is twice its strength, whereas twice the depth gives four times the strength, and twice the length equals nearly half the strength. Taking the 16 feet beam above referred to, and calling W the breaking weight equal to 651 lb. to one foot long one inch square, B the breadth in inches, D the depth, and L the length in feet, then

$$\left(\frac{WBD^2}{L}\right) - (\tfrac{1}{5}LBD^2) = x,$$

or, in figures, an oak beam 16 feet by 5 inches by 5 inches, will have 4461 for the breaking weight in foot-pounds, one fourth of which only should be used in practice.

$$\frac{651 \times 5 \times 25}{16} = 5086 - (5 \times 5 \times 25) = 4461 \text{ lb.}$$

Timber beams to carry heavy loads are strengthened by iron or trussing, so as to increase their rigidity, also frequently by cutting down, reversing, and bolting together, which from the principles already advanced, you will perceive must be next to useless, if it does not tend to weaken. Another method is to connect with it a more rigid material, as oak or iron. In the case of fir, or oak and iron, the calculation will be simple enough, merely by finding the sum of the strength of the two materials. In the case of trussing, whether above, below, or within the beam, the actual strength of the wood is increased by the separate strength of an iron rod truss, which on the top will be in tension and when at the bottom in compression, the strength of which will be hereafter described under trussing: the actual tie bar being replaced by the material of the beam in the place of a king truss the beam can only be equally strong throughout for a central load, therefore a queen truss is preferable where the load is distributed.

The balance of framework may be commenced with two inclined timbers, as the rafters of a common roof (strictly it requires not less than three timbers to form a frame, but the thrust of these are so closely connected with framework that I have introduced them here). The permanent or distributed weight on a roof is generally calculated at 40 lb. to the superficial foot and taken from centre to centre of trusses or rafters as the case may require. The two rafters are taken at 10 feet long, and at an angle with the horizon of 30 degrees. The weight each rafter bears is 400 lbs. First, as to the scantling required, which must be calculated for the proof load, or one fourth the breaking load, (I may add that this method of proceeding applies to all beams on two supports when the weight to be carried is known) this makes the load to be calculated 1600 lb., and an inch bar of fir one foot long breaks with 450 lb. applied in the middle, therefore the following formula (as before given) $\frac{450 \times B \times D^2}{L}$ equals the breaking weight, or 41 lb. for each bar 10 feet long and one inch square, doubling this for 2 inches the breadth of the rafter gives 82 lb., which multiplied by 2 inchs deep or 4 equals 328 lb., by 3 inches deep or 9 equals 738 lb., by 4 inches deep or 16 equals 1312 lb., by 5 inches deep or 25 equals 2054 lb., a little over what is required; therefore 5 by 2 will be sufficiently strong for the rafters of a roof having a 10 feet bearing. Tredgold gives common rafters with a 12 feet bearing, 6 inches by $2\frac{1}{2}$ inches, which considering the heavy scantling generally given by him, the working out shows is a very fair approximation to the actual strength required. Now as to the actual weight upon the walls, the horizontal and the vertical thrusts. First, as to the direct weight, imagine the rafter divided into four equal parts, each representing 100 lb. Dividing it into pound divisions from the centre b, let fall the perpendicular $a\ b$, fig. 12, which will be the sine of the angle, and equal in length to ·5 supposing the distance $c\ b$ to be the radius, and equal to 1, from b as a centre transfer the length $a\ b$ to d, which will make it equal to 1·5 or $\frac{3}{4}$ the length of the rafter, therefore equal to 300 lb., which is the proportion of the weight upon the wall acting in the direction $c\ d$, the remaining 100 lb. being the vertical weight or pressure from the apex or upon another support placed there.

The amount of thrust the rafter would have upon the wall c will depend on the angle of the slope and the consequent leverage. You will observe, as shown on the diagram (fig. 13), that the greatest force required to hold the horizontal beam in its position, by a weight at A, is greater than at any other angle; therefore the greatest tension and compression is exerted as the pitch of the roof becomes flat. The line AB represents half the total weight on any roof, DC will represent the tensile strain, and BC the compressive strain. This is known as a diagram of force, and, as you will observe, dependent on the parallelogram of forces. Referring to our former diagram, we require the thrust on the wall—form a diagram of forces, and make *e f* equal to 800 lb., the total weight; then *e h* will represent compressive and *g h* tensive strain, the horizontal thrust being equal to it. To confine the feet of the rafters, and convert this outward thrust into a vertical pressure, the tie or tension beam is connected to them by a notched joint, the force is then exerted to shear off the end piece, unless secured with straps; the resistance to the force is by the adhesion of the fibres of the wood to each other, the resistance to shearing being 650 lb. to the square inch, one-tenth of which only should be trusted, as a force suddenly applied acts powerfully in the shearing of the wood.

In the case of a king-post truss, the weight being ascertained, the former rules for finding the compressive and tensive trains on inclined timber are just the same—as the span is wider, the ties and principal rafters require supporting by struts and rods. When the truss is merely a triangular frame of three bars, the load is considered as concentrated at the apex, but when braced or strutted, so as to portion the weight equally at the junction of the braces with the rafters, this causes the compressive and tensive strains in the tie and rafters to become greater as they near the supports, and decrease to the centre.

In an ordinary king-post roof, with a span of 30 ft. and a rise of 8 ft.—let the lines in the diagram, fig. 14, represent the centre lines of the timbers, with a total weight on the ridge of 20 cwt., to be divided on four bays of the rafters—giving 5 cwt. to each.

To find the strains on the timbers, you proceed as follows:—1st, the tie beam, determines the greatest, which will be at *a a*, and let the letters denote respectively—the rafter, half tie, and rise, L being the gross load—then tension or $t = \frac{LT}{2R}$ at *a*; and $\frac{1}{4}$ less at *b*; or calling N the number of bays $\frac{t}{N}$ deducted from the first gives the strain on that portion, and so on for any more bays required. The compression is found in precisely the same manner: $C = \frac{LP}{2R}$ for the first, and $C = \frac{LP}{2R} - \frac{C}{N}$ the strain on the tension rod.

To apply these rules to a roof of 60 ft. span, fig. 15, without intermediate supports—first find the angle with the horizon the roof is to be, say a rise of 20 ft., by which you find the length of the rafter—twice this, by the distance between the trusses, say 9 ft. by 40 lb. per foot, or nearly 12 tons, without the weight of the trusses; the rafters, 36 ft. long, have to be supported in not less than four bays, giving them a 9 ft. bearing—how to obtain the scantling of them, as well as the purlins, has been described—the strains on the truss timbers then enable us to find their scantling.

The tensive strain on the tie beam is equal to load × half the span divided by twice the height $\frac{12 \times 30}{40} = 9$ tons for the roof alone, pull or tension on the tie beam, and the strength of fir in this direction is very great, requiring about 5 tons to tear asunder a bar 1 inch square: therefore a bar having 12 square inches in it would be amply strong to resist the tension—it has though a 15 feet bearing, probably a heavy ceiling, loft, or floor to carry, allowing then 1 cwt. per foot super for this, we have 30 tons to carry, multiplied by 4 for the safety load=120 tons.

The usual calculation for floors to carry a distributed load for general purposes is 1 cwt. per foot superficial; then, taking the floor joists as 15 inches from centre to centre, and the bearings as 10 feet, we have $12\frac{1}{2}$ cwt. on each joist calculated in the usual way, as before given, we have then a gross weight of 130 tons to calculate for in strains. Taking for certain that the whole is in equilibrium, and all the strains neutralised and converted into vertical pressure—taking 8 inches for the thickness of the timber—what will the depth be? 15 ft. is the greatest distance between supports, represented by L or length in feet, B equals the breadth or 8 in., and 1·47 represents nearly $1\frac{1}{2}$ cwt., nearly the constant or strength of fir—then D equals $\frac{L}{\sqrt[3]{B}} \times 1{\cdot}47 = D$ or $\frac{15}{2} \times 1{\cdot}47 = 11{\cdot}025$, or 11 for the depth. Let us now suppose the central tension rod removed: $\frac{30}{2} \times 1{\cdot}47 = 22{\cdot}05$, which would require secondary trussing or otherwise strengthening, so as to reduce the depth, or else increase the width.

For the principal rafter—let the former letters apply as before, but change the constant to decimal 0·96 $\frac{L^2S}{B^3} \times 0{\cdot}96 = D$, S equals the entire span—in figures it stands $\frac{81 \times 60}{512} \times 0{\cdot}96 = 9{\cdot}114$ giving 9 inches for the depth of the rafter, or 9×8.

For a king-post you find the sectional area A, which will be equal to the length of the piece in feet by the span of the roof × decimal ·12, or tensile constant $LS{\cdot}12 = A$, $10 \times 60 \times {\cdot}12 = 72{\cdot}00$, then the breadth is equal to the area divided by the depth, and the depth is equal to the area divided by the breadth; thus:

$$B = \frac{72}{D} \text{ or } \frac{72}{9} = 8, \text{ and } D = \frac{72}{8} = 9,$$

showing the king-post to be 9×8: in the case of a queen-post, the tensive strain being divided in two parts, the sectional area can be smaller, or found thus:— the length of the queen-post multiplied by $\frac{1}{4}$ the length of the tie beam, or that portion carried by it—$A = Ll{\cdot}27$ or $10 \times 15 \times {\cdot}27 = 40{\cdot}50$, or nearly half the sectional area of the king-post. The straining piece acting entirely in compression, is found by extracting the cube root of its entire length, multiplied by $\frac{1}{2}$ the span, and by ·9 as constant, $\sqrt[3]{LS\frac{1}{2}9} = D$, or depth, and the breadth by multiplying the depth by ·7, thus we have $\sqrt[3]{30 \times 30 \times {\cdot}9} = 9{\cdot}32$, or depth, and the breadth by $9{\cdot}32 \times {\cdot}7 = 6{\cdot}52$.

Lastly, the struts or braces are found by finding the square root of its entire length multiplied by half the length of the principal rafter it bears, and the width by multiplying the depth by ·6, thus, $\sqrt{Ll\frac{1}{2}{\cdot}8} = D$, and $D{\cdot}6 = B$, or $\sqrt{9 \times 9 \times {\cdot}8} = 8$, or the depth, and $8 \times 6 = 4{\cdot}8$, or the breadth.

In the case of a polygon roof, where the directions of the strains vary, and are in the line of angle, it is necessary to form a diagram of forces, Fig. 16, from which the different strains may be measured or worked out in trigonometry.

Imagine an ordinary curb roof, Fig. 17, whose rafters equal 10 feet in length, and supporting 4 cwt. each, as shown at A B C D—1 2 3 4 5 representing the joints or centres of resistance, from 0, as a centre draw four lines equal in length to 4 cwt. (or another weight as circumstances require), and parallel to the line of direction of the given slopes, and represented by OA, OB, OC, OD, OE; join the extremities of those lines, and the sides 1 2 3 4 5 of the polygon figure will be equal to the forces applied at the joints to hold them in, acting in the direction of the arrows. If the forces applied act in a vertical direction, the polygon A B C D E merges into a straight line, the line AD, Fig. 18, representing the vertical force or thrust of the gross load, and OH its horizontal, the part AB, BC, CD, the vertical forces required at joints 1 2 3: if the load were unequally divided upon the two supports, the proportions would be represented by DE, EA, the other forces being proportionate—if the tie E is omitted, the diagram of forces is shown by omitting the lines that represent the horizontal thrust; that is DE, EA, and OE for inclined forces, and OH for the vertical; the supporting forces being represented by DO, AO respectively. For this, and the rules on the polygon of thrusts, I am indebted to Professor Rankine.

Gothic Roofs.—In the case of Gothic roofs, when the tie is fixed above the springing in the form of a collar, the thrust at the bottom is in some cases very great, and the roof requires to be patched and braced to enable it to stand without throwing over the walls, showing that a Gothic roof, however pretty and attractive it may appear, is not so perfect in construction as the ordinary class of trussed roof. I do not wish to be understood that this class of roofs cannot be made perfectly sound with bolts, straps, and braces when required to make them rigid, but it is opposed to the simplest and best laws of construction.

The thrust on the wall of a plain rafter and collar roof, Fig. 19, is not difficult to resolve, for the total weight from the apex to the collar must be first ascertained by the methods before given, which forms the vertical of the diagram, and equal to half the weight of the upper part of the roof, or one-fourth the gross weight, when the collar is half the distance up, and proportionately for any other distance; then the triangle, *a b c*, represents the strains and thrusts on the upper part, which is considered as a secondary truss, but still acting in a line with the rafters; half the lower part of the truss (without the tie beam), being equal to one fourth the gross weight, is equal to half the above from *a* to *b* (because the vertical only represents half the diagonal of the parallelogram). The consequent strains at the springing of the roof are represented by the triangle *a e d*, supposing *a d* to equal three-eighths of the gross weight of the roof, or the force tending to throw over the wall at each sides *e d* of *a d*.

In the next figure, 20, is given a more complicated form, with hammer beams, wall braces, &c. First form the diagram of forces for the upper part of the whole truss, which, for simplicity, we will divide as before into equal parts, taking three-eighths the total load at once for the vertical. Draw *a c* paralel to *a c*, *c e* paralel to *c e*, and *a d* paralel to *a d*, then will the triangle *a b c* represent the forces at the springing of the roof; *a c*, *a e* giving the inclined strains, *c b* the horizontal strains, and *a b* three-eighths of the gross weight. The triangle *a d e* giving the strains on the upper part of the truss, you will observe the assistance given to the inclined thrust by the hammer-beam bracing, converting it into a vertical one, and reducing the horizontal strain. The curved braces certainly tend to strengthen the truss, but depend upon the cohesion of the material, bolts, &c.; therefore not generally considered in relation to the direct strains, but properly secured in at the joints, and supposed to be straight; the strain in that direction will be given by the line *c e* in the diagram of forces.

Arches and Walls.—If two cubes of stone (Fig. 21) be so placed as to touch another block half the size, as in the sketch, the block *b* will be sustained by them, by reason of the inequality of the granular surface or friction, with a force equal to twice its weight, its consequent tendency is to push the two outside cubes in a horizontal direction equal to that force: if a succession of these stones (Fig. 22) when placed together and supported at the ends, by an immovable abutment, we have an example of the straight arch or plate bande, if the span of the arch at top be divided into four equal parts, and we join *a b*, it gives the direction of pressure of the arch upon the abutment. If we construct a diagram of force upon the top, whose side *d c* equals *a b* and its length *e d* equal to half the span of the arch, then if we suppose it to be of the same material as the stones of the arch, then it will be equal to the whole pressure on the abutment (*a*) in the direction *a b*. Again if the height be made equal to *c b*, the parallelogram *e f*, it will be equal to the horizontal outward thrust. The resistance of a pier is of course dependent on the direction of the force applied. Let the arrow in sketch (Fig. 23) represent that direction, for simplicity say an angle of 45°, then supposing the resultant of the horizontal and vertical forces to be represented by that line, they will be equal to each other, then the line of resistance in a pier or wall will be an hyperbolic curve represented by the dotted line in the direction of the arrow. Should the direction of the force not be at an angle of 45°, let the dotted portion above the pier represent the proportion of the vertical (*d e*) to the horizontal forces (*d c*). From the centre of the pier set off a distance *a b* equal to the horizontal force *d c*; *f* then will be the centre of the hyperbola, and the vertical *f g* will be its asymptote. The property of this curve being that it is always approaching but never touches its asymptote; therefore, while this line is within the pier or wall, the line of resistance is, and no force in the direction and quantity given can overthrow the mass. Supposing that the horizontal thrust to give the vertical outside the wall (as in Fig. 24) it must be either reduced in height, or a buttress must be added to bring the line of resistance within the wall. Taking *a b* as before to represent the horizontal thrust, let fall the vertical *b g*, join *b h*, and draw *a i* parallel to *b h*, and draw in the hyperbolic line *d g*, which will indicate the height of the given wall to resist that pressure, or the amount of buttress required to give the pier its requisite strength. I am sorry time will not allow me to pursue this subject further just now, as I have a little to say on arches.

The friction of an arch stone is considered horizontal up to an angle of 30° from its springing, because a mass of stone will stand upon an inclined plane at that angle without moving down. Taking then a semicircular arch, with the stones containing 20° each. Stone 1, next the springing sustains itself on a horizontal bed. Stone 2 is also considered the same, as it is under an angle of 30°. They do also resist a horizontal thrust equal to half their weight. Stone 3, being on a bed at 40°, requires a horizontal force to maintain it in equilibrium, that will be found in the equation, that the force is to the weight as the line of 10° is to its cosine:

$$W : T :: \sin 10^\circ : \cos 10^\circ$$

and so on for the remainder. This will enable you to find the horizontal thrust of any arch, which if the piers are not calculated to resist, throws them out at the springing, and the arch in at the crown, causing it also to open at the haunches.

Those wishing to pursue the subject of Arches, Piers, &c. will find them ably treated by Professor Moseley in Vol. 6 of the "Cambridge Transactions," Rondelet's "Art of Building," and Rankine's "Applied Mechanics," Tredgold, and Telford's memorandum book,—works to which I gratefully acknowledge my obligations in the preparation of the foregoing notes.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

At the ordinary general meeting of the Royal Institute of British Architects held on the 30th of April last, A. J. B. Beresford Hope, M.P., President, in the chair, the Royal gold medal for the year 1865 was presented to M. Digby Wyatt, F.S.A., of Tavistock-place, Tavistock-square, Fellow, and the other medals and prizes as follows:—To Mr. Charles Henman, junr., of Bedford-place, Croydon, the institute medal with five guineas; to Mr. Arthur Baker, of Inkerman-terrace, Kensington, the institute medal; To Mr. M. H. Renault Mangin, of Nottingham-street, Regent's-park, the late Sir Francis E. Scott's prize of ten guineas; to Mr. J. S. Nightingale, of Parliament-street, the students' prize in books.

The following paper was read at the meeting, by Prof. Robert Kerr, Fellow: "Remarks on the evidence of architects on the obstruction of Ancient Lights, and the practice of proof by measurement, with reference to recent cases in the courts of equity." The discussion on Mr. Kerr's paper, to be commenced by Prof. T. L. Donaldson, past president, was adjourned till Monday, the 28th of May.

At the annual general meeting, held on the 7th of May, 1866, A. J. B. Beresford Hope, M.P., President, in the chair, the following office bearers were elected for the ensuing twelve months:—As President, A. J. B. Beresford Hope, M.P., Honorary Fellow; Vice Presidents, T. Hayter Lewis, D. Brandon, J. Fergusson; Honorary Secretaries, John P. Seddon, Chas. Forster Hayward; Honorary Secretary for foreign correspondence, C. C. Nelson; Treasurer, Sir W. R. Farquhar, bart.; Honorary Solicitor, Frederick Ouvry; Ordinary members of Council, A. Ashpitel, E. M. Barry, A.R.A., F. P. Cockerell, J. Gibson, E. B. Lamb, E. Nash, Wyatt Papworth, J. Peacock, J. Spencer-Bell, A. Waterhouse, J. Whichcord, W. White, M. Digby Wyatt; country members, M. E. Hadfield, Sheffield, R. M. Phipson, Norwich. Auditors, E. H. Martineau, Fellow. T. H. Watson, Associate. As examiners under section 33 of the Metropolitan Building Act, 1855, the three Vice Presidents, and Messrs. C. C. Nelson, A. Ashpitel, C. Fowler, jun., J. Gibson, J. Jennings, H. Jones, E. Nash, H. Oliver, J. W. Papworth, J. Spencer-Bell, J. Whichcord, G. B. Williams, S. Wood, and the two Honorary Secretaries. Votes of thanks were passed for the services of the President, Vice Presidents, Honorary Secretaries, Ordinary members of Council, and the other office bearers during the past year.

At the ordinary general meeting held on the 21st ult., David Brandon, F.S.A., Vice President, in the chair, a very interesting paper on "Battle Abbey, and its conventual remains," was read by the Rev. Mackenzie E. C. Walcott, M.A., F.S.A. At the same meeting the chairman announced that the following letter had been received in reply to an application made by the President to Sir George Grey, H.M. Secretary of State for the Home Department, at the request of the Council under the advice of their Honorary Solicitor, Mr. Frederick Ouvry.

Whitehall, 18th May, 1866.

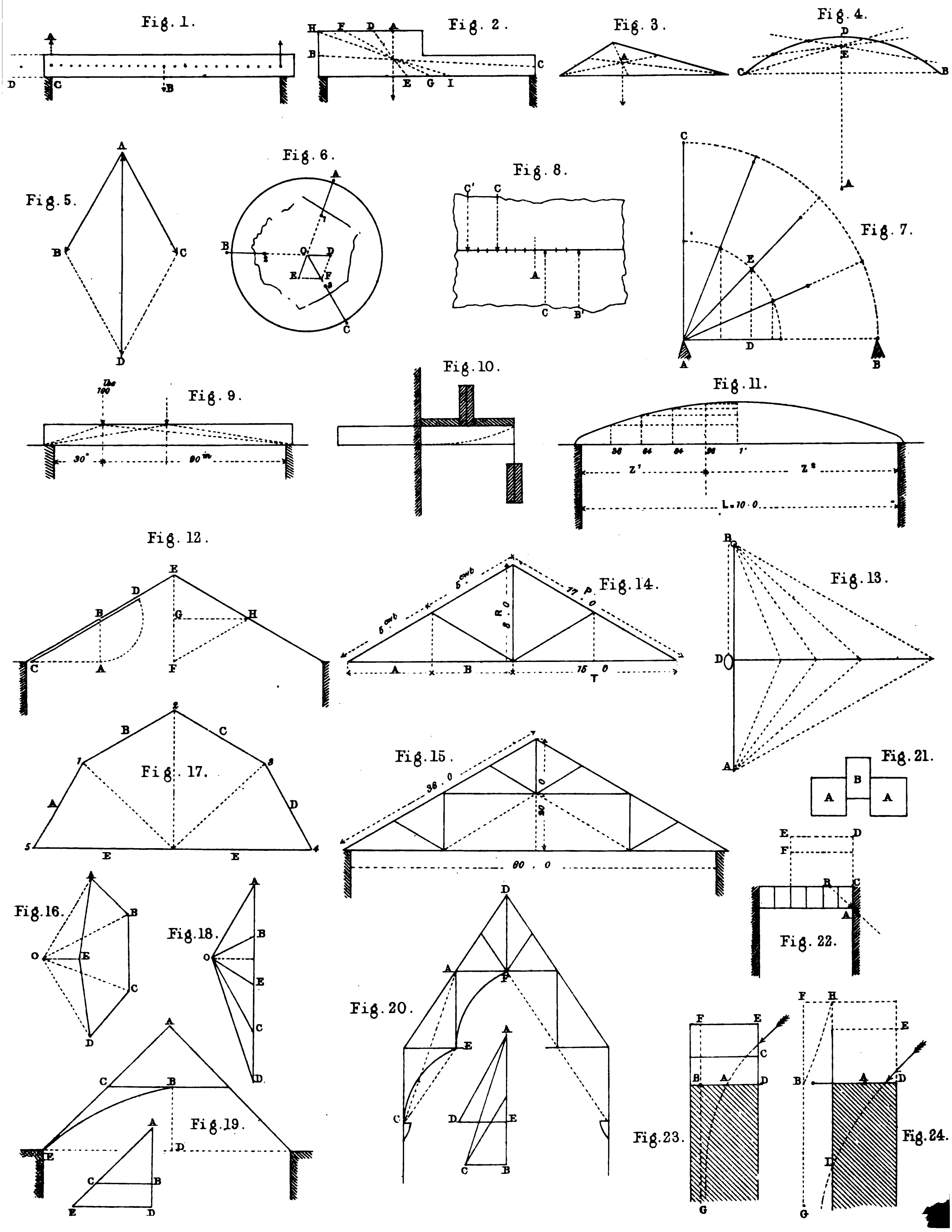
SIR,—I have had the honour to submit to the Queen your request that the Institute of British Architects may be permitted to assume the title of Royal; and I am to inform you that Her Majesty has been graciously pleased to accede to your request, and to command that the Institute shall henceforth be styled the "Royal Institute of British Architects."—I have the honour to be, Sir,

Your obedient Servant,

A. Beresford Hope, Esq., M.P. (signed) G. GREY.

It was explained that this title of Royal, though assumed by the Institute, was not granted by the original Charter, and the object of the application was to remove any doubt or difficulty on the subject.

MECHANICS APPLIED TO ARCHITECTURE



ROADS AND RAILWAYS IN INDIA.

By Sir William Denison, K.C.B., Colonel, Royal Engineers.

(Continued from page 138.)

Maintenance.

The next matter for consideration will be the cost of the maintenance of way, that is, the annual outlay required to maintain the road in a state of thorough repair.

This must, of course, so far as the macadamized road is concerned, depend upon the amount of traffic, while the quality of the materials employed will have some action upon the annual charge. A fair approximation, however, may be arrived at by a reference to the amount commonly allowed for maintenance upon the great trunk lines of road in this Presidency, and Rs. 300, or £30 per mile, would be considered sufficient for a road upon which the standard amount of traffic is conveyed. The cost of repairs upon a road over which 1872 vehicles pass per day has, in an average of five years, amounted to £119 14*s*. 9*d*. In order to be on the safe side therefore, I propose to allow £55 per mile for the maintenance of the macadamized line of road in thorough repair.

On the railway for animal power an allowance must be made for the wear and tear of rails and sleepers. The actual wear of the road itself will be very much less of course than that of the macadamized road, for the iron rail takes the action of the wheel; if, then, the rails and sleepers are renewed in twenty years, one-twentieth of the whole cost may be provided as an annual charge; and as this cost is £1700, one-twentieth of that sum will be £85. One-half of the ordinary sum of £30 will be sufficient to cover the cost of other repairs; so that 85 + 15 = £100 will cover the cost of the maintenance of the railway for animal power.

The maintenance of way upon the railway for steam power must necessarily include an allowance for the renewal of rails, chairs, &c., and by taking the duration of these at twenty years, as in the railway for animal power, an advantage will be given to the locomotive line; as the action of the heavy engine, going at the rate of from 20 to 30 miles per hour, must wear away the rail much more rapidly than the light and slow action of the animal power. Assuming then 5 per cent. to be the annual deterioration of the rail and sleepers, and the cost, as on the Madras line, to be £3000 per mile, the annual charge for renewal of rails and chairs will be £150.

The other items under the head of maintenance are grouped together in the returns, and the cost may be put on an average at about £100 per annum per mile, while the charge for superintendence may be put at £5. The cost of maintenance of way on the steam power line will therefore be as follows:—

	£	s.	d.
Renewal of rails and sleepers	150	0	0
Labour, ballast, &c.	100	0	0
Superintendence	5	0	0
	£255	0	0

The annual charge upon the three descriptions of road, under the head of interest of capital and maintenance of way, will be shown in the accompanying table:—

	Macadamized road.			Railroad, Animal power.			Railroad, Steam power.		
Interest	37	10	0	131	7	0	600	0	0
Maintenance	55	0	0	100	0	0	255	0	0
Total	£92	10	0	£231	7	0	£855	0	0

Traction.

Having thus arrived at the cost of constructing the different lines of road, as well as that of maintaining them in a good state of repair; all that remains to be done is to determine the actual cost of traction upon each. To do this, however, would involve the solution of a variety of very complicated questions. It will be far more simple therefore to show, for the ordinary roads and for the existing railroad, the actual charge for the conveyance of passengers and goods. In the case of the railway, the returns show the actual charge for locomotive power under several different heads; while on the macadamized road the contract price per passenger or per ton of goods includes not only the charge for power, but a variety of other items to which I shall allude hereafter.

With reference to the railway for animal power, I propose to submit a detailed estimate, on a liberal scale, of the cost of working it, as in this country I cannot obtain any direct information to guide me.

The cost of conveying goods upon the ordinary roads has been shown to be 3¾*d*. per ton per mile. This sum includes the interest upon the first cost of the vehicle and the cattle; the maintenance in repair of the vehicle; the maintenance of the cattle, and the hire of the persons employed to drive them; it will also include a premium of insurance upon the carriages and cattle, so that they may be replaced in case of destruction or death by accident or disease. It also includes, or should include, some premium of assurance against the risk incurred as a carrier who is responsible for the goods under his charge. In addition to all these, it must include such a fair amount of profit as the contractor has a right to expect, besides the simple interest on his capital.

The charge of conveying first-class passengers may be put at 6*d*. per mile. This is arrived at by taking the cost of conveyance, by the Transit Company, from Tripatore to Bangalore, a distance of 80 miles; the transit is capable of accommodating two persons inside, and a servant on the box by the driver. Each person may take 40 lb. of baggage, and the total charge by the company is Rs. 40, or 80*s*., that is 1*s*. per mile, or 6*d*. per each passenger.

A class of passengers analogous to the third-class on the railway is conveyed to and from places in the vicinity of Madras, at a reasonably rapid rate, in vehicles drawn by bullocks or ponies; each of these vehicles is capable of containing four people, and the rate of charge varies from 2¼*d*. to 3*d*. per mile for the whole vehicle; taking the largest sum, the cost per mile for each passenger would be ¾*d*.; but it would be safer to estimate the average cost at 1*d*. per mile per passenger, and this may be taken as a fair charge for such work in any part of the Presidency; as the Madras prices are probably in excess of those of the country districts. The cost then of conveying 3220 first-class and 152,000 second-class passengers, and 32,000 tons of goods, will be as follows:—

		£	s.	d.
3,220 at 6*d*.	=	80	10	0
152,000 at 1*d*.	=	633	6	0
32,000 at 3¾*d*.	=	600	0	0
Total		£1313	16	0

The returns for the North West Railway, for the same amount of traffic, exhibit the expenditure under the various heads of classification, as shown in the following table:—

	£	s.	d.
Locomotive department	1906	5	2¼
Fuel	3054	12	0
Coaching	1259	1	0¼
Tickets	12	2	4½
Repair of vehicles	116	2	5¾
Electric telegraph	11	9	0
General charges	117	6	6
Total	£6476	18	6¾

This sum, divided by 41·25, the length of the line, will give £157 0*s*. 3¾*d*. as the cost of conveying the whole of this traffic over one mile of railway. No attempt is made to distinguish the actual cost of conveying the different classes of passengers or goods; in fact any attempt of the kind would merely be a matter of guess work. The above may be taken as *facts*, which do not involve any calculation.

I have now, however, to form an estimate of the cost of conveying the same quantity of goods, and the same number of passengers, along a railway by means of animal power.

The number of first-class passengers has been put at 3220, or roughly, 10 per day, or 5 each way. To convey these, one first-class carriage would be required, which would travel at the rate of 10 miles per hour. It would be drawn by two horses,* and would be capable of accommodating 16 passengers. The distance of 41·25 miles would be divided into five stages, each pair

* Capt. Yule says in his Project, &c., "draft horses for such a purpose can scarcely be said to exist in India, and we must therefore look to oxen." It would have been well perhaps if this objection so often stated, had been met in the present year. In the Punjab the Cabul horses, though small, are excellent for draught, and could be procured well under the estimated price, probably for Rs. 800 each. But the supply is very limited, and in the N. W. Provinces, good draught horses, able to do hard work at a fair speed, are unknown. It is to be noted, however, that it is only the passenger traffic which is to be conveyed by horses.

of horses going a stage out and a stage back, or about 16 miles per day; a spare carriage would be required, and a spare pair of horses.

The capital expended would be—

		£	£	s.	d.
3 Carriages	...	at 250 =	750	0	0
12 Horses	...	at 45 =	540	0	0
10 Sets Harness	...	at 10 =	100	0	0
		Total	£1390	0	0

152,000 second-class passengers divided by 365, will give 416 as the daily number conveyed both ways. It will, however, be necessary to reckon upon some extra pressure occasionally; and carriage accommodation must be provided for, say 240 each way, or 480 altogether. Each carriage will contain 30 passengers, and will be drawn by two horses at the rate of about 6 miles per hour; travelling the same distance as the horses drawing the first-class carriages.

The total number of carriages and horses required for the actual work will therefore be 16 carriages, and 80 horses; but it may be as well to estimate for 20 carriages and 100 horses.

The capital expended, then, upon rolling stock and animal power will be—

		£	£	s.	d.
20 Carriages	...	at 250 =	5000	0	0
100 Horses	...	at 40 =	4000	0	0
16 Sets Harness	...	at 10 =	160	0	0
		Total	£9160	0	0

32,000 tons of goods may be put at 100 tons per day, or 50 tons each way.

Three tons may be allowed for each truck, and 34 therefore would be required; each would be drawn by 3 bullocks, 6 extra trucks might be allowed to meet casualties; and a few extra bullocks should be purchased. As the daily journey of a bullock may be put at ten miles, the distance of 41·25 would be divided into four stages; so that 12 bullocks would be required for each truck, 40 × 12 = 480, would be in daily use, or say 500 to cover contingencies.

The trucks ought not to cost more than £100 each, and the bullocks £15 the pair.

The capital, therefore, expended upon the rolling stock and animal power for the goods traffic will be—

		£	s.	d.		£	s.	d.
40 Carriages ...	...	at 100	0	0	=	4000	0	0
500 Bullocks ...	...	at 7	10	0	=	3250	0	0
					Total	£7250	0	0

The total amount of dead and live stock required for the conveyance of passengers and goods along a railway worked by animal power would be as follows:—

		£	s.	d.
First-class passengers	...	1390	0	0
Second-class do.	...	9160	0	0
Goods	...	7250	0	0
	Total	£17,800	0	0

Say £18,000.

The annual charge may be estimated as follows:—

	£		£	s.	d.
Interest upon £18,000 at 5 per cent. ...		=	900	0	0
Wear and tear of carriages and repairs, 15 per cent., on ...	9750	=	1462	10	0
Cost of re placing horses and bullocks, 15 per cent., on ...	7790	=	1168	19	0
Repairs and re-placing harness, 20 per cent., on ...	260	=	52	0	0
Keep of 112 horses, at £24 each...		=	2688	0	0
Keep of 500 bullocks, at £8 each		=	4000	0	0
Hire of 20 coachmen, at £50 each		=	1000	0	0
Hire of 166 bullock drivers, at £10 each		=	1660	0	0
Repairs of stables, at 5 per cent., on ...	2,000	=	100	0	0
Telegraph, &c., charges as on locomotive line ...		=	11	9	0
General charges, including clerks, &c. ...		=	442	11	0
		Total	£13,485	9	0

This sum, divided by the total distance of 41·25 miles, will give the charge per mile for traction £302 12*s.* 10*d.*,* and the general comparison between the cost of conveying the standard number of passengers and tons of goods per mile, on the three kinds of road, will be as follows:—

	Macadamized road.			Railroad, Animal power.			Railroad, Steam power.		
	£	s.	d.	£	s.	d.	£	s.	d.
Interest ...	37	10	0	131	7	6	600	0	0
Maintenance ...	55	0	0	100	0	0	255	0	0
Cost of working ...	1313	16	0	302	12	10	157	0	3¾
Total	£1406	6	0	£534	0	0	£1012	0	3¾

I have, in calculating the cost of working the animal power railway, made an allowance for a variety of extra expenses; and I feel confident that the sum shown in the above table will be ample to cover the whole cost of working the line, and of paying an interest of 5 per cent. upon the capital expended. Under these circumstances, it is evident that, until upon any given line of road the amount of traffic very far exceeds that which passed over the North West line of railroad in the first half of 1863, it will be far cheaper to employ animal power than steam, in the movement of passengers and goods.

It remains to be seen what charge it will be necessary to impose upon the traffic, in order to cover the whole of the charges upon the road; namely, interest of capital, maintenance of way, and cost of transport. An analysis of the cost of conveying the different descriptions of traffic will show that the following is pretty nearly the ratio of the outlay upon each

First-class passenger	...	·066
Second-class do.	...	·430
Goods	...	·504

and if the whole charge of £534 per mile be divided in these proportions between the different heads of traffic, the charge upon the first-class passenger must be such as would return £35 4*s.* 10½*d.*; that upon the second-class, such as would yield £229 12*s.* 4¾*d.*, and that upon goods such as would give £269 2*s.* 8¾*d.* Now the charge of £35 4*s.* 10½*d.*, divided by the number of first-class passengers, viz., 3220, would give 2·6 pence as the charge per head per mile. In the same way, £229 12*s.* 4¼*d.* divided by 152,000, the number of second-class passengers, would give 1·38 farthing, as the exact charge per head per mile; while £269 2*s.* 8¾*d.*, divided by 32,000, would give 2·018 pence as the charge per ton per mile. A first-class passenger, however, might very fairly be charged at the rate of threepence per mile, and a second-class at a half-penny, while the charge for goods might be put at 1½*d.* per ton per mile; at these rates, with the standard amount of traffic, the gross returns would be £556 18*s.* 4*d.*, or £22 18*s.* in excess of the amount shown above to be sufficient to cover the interest of capital, maintenance of way, and cost of conveyance. Provision, however, has been made for the conveyance of upwards of 11,000 first-class passengers, 190,000 second-class, and 44,000 tons of goods without any extra charge; and should the traffic increase to this extent, the returns of the rate mentioned above would be—

		£	s.	d.
First-class passengers ..	...	137	10	0
Second-class do.	...	395	16	8
Goods ...	...	275	0	0
	Total	£808	6	6

And the profit upon the capital expended (which, at the rate of £2627 per mile of road for construction, and £18,000 ÷ 41·25 or £436 for live and dead stock, would amount to £3063) would not be less than 13 per cent.

* Capt. Yule's estimate per mile for a cattle draught line, is only Rs. 1317, of which Rs. 140 are charged to maintenance of way (not included above); Rs. 430 to wear and tear of rolling stock; Rs. 374 for hire of cattle, and the same for establishment; the cost per ton per mile being reckoned at 0·7 anna. Mr. Hardy Wells in his report on the same line, estimated the draught expenses per mile of a horse railway at Rs. 5650, and of a bullock line at Rs. 6361.

The great difference in this last estimate is in the number of animals estimated for, 2000 horses or 4000 bullocks for a line of 110 miles in length, being double the number set down in the present estimate for a similar length. Mr. Wells' calculation is for 105,000 tons of goods, and 224,000 passengers, yearly; each passenger is reckoned at 3 mds. = 240 lb. probably to include his baggage. The cost, therefore, of haulage per ton per mile, would be 0·7 anna for horses, and 0·8 anna for bullocks. It is to be noted, however, that these estimates do not include any charge for the interest on the dead and live stock, which is probably considered to form a part of the whole capital sunk. In the present estimate, deducting this item, and dividing the annual cost by the traffic, the cost per ton mile will be 0·75 anna, showing a striking agreement between the three estimates, considering that all are worked out on totally different data.

The fair conclusion to be drawn from what has been stated is, that with an amount of traffic larger than that which is likely to pass over most of the feeders of the railways now in progress, a railway worked by animal power would be a much cheaper mode of communication than either a macadamized road, or a railway worked by steam power.

If, however, this would be the case when the traffic is already heavy upon the line of road, the advantages of animal power over steam would be still more marked when the traffic is comparatively light, and requires to be developed gradually. A railway worked by steam must be provided with engines of power sufficient to drag the largest train over the steepest gradient on a line; and though the consumption of fuel is, to a certain extent, proportioned to the load the engine has to convey, yet, as this load is in very great measure composed of the dead or unprofitable weight of engines and carriages, the saving of fuel is not very great; while the other items which make up the working expenses are in great measure independent of the load, and form a mileage charge.

With a railway worked by animal power the case is different; here the power required is strictly in proportion to the load; no more horses or bullocks are kept than will be sufficient to meet the demands of the public for conveyance; and if these demands are casual or intermittent, arrangements can easily be made to meet the casual portion of the demand without the expenditure of capital, or the imposition of a permanent charge upon the promoters of the line of railway. Again, the power of a locomotive engine must be proportioned to the maximum effort it has to make; that is, it must be competent to overcome the steepest gradient in the line with a full train behind it; it must, therefore, have an amount of power more than sufficient to do the work of the more level portions of the line; in fact, it is necessary to have an engine of 100 horse power, which it might have to exert for a mile or two, while an engine of 50 horse power would be amply sufficient to do the remainder of the work.

This is not the case with a railway worked by animal power. If there be a hill too steep to be surmounted by carriages drawn by the ordinary team of horses or bullocks, the simple plan is to have a spare pair at the bottom, to help the carriages over the hill. This, however, will seldom be necessary with horse teams; for a horse has a reserve of muscular energy, which enables him to exercise for a short time a much greater amount of power than is wanted for his ordinary work.

It is not, of course, probable that the ratio between the passengers and goods traffic, which I have assumed as the standard for calculation, will obtain upon ordinary branch lines. The passengers' traffic will be less than the standard, while the goods traffic will exceed it; looking, however, to the fact that I have estimated the cost of the rolling stock and the animal power at a high figure, and have been very easy in my demands upon the animal power, it is more than probable that, when worked by a company or an individual, the charge of 1½*d.* per ton per mile will be found sufficient to cover all expenses, and to give an interest upon the capital expended of at least 5 per cent.

I think, then, that I am justified in applying, to by far the larger number of branches from the main line of railway in India, the following conclusions:—

1. That the cost of transport upon a macadamized road is largely in excess of that upon a railroad, whether such railroad be worked by animal or steam power.

2. That the actual cost of steam power is much less than that of animal power upon railroads, but that this cheapness is, with a limited amount of traffic, more than compensated for by the increased cost of construction and maintenance of the railroad worked by steam.

3. That the circumstances of the country are not such as to admit of so large a development of traffic upon the branch lines of railroad as would compensate, by the saving in the cost of motive power, for the increased charge under the heads of interest of capital and maintenance of way consequent upon the adaptation of road for steam power.

4. That, as a general rule, it would be far cheaper, and therefore more advantageous in every respect, to construct the branch lines of railway with a view to their being worked by animal power.

ON THE CONNECTION OF PLATES OF IRON AND STEEL IN SHIPBUILDING, ESPECIALLY SUCH AS ARE SUBJECT TO SUDDEN TENSILE STRAINS.

By Nathaniel Barnaby, Assistant Constructor of H.M. Navy.

Much yet remains to be done to make iron shipbuilding a perfect art, and there is perhaps no one step remaining to be taken in the path of improvement more important than that of substituting a simple and efficient means of joining plates by welding, should it ever be discovered, for the present system of rivetting. The loss of strength caused by the present system is considerable in iron, but appears to be still more serious in steel. It forms, in fact, the great bar to the introduction of this most promising material into ships of war. I may give, as an illustration of this, one or two of the many experiments which have been made by the Admiralty at Chatham Yard on Bessemer steel of the best quality. A piece of steel 4 feet long, and 12 inches broad, was cut from a half-inch plate, of which the proof strength was 33 tons per sq. inch. This piece was reduced to 5 inches in width at the middle, was supported at the ends by square plates rivetted to it, and was carefully centred. The plate should have broken at 82½ tons, and through the narrow part. It actually broke at 95¼ tons, and then, strange to say, broke through the wide part of the plate, tearing away through the rivet holes. Thus while the material in the middle of the plate withstood a strain of 38 tons per square inch, it actually broke through the holes at 16·38 tons per square inch, or less than one-half the strain. In a precisely similar plate, differing from the other only in the fact that the rivets connecting the end pieces were 1¼ inch from the edge instead of 2½ inches, the plate broke in a similar manner at 73 tons, which is only 15 tons per square inch of the section of steel broken. The holes in both these cases had been punched, and in order to ascertain whether these curious results were due to the injury supposed to result from punching, an exactly similar arrangement of plates was again tried, in which the holes were, as in the first 2½ inches from the edge, but were drilled instead of being punched. The plate then broke through the narrow part at 106·75 tons, or 47·53 tons per square inch of the steel broken. I do not propose to draw here any inferences from the experiments detailed, or from the series of which they form part, further than this, that all which I propose to say concerning the necessity of bestowing greater attention on the comparative strength of different modes of connecting plates intended to give tensile strength, is even more applicable to steel than to iron. Admitting, then, that for the present, at least, we must be content to connect iron plates by rivets placed in holes punched or drilled out of the material, and therefore by the sacrifice of a considerable portion of the strength of the plate, it is manifestly the duty of the engineer and shipbuilder to study to make this connection with as little sacrifice of strength as possible.

In every such connection the tensile strength of the plates across the outer line of holes, of the butt strap or straps across the inner line of holes, and the resistance of the rivets to shearing, should be all equal. Two plates may be connected, for example, by butt straps, so as to reduce the strength of the plate by one hole only. The strength of the several parts has in this case been estimated on the assumption, verified by careful experiment at Chatham, that the shearing value of ¾ Rowling rivet, including friction, and taken singly or in conjunction with others, is 10 tons, and that of rivets or other diameters is in proportion to the squares of the diameters; also, that the tensile value of the iron between the holes is reduced in proportion to the number of the perforations, and that this reduction is about 25 per cent. when the holes are punched three or four diameters apart. This description of butt strap is of no value in shipbuilding, because the stringer and tie plates, to which it might otherwise be applied, have to be perforated between the butts by rows of holes to connect them with the beams. In such plates, in order to economise material, it is therefore desirable to reduce the amount of fastening at the beams as much as possible. I do not think it necessary to punch away for this purpose more than $\frac{1}{8}$ of the iron; the remaining strength of the iron would then probably be $\frac{7}{8} \times \frac{7}{8} = \frac{3}{4}$ths of the whole, so that the straps connecting them should also give $\frac{3}{4}$ths of the full strength of the plates. Any greater strength at the butts would, of course, be thrown away. If the butt strap has to be caulked, this proportion of strength cannot be retained, as the rivet holes must then be placed nearer together. Let us take, for example, the connection, by means of a butt strap, of two plates, $\frac{3}{4}$ inch thick and 12 inches wide, in which the rivets are 1 inch diameter, and are spaced three diameters apart. Then we punch out $\frac{1}{3}$ of the iron, reduce the strength of the remaining iron about one-fourth, and have left only $\frac{2}{3} \times \frac{3}{4} = \frac{1}{2}$. The tensile strength of the plate at 20 tons to the inch is 180 tons, and the tensile strength through the holes about 90 tons. If the connection is made by means of a single strap, the value of the rivets will be about 71 tons; and if by a double strap, 142 tons. No appreciable advantage could be obtained from a second row of rivets in this case, unless the spacing along the edge could be increased. If the rivets are no nearer together than necessary for caulking, a second or third row could give no advantage, except in enabling us to reduce the thickness of the butt straps to less than the thickness of the plate, by reducing the number of rivets in the inner row where the butt straps are obliged to break. None of these considerations are new, but they have been so much neglected that those who are familiar with them will, I hope, justify me in thus restating them. But there are certain other considerations equally important, which have, I think, altogether escaped the notice of shipbuilders.

Let us suppose that we have a stringer or tie plate, the strength of which is, at the beams, and at the butts, $\frac{7}{9}$ of the full strength of the plates, and that we have no means of increasing the strength at these points. Have we any means by which we can, without altering the strength at these points, increase the tensile power of the plate? I think the answer would generally be, we have not—the strength of the tie will be measured by the strength of the weakest place, and this strength is fixed.

Now what I want to show is that this is not the case, and that we have overlooked an important element of strength, which is conducive to economy of material. Take the case of a stringer or tie plate crossing a number of beams, say 3 ft. 6 in. apart, at each of which the strength is reduced to $\frac{7}{9}$ths of the full strength of the plate. If this plate is brought under the action of a steady strain it is a matter of indifference practically how many such points of weakness there may be, and how much stronger the material may be lying between the weak points: But when strains are suddenly applied, we have to consider not only the number of tons required to break the weakest section, but the amount it would stretch before breaking. It is, in fact, the work done in producing rupture, viz., the force applied, multiplied by the distance through which it acts, which is the true measure of the resistance to rupture. Under these circumstances no elongation will take place in the strong parts of the plate lying between the beams: it will all be thrown on the weak points; and if any one of these be weaker in any sensible degree than the rest it will be confined to that point. This being the case a large increase of power may be obtained by reducing the strength of the plate between the weak points to the strength at these points, or even to less than this, provided we get long spaces of uniform strength to give elongation.

To illustrate this I beg leave to refer you to some experiments made at Chatham with armour bolts, with reference to a proposal of Captain Palliser's. The proposal was to apply to armour bolts, having screws cut on them, the well-known principle that the bolts would be strengthened at the screw thread, and become less liable to break at a sudden jar, if the bolt, or a portion of it beyond the thread, were reduced in section to the same area as the iron left uncut at the thread.

The experiments referred to, made under my own careful observation, showed—

1. That iron bolts of good quality and of uniform diameter, subjected to a steady increasing strain, elongate before breaking about one-fifth of their original length.

2. If the diameter is not uniform, but is decreased through a portion of the length, then the reduced part elongates about one-fifth of its length before breaking, and the larger portion scarcely stretches at all.

3. If this reduced part is very short, as in the thread of a screw, the strain required to break the bolt is the same per inch of the unstretched or original section as in the previous cases, but there is scarcely any elongation before rupture.

4. If the whole length of the bolt is made to the reduced diameter of the screw thread, so that the thread projects from the bolt, the breaking strain (gradually applied) is the same as before, but as the bolt will stretch one-fifth of its length before breaking, it becomes thereby less liable to rupture by a sudden blow, because, as already stated, the work done in producing rupture is in proportion to the weight or strain applied, multiplied by the elongation or the distance through which it is applied.

The details of one portion of these experiments were as follows:—

Four bolts were taken, all made of best-selected scrap iron, for the purpose of the experiment, and all of the same diameter, viz., $2\frac{1}{4}$ inches; screw threads were cut in the ends of these, and nuts fitted. The other ends were formed with heads, leaving a length of 21 inches between the heads and the nuts. The four bolts being thus as nearly alike in every respect as they could be made, two of them were reduced down on the anvil for a length of $4\frac{1}{2}$ inches in the middle of their length, to a diameter of $1\frac{7}{8}$ inch, which was the same as that of the iron remaining within the screw threads. The other two bolts retained the full diameter throughout. They were broken in the hydraulic press, with the following results, which are also shown in the accompanying photographs:—

	Breaking Strain in Tons.	Sq. inch in Sec. broken.	Tons per sq. in. of this Sec.	Elongation.			Where broken.
				In 5 in.	In 15in	In 21in	
Bolts not reduced							
No. 1 ...	63	2·76	22·8	Nil.	$\frac{1}{4}$	$\frac{1}{4}$	At thread
No. 2 ...	69	2·76	95·0	Nil.	$\frac{5}{16}$	$\frac{1}{2}$ bare	Ditto
Bolts reduced							
No. 1 ...	64	1·67	38·33	$\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{4}$	In reduced part.
No. 2 ...	65·5	2·07	31·58	$\frac{7}{8}$	1	$1\frac{1}{8}$	In reduced part, but at the shoulder where there was a slight defect.

The fact that the strains of greatest magnitude in a ship are sudden in their nature, makes the principle under consideration one of no slight importance, because we see that by its application we are able to increase the time during which a given force must be applied in order to produce rupture.

As the material is disposed at present in iron decks, and stringer and tie plates, the plates are perforated in the lines of the beams, not only by the holes required for the rivets to attach the plating to the beams, but by the deck bolts which secure the wooden deck lying on the iron plating. The loss from the iron punched out, and the weakening of that which remains, amounts, on the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 ft. 6 in., and between them the plate has its full strength, except where a butt occurs. The consequence of this is that, when the deck is put in tension, the stretching is confined to these weak places, and the amount of work which the whole combination is capable of doing before rupture is extrêmely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beam. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across the lines of rivetting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates; but instead of this I propose to to omit the butt straps, and to arrange the plates so that in each of these spaces there shall be a continuous series of butts and plates in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spaces of uniform strength between the beams. The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the shearing value of the rivets, and allows about one-third of the distance between the beams to be omitted.

The advantages of one system over the other are, I think, the following:—

1. In the ordinary system one-fifth or one-sixth of the iron is punched away: by that proposed only one-ninth or one-tenth is punched out. There is from this cause a gain to direct tensile strength, to which must be added an increase of strength in the iron between the holes. These are together equal to about 12 per cent.

2. The strength of an iron deck under *compression* is limited, not by the area of section, but by its resistance to buckling between the beams. According to the ordinary mode this is very small, since it is quite free to bend downwards between the beams. But by spacing the deck fastening, as shown, at intervals of about 2 feet instead of 3 ft. 6 in., the tendency to buckling would be reduced. The wooden deck would thus, both by its own direct resistance to compression, and by the support it gives to the plates, play a most useful part in compression, although it is powerless as against extension when in connection with iron. I therefore conclude that no loss of compressive strength is incurred by the holes in the plates.

3. All the holes for receiving the deck fastening may be punched, whereas if the fastening is in the beam flanges, the holes for them must be drilled either in the plates or in the beams.

4. The expense of cutting, fitting, punching, and rivetting butt straps is avoided. Where the material employed is steel, the gain is more considerable, as all the holes in the butts of the plates and in the straps have to be drilled to prevent the injury done by punching.

5. The weight of material omitted at the butts amounts to one-seventh of the whole material employed.

6. There is a gain in strength against injury and rupture by the action of sudden forces, the amount of which is not susceptible of calculation, but which, being in proportion to the extent of the spaces of uniform strength which have been introduced, is I think very considerable.

The novelty of this proposal may be said to consist in so arranging the iron or other metal plates forming the flanges of girders, bridges, and other structures, or employed in decks, partial decks, stringers, or ties in a ship or vessel, as to make the tensile strength of the unperforated plates intervening between adjacent butts equal or nearly equal to the strength of the said intervening plates taken together with that of one of the butted plates where they are perforated, *i.e.*, across the row of holes made for the purpose of attaching the plates to the beams, angle irons, stiffeners, or other iron framing, and by this means rendering the use of butt straps in such combinations unnecessary. In other words, a section through the plates between the beams or stiffeners is made to have, without butt straps, about the same tensile strength as a section through the fastening at the beams or stiffeners, for the purpose of forming spaces of uniform tensile strength not greater than that of the weakest place in the combination. In those intervals elongation will take place (to an extent depending on their length) before the materials can be ruptured, so that an increased amount of work will require to be done by the operation of a given strain in producing rupture. Also, in increasing the resistance to rupture under sudden strains in single plates, by reducing the tensile strength throughout certain intervals between the beams, angle irons, or stiffeners, and approximating to that at the beams, angle irons, or stiffeners, by cutting out portions of the plate.

I am aware that iron decks are not used in merchant vessels, although they are in all iron war ships built for the Admiralty, and I consider it to be false economy to substitute, for such deck or decks, stringers on the ends of the beams, tie plates near their middle, and diagonal braces between them; as I think it clear that from the round up to the beams, and other, causes a considerable portion of this material is unable to succour the rest when the top of the ship is put in tension or compression. The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than than the top. Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I indulge the hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private shipbuilders to introduce partial iron decks so formed into ships designed for commerce. I may, perhaps, be allowed to add in conclusion that these proposals do not form the subject of any patent.

ON THE SAFETY AND SEAWORTHINESS OF VESSELS.

(*Continued from p.* 128.)

Mr. W. Simons agreed with Mr. Smith that the topgallant forecastle was a very bad place for the crew. He thought that all the Atlantic steamers should be fitted with spar-decks for safety; but he apprehended that something more was required. If marine insurance were abolished they would have a better class of steamers trading either to America or India. He believed if this were the case shipowners would spend more money on the construction of their ships, and they would have stronger vessels. For instance, it was well known that the loss of the Amalia, built on the Clyde, and the London, built on the Thames, astonished everybody but those who knew the reason why. He was of opinion that the London was 12 feet too narrow, that she ought to have been formed on a different construction altogether; and that if her owners had been her insurers she would have been a different vessel altogether. A ship for passenger service ought to have vertical beams, with diagonal stringers both above and below deck. He was of opinion that the London would have been a much stronger vessel if her stanchions in the centre had been like those of a lattice girder bridge, instead of vertical. Then, again, the London had long plates, and perhaps as many as 500 vertical joints, whereas in a wooden vessel of her size there would perhaps not have been above one-tenth of that number. His impression was that those joints gave way; and that in his opinion was the cause of the vessel foundering.

Mr. R. Bruce Bell asked whether that was merely a matter of opinion on the part of Mr. Simons, or was there anything in the evidence to show that the vessel had strained herself, as Mr. Simons had assumed?

Mr. Simons believed that the cause of the loss of the London was quite conjectural; but his opinion was, that enough of water could not have got down her engine hatch to cause her to founder, but that she gave way as he had indicated.

Mr. Mansel said that the London was very deep in the water to begin with, and she shipped a good deal of water, and sat down by the stern. She got the dead lights in her stern broken by the waves, and consequently would ship a good deal of water there. Whenever the stern lights were staved in, the water had free access to the cabin below by a large opening 7 feet by 4 feet in the poop, having no protection but an ornamental railing round. In his opinion that was sufficient to explain her sudden foundering.

The President said he believed that they were not dead lights, but stern ports, that were broken in.

Mr. R. Bruce Bell approved of sticking to the evidence in the case. What Mr. Mansel had told them was brought out in evidence, but what Mr. Simons had said was his own individual opinion of what might have taken place.

Mr. Ferguson said there was nothing in the evidence to show that the London had been straining at all. It was shown that when the engine covering was knocked away there was a hole left of about 12 feet by 10 feet; that the water would get in there before reaching the ports; that the deck would contain 100 tons of water before it got out at the ports, which would put her 6 inches down; and that the stern windows being staved in, the water rushed in, and found a hole about 7 feet by 4 feet, through which it poured into the lower cabin.

Mr. Simons did not believe that 100 tons of water could remain in the waist of such a deck for three minutes. It would have broken through the bulwarks.

Mr. Ferguson said that she had a box waterway twenty inches high. He could not see how the water could have broken through those two thicknesses of plates—the one about ½-inch and the other about ⅜-inch thick.

Mr. George Smith asked whether Mr. Ferguson had made any allowance for list?

Mr. Ferguson said he had not.

Mr. Smith remarked that that would make a difference in the amount of water on the deck.

Mr. T. Davison said that the water on the deck of a ship rolling at sea did not run off so much as was thought, as the water partook of the motion of the ship, and the full benefit of the roll or list of a ship at sea was not obtained in displacing the water.

In answer to Mr. Simons, Mr. Mansel said that the London had five ports on each side.

Mr. Simons replied that it was impossible all those ten ports could have kept tight, so as to retain all the water indicated.

Mr. Mansel said that not above two or three of the ports were in the waist of the ship, where the water was.

Mr. Boolds remarked that the only case bearing upon the subject which had ever come under his notice was that of a screw steamer which was lost four or five years ago. She was an iron steamer, and sailed from Greenock. In going into the North Channel she encountered a storm, and shipped a great deal of water, which drove the front of her poop in, and knocked a very large hole through the stern. She put back to Greenock in that condition for repairs. On inquiry of the captain and mate it was found that she had high bulwarks and a high poop and forecastle, and that she filled with water in the middle part; but from the fact that the front of the poop gave way and carried away part of the stern, she got free of the water, and in this condition came back to Greenock. There she got the front of the poop replaced and made strong enough to resist any pressure of water to which it might be subjected, and also the bulwarks were strengthened, and afterwards went to sea, but was never again heard of; and to his mind there was no doubt that she had foundered, because her poop was so strong as not to give way, when struck by seas which filled her, as on the former occasion.

Mr. Robert Duncan said there seemed to be a great deal of speculation about the cause of the loss of the London. The survivors from the wreck were not experienced in the construction or form of the ship; but Mr. Barber, one of Lloyd's surveyors, gave important evidence. He stated that those things were managed better on the Clyde; and showed particularly that the engine-room skylights were so constructed that water on the deck would find its way out of the ports before it could "run down" into the engine-room. On that principle he had constructed the Pomona and other vessels, so that the iron coaming or solid part of the skylight was always on a level with the main rail of the bulwarks. He believed that was a very good plan. He thought it was expedient to carry this matter before the Board of Trade, as the Scottish Shipbuilders' Association had done before. On that occasion Mr. Moorsom had made some remarks in reference to what he (Mr. Duncan) had said at the meeting, to the effect that vessels ought to be allowed a proportion of space for the crew. Mr. Moorsom said that the thickness of the deck was sufficient compensation. Now, he maintained that that was not a sufficient percentage towards the tonnage of the ship. If a vessel of 2000 tons had a deck four inches thick, the percentage was only two per cent., whereas the allowance given for the crew space in the topgallant forecastle was equal to five per cent. Small vessels, also, did not proportionately benefit in that way. By the present measurement, large vessels were greatly favoured. He thought, therefore, they should ask the Board of Trade to make an allowance for the crew in all vessels.

Mr. D. Rowan was sure that a more interesting paper had never before been brought before the society. He could now understand some of the causes which might have led to the loss of the London; and both Mr. Ferguson and Mr. Mansel had shown that some gross omission had been made in her construction. Looking at it in a humane point of view, he was quite clear that they ought to memorialise the Board of Trade in reference to the tonnage laws.

The President then moved a vote of thanks to Mr. Ferguson for his paper; and called the attention of the meeting to a Bill to amend "The Merchant Shipping Act, 1854," now before Parliament, and which was to come on for the second reading on the 9th April. It had reference solely to the measurement of the engine-room; but as the Government had moved in the matter the council thought this was an opportune occasion to approach them, with the view of getting some of the anomalies connected with the measurement of ships removed. On a former occasion, when the Scottish Shipbuilders' Association memorialised the Board of Trade on this subject, the reply received was as follows:—"With reference to your letter of the 15th January last, inclosing copy of the proceedings of the Scottish Shipbuilders' Association, relating to the measurement of ships for tonnage purposes, and communicating a suggestion by a committee appointed by the Association for the special consideration of the subject, to the effect that the deduction on account of accommodation for crews should be allowed in cases in which it is not now allowed, I am directed by the Lords of the Committee of Privy Council for Trade to acquaint you, for the information of the Association, that in the event of any further legislation on the subject of tonnage, the points to which you have directed attention will receive the careful consideration of their Lordships." The Board of Trade were thus committed to the consideration of the subject, and he thought they ought to remit the 5 per cent. of the gross tonnage for crew space, whether it was above or below deck. In regard to spar-decks, he thought it was rather anomalous that tonnage should not be charged for deck-houses when two great holes were left on each side of them, but whenever a deck was placed across those empty spaces that tonnage should be counted.

The President called on Mr. Costelloe to give the meeting the benefit of his views on the subject.

Mr. Costelloe said he should be very glad to give the meeting every information in his power regarding the Bill introduced by Mr. Milner Gibson. He had no reserves on the subject, because he was aware that the Board of Trade courted inquiry, and invited public bodies, dock companies, and steamship owners to express their opinions on the matter. The Board of Trade had no object in view but the public good. There was no question of revenue at stake, for although the Government appointed officers to survey and register ships, and give forms and advice frequently, gratis, it ought to be known that they derived no benefit whatever from their labours. The question of tonnage was not new to the members of the Scottish Shipbuilders' Association. It had frequently come up before that body, and had been made the subject of admirable papers read by their president and other prominent members; and they might well congratulate themselves on the result. They had obtained a promise from the Board of Trade that their views would receive consideration, and had received from the late Surveyor-General for Tonnage an assurance that he concurred in those views. It might be desirable to explain for the satisfaction of those not conversant with the subject before the meeting, that the immediate cause of legislation was this—The Act of 1854 provided that a certain allowance should be given to all steamers for propelling power. This allowance in its general application was, 37 per cent. of the gross tonnage in paddle steamers, and 32 per cent. of the gross tonnage in screw steamers, and in extreme cases once and one-half the actual space occupied by boilers and engines in paddle steamers, and once and three-fourths of the actual space in screw steamers. Well, this arrangement led to anomalies, and in 1860 the Board of Trade amended this part of the Act of 1854, as it was held it had power to do under the provisions of the 29th section of the Act in question. The new mode of calculating the allowance for engine-room was founded on the length of the space occupied by engines and boiler, and consisted of the cubic content of the section of the ship in which the boilers and machinery were placed. This system continued in operation since 1860, not unquestioned, however, for those steamboat owners who suffered by the alteration complained of the effects of the new rule, and eventually took legal proceedings against the Board of Trade, which eventuated in a judgment adverse to the Government, and hence the necessity for obtaining the sanction of Parliament, not only for what had been done, but for the continuance of the present system of calculating the allowance for propelling power. Into the merits of the law as altered he did not think it necessary to enter. There has been ample time to test the working of the system, and he was of opinion that the question may be safely left in the hands of steamboat owners, who should be the best judges of their own interests. They are a large and influential class, and he thought it would be admitted that they have much at stake, and are well able to take care of themselves. But there is another and a larger question raised by Mr. Ferguson's paper, the importance of which cannot be over-estimated, and that is, does the registry law stand in the way of improvement in the building and equipment of ships? Mr. Ferguson seems to think it does, and if his views are sound, he admitted that the Act of 1854 required amendment. He was aware that the rules that govern tonnage influence to a great extent the arrangements of shipowners and shipbuilders, and have always done so; for previous to 1854 every change in the tonnage laws produced a change of model, the form of ship adapting itself to the law, so as to insure the greatest amount of carrying capacity on the smallest registered tonnage. But the Act of 1854 applied a remedy to this evil, because, as far as the under deck tonnage is concerned, no form of vessel could evade its provisions; but like all other human productions it had defects—it was not perfect; what law ever was? It provided that nothing should be added to the tonnage for any closed-in space on deck occupied by the crew unless such space exceeded 1-20th of the gross tonnage of the ship; but from this allowance all vessels are necessarily excluded unless they can berth their crews on deck. Now, he thought that it was amply clear that it was unfair to give an allowance to any one class of vessels of which other ships could not avail themselves; and it was equally clear that this provision had led to the deck arrangements of which Mr. Ferguson complains. It must be confessed that spar-deck ships are hardly dealt with, and that the penalty paid by the owner for joining his topgallant forecastle and poop by a flush deck is heavy, and has no doubt deterred many from building spar-decked vessels, however superior; and so long as we offer so large a premium for the erection of deck-houses, he feared we shall have them built and fitted to a dangerous extent; but withdraw the premium, and the practice would die a natural death. There is another class of vessels excluded from the allowance. He meant that numerous class of small sailing vessels engaged in the coasting trade. Now, as all dues and port charges, including towage, are levied per register ton, it follows that all small vessels are compelled to pay 5 per cent. more than they are entitled in justice to be charged with. He need hardly say that there are no vessels afloat that have so many difficulties to contend with, and no capital that pays so small a per-centage as that invested in coasting vessels. He therefore concluded that coasters are hardly dealt with in being excluded from the allowance for crew space. But there is a higher ground from which he thought this subject should be looked at—the sanitary condition of the sailors that man our coasting craft. He knew from personal observation that the space allotted to them is so small that neither cleanliness nor comfort is possible, and the excuse frequently advanced in justification of this state of things is, "we cannot afford more room." He would remedy this by extending the allowance for crew space to all vessels, whether berthed on deck or not, making provision under heavy penalties that the space allotted to each of the crew should be similar to that provided for a steerage passenger. These men have strong claims on our sympathy, and he submitted that this institution is entitled to be heard in their behalf. He also thought that engineers and shipbuilders are entitled to consider and pronounce an opinion on the still more important question of spar-deck ships, as contrasted with that class of vessels referred to by Mr. Ferguson, and he was quite sure that any well-considered suggestion will receive due consideration in the proper quarter.

Mr. SIMONS said that no one would question the propriety of having the spar decks free of dues, with regard to the spaces not used for stowing cargo, but it would be necessary to prohibit putting cargo in such places.

Mr. COSTELLOE replied that that part of the matter could be very easily settled. He would grant exemption from dues for it on the same condition as a ship without such a deck, provided that nothing was stowed in the passages; and in regard to small vessels, he would require that each of the crew should have the same space allotted him as every steerage passenger had.

The PRESIDENT held that the covering of those deck holes was just like the privilege granted to vessels of the same class as the Iona.

Mr. COSTELLOE agreed with the President in that opinion, and believed that if the matter were placed before the Board of Trade it would be settled satisfactorily.

Mr. JAS. ALLAN did not think there could be any doubt as to the superiority of a four-deck ship over a three-decker. The object his firm had in view in putting in a fourth deck was, that in going through the Northern Atlantic the passengers might get exercise in bad weather when they could not get on deck, and they thought they had got as much assurance from the Government as to warrant them in continuing to build them. Accordingly, they contracted to build two of that description. When they got one finished they found that the gross tonnage was so much more than they expected, that they countermanded the order for the second in so far as the fourth deck was concerned. The effect was that, although the latter was 9 feet longer and 1 foot broader than the former, yet she was 300 tons less register! Consequently, they paid about £1200 a year less dues for the larger vessel. The fourth deck greatly tended to the comfort of the passengers, so that on the point of humanity there was great reason for an alteration in the law. He thought that, if the matter was properly represented, there was scarcely a chance of a refusal. With regard to carrying cargo in those spaces, he was of opinion that no one would try to do so; and if the load-line were kept to the main deck, no cargo could be carried there. Dry cargo could not be put there, for it would be damaged by the water, so that that objection was easily disposed of. He suggested that a committee be appointed to draw up the heads of a memorial to the Board of Trade, which he believed would be attended with the best effects. As a shipowner, he had no doubt at all that the present tonnage laws prevented the improvement of ships in many ways. He did not ask for the exclusion of the poop from the register tonnage.

Mr. J. M'DONALD said that all parties seemed to be agreed that no change should be made on the measurement for any advantage that is to accrue to passengers on board a ship; and what he would suggest to that institution was, that they recommend that every part of a ship, no matter whether to carry passengers or not, should be measured, but make an allowance for the accommodation of sailors. Make a distinction between what brings revenue *per se*, and leave the rest free to benefit the crew.

Mr. R. DUNCAN suggested that the Board of Trade should be recommended to measure every part of a ship that was inclosed, whether it was on deck or below it, and that they give an allowance on the gross tonnage for the crew. At present the shipbuilder had to build tons of space for which possibly he was not paid, it not being measured; hence he thought it would be better if the whole vessel were measured, galleys, water-closets, topgallant forecastles, &c., and a fair allowance made for crew space. At present a great portion of the deck-houses, forecastles, &c., were left to the surveyor to measure or not as he thought proper.

Mr. COSTELLOE said that Mr. Duncan was in error if he supposed that it was optional to the surveyor whether he measured some spaces or not. The words of the act were—"Every permanently closed-in space," whether it was sufficient for sheltering cargo, passengers, or crew. Now, among the spaces referred to by Mr. Duncan were those over the hatches, steam winches, and others, which were sometimes fitted with sliding bulkheads, which were run out and in as required; but the surveyor had no power to measure such—they were not permanently inclosed.

Mr. SIMONS did not admit that such deck spaces, if covered in, would not be used for cargo. Many things in the East India trade might be stowed away in them.

The PRESIDENT said that he thought Mr. Duncan wished for the full measurement, in order that shipbuilders might be paid for every registered ton they supplied.

Mr. DUNCAN thought it would be the fairest way for all if the whole vessel were measured; the builder would know what he was giving, and the owner what he was getting. That would do away with the great difference apparently in tonnage, as shown by Mr. Allan.

Mr. GEORGE SMITH, jun., said Mr. Costelloe seemed to say that 5 per cent. would be a full allowance for the crew. He would suggest that in any memorial sent up to the Board of Trade they should stipulate that the crew should get the benefit of all such allowance. Then, with regard to the spar-deck, he agreed very much with Mr. Simons' opinion, that there should be a distinct proviso that no cargo should be put into such excluded places. He did not think any deduction should be made for cabin passengers; but he did not think space ought to be included in the tonnage which was for the exercise of steerage passengers. Let the whole be measured, and an allowance made for the crew space and what was required for the comfort of steerage passengers. The rate per ton which builders would charge would soon regulate itself accordingly.

Mr. COSTELLOE said what he suggested, in reference to the crew space, was that each seaman should be allotted as much space as a steerage passenger. With reference to the spar-deck, the only immunity claimed by the advocates for spar-decks was that nothing be added for the space covered in for exercise in bad weather and not used for carrying a cargo, and nothing be added for the closets, galleys, or washing-houses for female passengers.

The PRESIDENT said the memorial must be presented without much delay if it was to be of any use. It would therefore be necessary to remit it either to the council or to a committee. He moved that a committee be appointed.

Mr. SIMONS thought they should each have a copy of the memorial before them, previous to committing themselves to anything.

Mr. HUNT thought there was not time for that. He would leave it to a committee. He seconded the President's motion.

The motion was carried.

Mr. D. ROWAN then proposed that the following be appointed a committee to draw up a memorial to the Board of Trade on the subject:—Messrs. J. G. Lawrie (convener), George Smith, jun., J. Allan, John Ferguson, R. Duncan, R. Mansel, M. R. Costelloe, A. Gilchrist, D. Rowan, W. Simons.

Mr. R. BRUCE BELL seconded the motion, which was carried unanimously.

Subjoined is an extract from the Memorial sent, on the 3rd of April last, by the Institution of Engineers in Scotland, to the Board of Trade:—

"This institution having learned that your Lordships are at present legislating on the subject of Tonnage in a Bill now before Parliament, prepared by Mr. Milner Gibson and Lord Clarence Paget, have resolved to renew the application to you on the important subject of the tonnage of the spaces occupied by the crew, and have appointed us a committee to make the application.

By section 21, clause 4, of the "Merchant Shipping Act, 1854," it is directed that nothing shall be added to the tonnage for a closed-in space on the upper deck, solely appropriated to the berthing of the crew, unless such space exceeds one-twentieth of the remaining tonnage of the ship, and in case of such excess, this excess only shall be added.

Your Lordships will see that this enactment furnishes an inducement to provide the accommodation for the crew in closed-in spaces on the upper deck, such as topgallant forecastles, and deck houses, because the tonnage of such spaces not being included in the register tonnage is not chargeable with dues for docks, lights, or any purpose whatever.

In large ships, which trade in warm climates, the seamen can be, and are comfortably quartered in closed-in spaces on the upper deck; but in small vessels no such space can be provided on the upper deck with due regard to sea-worthiness; and in any vessels which trade to cold climates, the seamen cannot be placed in topgallant forecastles without subjecting them to severe discomfort. Thus those vessels which, for sea-worthiness and the protection of the seamen, have the forecastle under the upper deck, and of which the measurement is included in the register tonnage, are subjected to the payment of dues on the tonnage of the crew space.

We are not aware of any substantial reason that can be urged for this exemption of the crew space in the one class of ships and not in the other. No such reason exists with respect to the sea-worthiness of the ship, nor to the comfort and safety of the crew; nor can we imagine that it can be urged, for one moment, that a ship with the crew space under an upper deck should pay larger dock dues than a ship with that accommodation above the upper deck; nor that it should pay a higher tax for passing a lighthouse. If the crew space, when placed under the upper deck, was exempted from the register tonnage in the same way as when placed above the upper deck, shipowners would be free to quarter the crew in the situation most advantageous for the seaman, and to give them the extent of space necessary for their comfort.

We beg your Lordships most respectfully to consider these statements, and we cannot but express not only a great desire, but a strong conviction that you will be pleased to grant the exemption of measurement for the crew space, whether it be placed above or below the upper deck.

We have now addressed your Lordships on the subject which originally formed the object of our desire, but recent events—the shipwreck of two large ships, the London and Amalia, attended with the most lamentable results, furnish our reasons for addressing your Lordships on another provision of the Tonnage Laws, operating to the great injury of ships as well as to the danger of passengers.

With this letter, we beg leave to submit a drawing of a ship, showing an arrangement that is not unusual for passenger steamers. According to this plan, there is a poop, a topgallant forecastle, and a range of houses extending nearly from the poop to the forecastle, and all forming closed-in spaces on the upper deck. In such ships, the space forming the accommodation for the crew to an extent not exceeding one-twentieth of the remaining tonnage of the ship, the cook's-galley, the water-closets, &c., are not included in the register tonnage of the ship; but if these are covered over with a closed-in deck, they are at once included in the register ontnage, and subject the ship to greatly increased dock, harbour, and lighthouse dues. This additional taxation has prevented shipowners from building ships with decks covering over all open spaces, and has led to the use of ships constructed as shown on the drawing. Your Lordships will please to observe that in ships so constructed there are large spaces extending from the poop to the forecastle, on each side of the ship, between the ranges of houses on the deck and the bulwarks, spaces which are receptacles for immense quantities of water shipped in heavy weather, crippling and imperilling the safety of the ship.

If the Tonnage Laws excluded from the register tonnage the accommodation for the crew when placed under the upper deck, if the cook's-galley, the water-closets, the measurement of these dangerous receptacles for water extending all along each side of the ship, were excluded from the tonnage when covered over with a closed-in deck, called a spar-deck; if, in short, the register tonnage of the ship was unaffected by the use of a deck over all—a deck which adds at once immensely to the strength of the ship, and which reduces to a minimum the dangers to which the ship is exposed, shipowners would be freed from imposts that at present most severely hamper them. With this covering deck, or spar-deck, and with the netted bulwarks used with such decks, no lodgement for water exists; there is no spirketting, as in the London, to obstruct on one side of the ship the escape of water shipped on the other, there is no question about the size of ports through the bulwarks to pass the water from the deck of a labouring ship, and why should a ship constructed with a continuous deck, covering both the crew space and those spaces which without the deck afford lodgment for water, be charged more for lying in a dock, or be charged more for passing a lighthouse, than a ship not having the deck. To make a difference in the two cases, we respectfully submit, is unjust as between ship and ship.

We respectfully suggest, that your Lordships will be pleased to introduce clauses in the Bill now before Parliament for the purpose of carrying these exemptions into effect.

1. To exempt from the register tonnage of all ships the measurement of all spaces for the accommodation of the crew, whether placed above or below the upper deck, to an extent not exceeding one-twentieth of the remaining tonnage.

2. To exempt from the register tonnage of ships built with a covering-deck, or spar-deck, the measurement of all spaces under the spar-deck which are at present excluded from the register tonnage when the ship has not a covering deck or spar-deck, ample security being taken that the spaces excluded from the measurement, shall not be used for berthing passengers or stowing cargo."

BREADTH OF LIGHT AND SHADOW IN ARCHITECTURE.*

By Sir Walter C. James, Bart.

Our life may be said to be composed of lights and shadows. In studying this subject, therefore, it has appeared to me that it might be permissible to treat it not merely in a dry and technical manner, but with some reference to general principles. Not indeed that the technical part of it is insignificant, for it is a main element in the success not only of the architect, but of the painter and sculptor, that he should make himself master of that branch of his subject which the Italians call *chiaro scuro*, but which with us goes by the simpler name of Light and Shadow; and in the outset I cannot but express an opinion how unfortunate it is that the study of our architects is far too much confined to that of elevations and sections, rather than extended to perspective sketching, and, what must be even more useful and truthful, the construction of models in some detail of the structures they are about to erect. The appearance of a building with or without the sun upon it, in the morning or in the evening, is a matter of no slight importance, yet seldom much weighed or thought of. Does its outline come boldly out upon the sky, or is it backed by hills and woods? What is the depth of shadow cast by its mouldings and cornices? What is the setting of its windows—the best, perhaps only index we have of the strength and thickness of its walls? These are a few, but a few only of the questions which a study of the light and shadow of a building presents to the mind of the architect. The tendency of the revival of architecture in England has been rather towards technical excellence than the improvement of the great principles of design. Nor are the causes of this far to seek. The revival has had its origin more in the individual spirit and energy of private persons, than in any Government influence. The Church, indeed, as in the olden time, has been the main friend and supporter of the art, but here, too, the tendency has been to smallness and prettiness, rather than to size and magnificence: true, indeed, our cathedrals have undergone, to no insignificant degree, restoration and improvement, but it has been in the embellishment of the superstructure rather than in the extent of the foundations. Here, too, it is the unit, rather than the corporate idea, that has had its main influence upon the public mind. The parish church or the nobleman's mansion has been the scene of the architect's most successful labours. Of course, to this rule there are large exceptions. The vitality which has risen from individual energy and individual wealth has spread through every part of the body politic of England, and we have seen with our own eyes the erection of many noble public buildings of which no age or country, not even classic Italy, need have been ashamed; yet I dare affirm that the movement has been inspired from below rather than from above.

This is quite in accordance with the spirit of the age. The taste has spread from the labours of such men as Rickman, and Pugin, and Ruskin, rather than gained inspiration from public patronage, from the Government, or from the Crown. The consequence is, that our efforts, our experiments, are necessarily upon a small scale at first. We are like military officers who have not had much opportunity of moving large bodies of men; whereas, abroad, painters, sculptors, and architects generally, have much assistance from government, put themselves at the head of a large set of young men, and form a school, whether of painting, or sculpture, or architecture. We in England work in an isolated and therefore comparatively small way. Here and there a well-known architect or sculptor may have pupils; a painter, we may say, hardly ever.

Nor do I feel that this mode of working is altogether wrong. It interposes great difficulties in the way of struggling merit; but, on the other hand, those choice spirits who struggle upwards are probably men of higher genius than those who in the neighbouring country are raised up under the fostering wing of Imperial patronage. We have nothing to be ashamed of in the artists of our day. Finish, indeed, perhaps, bears a disproportional value in the market, and the excellence of detail, whether in architecture or its sister arts, is very highly appreciated; while genius like that of a Blake or of a Martin is little thought of. I mention these topics of the day as one excuse for recalling to your minds a few of what I would call the larger principles of the art,—its theory rather than its practice.

I would, then, ask you what is breadth? It is a word frequently in the mouth of the artist, but, perhaps, not readily present to the mind in any very clear and definite manner. Perhaps we may arrive at a sound notion of its nature by looking at its opposite, which I take to be "spottiness of effect," or "overcrowding of detail." As a general rule, we may say that the earliest styles of Gothic art, the Norman, the transition from Norman to Early English, the later transition from Early English to Decorated, present noble examples of breadth and simplicity of treatment, when compared with the Perpendicular in England, the Flamboyant style in France, and the Renaissance in Italy. It has been observed by a writer on morals, that we do not want a dinner to be "all sweets, or all dessert," or a beautiful dress to be all "flounces and furbelows;" so, too, we do not like a building entirely covered with ornamentation, which justly is compared rather to "filagree-work, or lace-work," than to the realisation of that noble idea of structure which makes the framework the basis of all real beauty, just as the bones of an animal are the true foundation of its features and its form. Not universal ornament, then, but ornament in the right place, in the right degree, and, above all, in the right perfection, are characteristics of breadth. With breadth is necessarily connected severity of style; and I would add this one observation upon the subject, which, I think, is agreeably to a remark of Mr. Burke's, in his essay on the Sublime and Beautiful. Breadth seems to be necessarily linked with size, and what may be called a certain masculine vigour in the de-

* Read at the Architectural Museum.

sign of a building. Small things are deprived of much grandeur, and its place is then supplied by the secondary attribute of prettiness or elegance. I would instance, as a proof of this, a small apartment as compared with a large; a lady-chapel as compared with a nave; metal-work as compared with stone-work; and jewellery as compared with iron-work. The more minute the object, the less need we fear that exquisite finish upon it will be contrary to the rules of taste. The dragon-fly or the humming-bird has colours more brilliant, hues infinitely more delicate, than we find in the plumage of the dusky eagle or tawny coat of the lion. Small things can hardly be too pretty; large works can hardly be too simple. If this were kept more in mind, I think much useless expense might be spared. Size in a building in no small measure supplies the place of ornament. There is dignity even in empty wall space. On the other hand, in small chapels, in the tombs of the wealthy, in the reredos, in the font, in the memorial stone, we have good examples where the true principles of simplicity and vigour may with great appropriateness be made to yield the palm to loveliness and grace.

Breadth, then, is always accompanied by grandeur.

> "Those Titanian fabrics,
> Which point in Egypt's plains to times that have
> No other record,"

are noble examples of this; and as we sail down the stream of time, and advance in knowledge of world architecture, the Doric temple presents to us the noblest example that can be found of "breadth" Ornament, varied and rich, is confined to the pediment, the cornice, and the frieze. Yet, what glories do these disclose. How simple, and yet how perfect, are those forms of heroes and horsemen which came from the inspiration of a Phidias. Sculpture, indeed, always was used as an adjunct of Greek art in the days of its true glory. Not merely the frieze, but the metopes between the triglyphs. The pediment, as before noticed, and the pedestals on the roof, are all useless and quite without intention, unless surmounted with sculpture. We may notice too, how accurately the principle of ornamenting "structure" is carried out. The ornament being almost always placed upon some essential part of the building, and but seldom superadded, as a mere wanton and useless luxury. The variety of form, too, which characterises this Doric style is notable. We may first of all observe the form of the building—a parallelogram or oblong. The cornices, the triglyphs, the bases of the columns, the steps leading to the portico, are all square in outline, and notable for the saliency of their right angles. The columns are all circles, and being circular present the finest contrast to the square masses of which the building consists; but the adjuncts of these noble shafts, the flutings, and the capitals present the form of delicate curves. The capital is ovoid. It used to be assumed that these columns were bounded by straight lines. Modern discovery has shown that they have a convex profile,—this in the Parthenon goes to $\frac{1}{550}$ part of the whole height of the column. The absence of this in modern work gives that poverty and rigidity to the style,—in other words, that want of breadth,—which is so frequently matter of just complaint.

We see, then, that although the Doric order is remarkable for its symmetry, its breadth, what may fairly be termed the opposite merit, variety of form, complexity of detail, was never absent from the mind of the Greek artists. Variety, indeed, may be said to be the note of the picturesque, as symmetry is the note of what is purely and simply beautiful. It is in the combination of the two that we have the acme, not only of architectural excellence, but of all art.

Another refinement was to give a slightly-inclined inward slope to the whole building. This, of course, brought out a great notion of support and strength. Each curve was designed upon principles truly mathematical. The care with which the mason-work was built has never been surpassed; and yet all this meritorious detail was not, even in its smallest part, superfluous, because it was bestowed upon a design at once simple, appropriate, and beautiful. The probability is that these splendid temples were not only remarkable for their lovely forms, for the depth and play of light and shadow on the rounded column, and in the deep recess, but that they were brilliant as precious stones, distinguished even at a distance by their sparkling colour. This topic, however, is scarcely within the scope of this lecture. I hasten onwards to notice some few other examples of breadth of treatment, as it is called, of which the pure Doric sample may fairly be termed the most natural and perfect form.

Taking a bold leap, as it were, from Pagan styles to Christian art, we perceive an unmistakeable analogy in their progress and development which can hardly escape the notice of any intelligent inquirer. The social state of man as he emerges from barbarism into civilisation, develops, at various periods of history, in similar ways. The Christian civilisation is unlike the Greek, and it is as superior to it as the character of its great Founder was to that of Socrates. Nevertheless, there are points of likeness, and if the theocratic system of the kingdom of Israel was intended (as most orthodox divines admit) to prefigure the sacerdotal and sacramental system of the Christian church—if, as lawyers will not be slow to acknowledge, we must look to ancient Rome as the fountain of all systematic laws, and what may be comprehensively called the organisation of civil society, to Greece we may confidently turn (as an able statesman has lately told us) as the divinely-appointed source of our knowledge in all matters of taste, literature, poetry, and art. The Indo-Germanic races which descended into Hellas proper, from Thessaly, from Thrace, from Scythia, were but men of like passions and kindred origin with those who, many centuries afterwards, came down from Germany and France into the plains of Lombardy. It is therefore not unnatural, upon general grounds, that we should trace in the early styles of Greek architecture, some faint likeness of the early styles of Christian art, and that, *mutatis mutandis*, we should see in Doric simplicity a prototype of Norman breadth and grandeur, a prototype undoubtedly more perfect in all technical excellences than its Christian successor, but less fertile in idea, in variety, in all those attributes which distinguish the Church architecture of Mediæval Europe from the Temple architecture of Greece. What the Doric style was to the Egyptian, the Norman style in England was to the Continental styles. This, Mr. Fergusson, in his able Handbook, remarks, is well exemplified in the nave of Durham Cathedral, a building differing in every respect from anything on the Continent. He proposes to give to it the name of "Norman Saxonised," but emphatically denies that it has any claim to the distinctive characteristics of Norman. In both, however, the common attribute is "breadth;" not so much largeness of dimension as largeness of proportion; an unnecessary strength in all the supports; an unnecessary depth in all the mouldings; an almost superhuman vigour in the style; and a superabundance of sculptured ornament, which, however rich it may be, never interferes with the main lines of the building, or the unbroken surfaces which are a necessary constituent of breadth. The beauty and minuteness of the Norman diaper work is a very remarkable thing, in a style where all else is so large and so bold. This nave of Durham, as Mr. Fergusson says, bold, massive, and grand, presents a striking contrast to later examples, such, for instance, as the nave of York Minster, which, though spacious and elegant, and presenting a degree of refinement in every process and every detail, to which Durham cannot pretend, is not nearly so imposing as the rude grandeur displayed by the latter, notwithstanding its far smaller size.

It is not impossible that the analogy I have noticed between the early Doric and the Norman might be carried further. There is in the Ionic style a character of elegant simplicity which is not alien to the Early English; and in the richness of the Corinthian a great likeness to the Gothic Decorated style. These may be feeble analogies—I will not too much insist upon them; and yet, on the whole, they appear to give a fair view of the various steps by which the human mind rises to the ideal in art. From rude strength we advance to an elegant simplicity, and thence, again, to richness of decoration; after which the course is generally downward; not, as has been before observed, in technic skill, but in all the grander attributes of art. As labour becomes more skilled, we economise our materials; and we therefore find in later periods of development less of originality, less of power, but more minuteness and elegance of finish.

Again, we may, perhaps, find it useful to compare our condition with regard to architecture to that of Imperial Rome, after the long peace which inaugurated the reign of Augustus. To Rome all heathen art tended; from Rome all Christian art originated. Not, indeed, that the Romans were artists,—quite the reverse; but, like a whirlpool in some mighty stream, Rome appropriated to herself, made her own, everything that came within her reach. Etruscan in her origin, she has left more remains of the period when she was governed by kings than of her consular and republican history, of which latter we have not, so far as I am aware, a single monument. But with the conquest of Carthage, the subjection of Greece and Egypt, and an extensive Oriental dominion, artistic wealth began to flow in upon her from all quarters. The consequence was a number of buildings of different and incongruous styles; remarkable rather for size and grandeur than for taste, and a masculine vigour of style. The same thing may be said of our modern capitals. Of the Emperor Augustus it was remarked, that having found Rome a city of brick, he left it a city of marble. The Emperor Napoleon, in like manner, having found Paris a city of streets, narrow, inconvenient, and dirty, has made it a city of palaces, airy, commodious, and clean; but it is a general and true remark, that in doing all this he has not added to its character. It is fine, it is magnificent; but compare its interest with any genuine specimen of old work, and we shall be constrained to confess that magnificence often means monotony, and costliness a sacrifice of individual freedom. In London matters are little better; though they are better. If Paris, like Rome of old, is delivered to the tender taste of an emperor, London is being gradually given up to the tender mercies of the engineer. In all this we see tendencies towards a state of transition, from old and time-honoured styles, to something new, something better, it may be, than the world has yet seen; but whether worse or better, it will probably be something wholly—or at least in its main features—novel. In the decline of imperial Rome, we can hardly suppose that the Romans saw (it is a philosophical remark of Mr. Fergusson's) the result to which the amalgamation of various styles then in vogue was tending, and yet they worked as distinctly to that end as if the spirit of prophecy had guided them to a well-defined conception of the future. And the same thing is going on with the earth upon which we tread, with the language we utter, with the political institutions under which we live. An insensible change, all the more efficient because almost imperceptible, affects us all; and from old forms new forms are being continually evolved. Let it not be thought that, although this be an expansion of our subject, it is altogether alien to it. It is at periods when things are changing—when one is forcibly reminded of the saying of the Greek philosopher, that all things are, as it were, in a constant flux,—it is so important to recur to first principles; not to waste our energy upon details alone (though invaluable in their way), but to look to something broad and grand, such as animated the architects of Mediæval Europe or Classic Greece. In this, as in most of the problems which guide you in the noble practice of architecture, Nature may be at the least as great a help to you as any building framed by man. Do you want to know how to support a superincumbent weight upon a slender and delicate shaft? Look at the mechanism of the wheat-stalk, in which you will see, in an undeveloped form, every principle which guided Stephenson in the formation of his iron tube across the Menai Strait. Do you want to resist the outward thrust of some continual pressure? Look to the buttresses of the everlasting hills, and there learn that it is in the strength and stability of the foundation, in the thickness of the wall—how often, yet how foolishly neglected now-a-days—that we can rely for a permanent and really substantial building. The lights and shadows of the landscape as they float across the plain, or betray by their undulating nature the forms of the superficies, are guides to us in showing how different may be the external effect of the same mass at various times, how form changes, how colour changes under the transient influence of light or shadow.

I am the more anxious to make these remarks, because I have lately heard from my friend, Mr. Scott, two admirable lectures on the various buildings open to the study of the young architect, both at home and abroad. He has shown them what advantages may be derived from the study of old churches, old halls, old ornament, wherever found; how the work of those whom we call the "old men," may serve in the solution of many a practical problem. He has well advised this, as the best means of exciting and quickening powers of observation.

I would fain add, while you give full weight to the architects of this or that century, this or that era, do not forget the works of the Great Architect of the Universe. Depend upon it, those old monks who raised such noble minsters hesitated not to see in the animal framework, or the floral decoration, the best possible models, both for permanent structure and appropriate ornament. Among the merits of Mr. Ruskin as an interesting writer, this must ever be considered as one of the greatest. He has never looked upon his case as made out because it has been established by thirteenth-century precedent, or any other precedent, but has gone straight to nature for the confirmation of his views. Having observed her laws, and the works of art in which her beauties are skilfully portrayed, with no common genius, he has brought to the study of architecture a mind stored with more than the ordinary amount of information; and, although we may fairly differ from many of his "dogmatic" rules, we must admit him to have shown a spirit in the study of art both catholic and sincere; catholic in the universality of its grasp, sincere in the truthful working out of any detail with which he may have charged himself. These few remarks, then, come to this,—that while admiring the skill of modern architects in all manner of detail, it is possible, by the over-study of these latter, to lose sight of that great principle of breadth which, whether we take it in form, or light and shadow, or colour, is a necessary, indeed the first, element in any great work. Secondly, if the principle of breadth have any value, it ought to be specially brought out at a time when prettiness and littleness are rather the characteristics of the day,—when we are more likely to produce Dutch minuteness than Italian magnificence, private luxury rather than public splendour.

I wish now to say a few words on art principles in general, and especially with regard to architecture. Art we presumed to be under most of its aspects an imitation of nature. Now, nature proceeds by fixed laws. What, then are these? Uniformity of plan is the first great rule, or, as the poet beautifully says, "order is Heaven's first law." Sir Isaac Newton, in the "Principia," in a remarkable passage quoted by Professor Owen in his book on the "Nature of Limbs," remarks on what we may call the bilateral symmetry of nature. Two eyes, two ears, two hands, two feet; each side of the body of animals corresponding exactly to the other. Such is the plan; and if we pursue our inquiry into vegetable nature, each flower, each leaf when bisected, cut into equal parts, produces two parts essentially the same, and both perfect. Again, we have in the various segments of animals an analogous uniformity. Thus we see the limb is in all its features the same, whether it be an arm or a leg, and botanists tell us that a flower is but a highly developed leaf. Now, to carry this law into the arts, we see that symmetry, or what may be called uniformity of plan, is the first great law. If we bisect a Doric column, or a Doric temple, each side of each part exactly answers to the other; and, in common language, the phrase that a thing is "lopsided," or "all on one side," is but another form of expressing our sense of its ugliness—an ugliness arising from imperfection, because the parts do not correspond.

God's handwriting is seen upon the surface of nature: if we want a test of what is true and beautiful in art, we must ask ourselves, is the handwriting the same? This, I think, is the best and only sufficient test of the beautiful. What, then, are the characters? This uniformity or symmetry of plan is the first. But underlying this principle, not opposed but rather in subtle and exquisite harmony with it, is the law of infinite variety, an adaptation of means to ends as marvellous and beautiful as its correlative law of symmetry. Buffon, the great French naturalist, has well remarked, "It is only by comparing we can judge, and our knowledge turns entirely on the relations that things bear to those that resemble them, and to those that differ from them," and he adds, by way of illustration, "if there were no animals, the physical nature and structure of man would be far more incomprehensible than it is." May we not in like manner say that if we had had no nature we could have had no art; and that without going to nature it is impossible to understand the true principles of structure. What, then, is this law of perpetual and never-ending variation? I will put it in a twofold light. 1st. The adaptation of means to ends, or what may be called creative ingenuity. 2nd. The principles of variety and contrast, as being, *per se*, an element of beauty in the physical world, and, therefore, essential to the beauty of any work of art.

On the first topic, the adaptation of means to ends, and the skill with which each part is made to play its due proportion or share in the wondrous whole, I know of no better illustration than the skeletons of animals. It is here that the most interesting and beautiful evidence, of adaptation to ends, as well as unity of plan, have been discovered.

No study could, I am persuaded, be more useful to the architect, as well as to the artist. The principle of the arch may be said to be the leading idea of the bony framework. Our skulls are arches; our feet are arches; our bodies form arches—for what are the ribs and concomitant vertebræ but an arch? The whole spinal marrow, as it descends from the brain to the pelvis, is enclosed in a strong, compact arch, to which the spines of the back act as a powerful keystone. But if the principle of the arch is to be found in the body of every animal, we may discover likewise that of the column, or vertical support. No superfluous material is here wasted by the great Creator. The limb of the elephant is well proportioned to sustain the enormous weight of his unwieldy yet majestic frame; while that of the camel or giraffe is slender, elegant, and bony, just in proportion to the superincumbent mass that presses upon it. Look, too, at the feet of the camel and the elephant. The foot of the elephant, like the instep of the human being, is arched in its structure, calculated to support weight. The foot of the camel is not arched at all, but flatly, horizontally, spread out, with soft, large cushions at its sides, to prevent the animal sinking into the sand of the desert. But Nature is as thrifty an architect in the choice of her materials as in the forms in which she disposes them. I select the following passages from a work of Owen:—"The bones of fishes are spongy in the interior; and where ossification takes place it is restricted to the surface of the primary gristly mould. The bones of the turtles and sloths are solid; but in the active land quadrupeds the shaft of the long bones of the limbs is hollow, the first-formed osseous substance being absorbed as new bone is being deposited from without. The strength and lightness of the limb-bones are thus increased, after the well-known principle of Galileo, exhibited by means of a straw picked up from his prison-floor, to answer a charge of atheism brought against him by the Inquisition. The bones of birds, especially those of powerful flight, are remarkable for their lightness. The osseous tissue is, in fact, more compact than in other animals; but its quantity in any given bone is much less, the most admirable economy being traceable throughout the structure of the bird in the advantageous arrangement of the weighty materials." Then, after illustrating this by showing how heated air permeates the bones of the bird, he concludes—"The bones of birds are filled with rarefied air. Their extremities present a light, open network of slender columns shooting across from wall to wall, these little columns being likewise hollow."

Every book that is written on natural history gives us something of the same kind. Now I hear, as it were, the word "Question, question," mentally uttered by my auditors, as if such arguments were foreign to my lecture. I must excuse myself by saying that, as Nature does everything with a clear and definite purpose, or final cause, the architect ought to do the same; and that the vegetable world as well as the animal kingdom offer most excellent subjects for the study of the young architect, —subjects hardly secondary, if at all so, to the study of the works of man, the temples of Greece, or the Mediæval cathedral.

The principle of the hollow column, which I alluded to in the earlier part of my lecture, though well known to the engineer, has seldom been brought into use by the architect. Mr. Butterfield, indeed, has used it in the Church of St. Alban, where the decorative columns are of hollow pottery, not unlike draining tiles. The effect is pleasing. I observe, too, that Mr. Barry has used the same contrivance for ornamenting the corners of some schools in Holborn, and has adapted these hollow tiles to convey water from the roofs of the buildings. But it is when we come to the higher region of the air (like the bird) that we may naturally expect to see bird-structure, if I may coin a word, imitated. What is the spire itself but a hollow tube? and it is in the building of spires that hollow tubes, as I conceive, might very effectually be introduced, as being good examples of a combination of lightness with strength, and enabling us to get what we as English builders are very defective in,—I mean altitude of proportion. This quality is necessary to grandeur, particularly in the Gothic style, and in edifices dedicated to the glory of God.

It is then in that variation which admits of the special adaptation of each form to the purposes for which it was designed, that we see the wisdom of nature, or, in other words, the wisdom of God. Why should not the same law guide us in our buildings. Pugin has well defined architectural propriety to be, that the external and internal appearance of an edifice should be illustrative of, and in accordance with, the purpose for which it was designed. The animal, the tree, or the flower, each has its own character. So should the building designed for God's glory, the collegiate establishment, the town-hall, the mansion, or the cottage. I need not point out how contrary to this wholesome principle is the idea of having a church like a Greek temple, with a Doric colonnade, a collegiate establishment like a large hotel, a town-hall like a theatre; a gentleman's house like a barrack, or little better, a Gothic abbey; or an entrance lodge decorated with an Egyptian Sphinx. There is a place in Nature for everything, and everything should be in its place.

Nor is this rule less applicable to small than to great things. It gives true simplicity and breadth of character, and cuts off useless ornamentation. It is allied to the equally important principle that ornament should never be introduced for its own sake, or as we may express it, for "mere show-off," but should be confined to the decoration of construction. We never see anything in nature overcrowded. Everything is subservient to some purpose, and beauty is superadded. How different is this from the faulty decoration of the upholsterer, who determines to do the thing in the Gothic, the Greek, the Italian style, or in what may be called a skilful medley of the worst features of all these, the upholsterer's style: crockets and finials project from every corner; here the claw of a beast, there the beak of a griffin; here a sideboard supported by a mahogany eagle, there a serpent twisting gracefully round the table's leg. Where, I ask, are simplicity and breadth in these things? Truly did Mr. Pugin remark, that a gentleman could hardly walk through a drawing-room fitted up in this style without danger either to the furniture or to his own clothes.

Mr. Pugin remarks, "Notwithstanding the palpable impracticability of adapting the Greek temples to our climate, habits, and religion, we see post-office, theatre, church, bath, reading-room, hotel, Methodist chapel, and turnpike-gate, all present the eternal sameness of a Greek temple outraged in all its proportions."

A few words may be added on variety, not merely considered with a view to the various purposes for which buildings are designed, but as in itself a principle of beauty, and a main source of the picturesque. Inequality of forms and quantities is necessary to make up an agreeable building or picture. It has, I think, been remarked with great truth, that the effect of the opposition of lines and the force of contrast is more noticeable in a work of art than in nature; for in the former the various objects strike upon the retina at once, in the latter they are dispersed over the landscape. A defect may be observed in a photograph, which would not strike the most delicate or critical eye in nature. To show what I mean, I have taken the trouble to draw out, as a diagram, the hand of a man and the hand of a monkey. Teleologically, that is, with the view of studying the purpose for which each is framed, they are equally well adapted; but in point of variety of form, observe, I beg, in the human hand, with what delicacy and variety the length of fingers is gradated; how much more subtle the difference is in the size of the finger joints, and how this infinite variety of size contributes to beauty. The same may be said of the graceful and swelling curves which bound the outline of the form of man.

I will, just for example's sake, give another illustration, from the floral kingdom—a rose and a convolvulus. The forms are equally lovely, yet both dissimilar; and if we examine the parts with care, we find no two leaves, no two petals, no two parts of any description, like their fellows. The flowing curves of the floral kingdom may be a study more congenial to the painter or the sculptor than to the architect, who deals in general with stiff and unyielding materials. In the midst, however, of these lovely curves, within the calyx, and often round the corona of the flower, there are exquisitely symmetrical forms, —hexagons, pentagons, octagons,—every conceivable geometrical form which, in the composition for instance of decorated windows, would be most serviceable to the architect. From their illuminated manuscripts, from their being great farmers, &c., we may well believe that the monks of the Middle Ages not only studied botany, but adapted it to their building purposes; and if we may trust the analogies of language, one beautiful feature in our Gothic cathedrals is the fruit of this research. I allude to the rose window.

I exhibit as an illustration of the same principle two houses of the commonest street type; No. 1, entirely unornamented; the second such as seen in a better kind of street, with at least a show of taste upon it. Why is one superior to the other? Both are equally symmetrical; but in No. 2, superadded to the symmetry, there is a show of variety,—of variety in the forms, and variety in the quantities. I should be glad if any one could point out any other difference to account for the extremely different effect of the two designs upon the eye. The next example I exhibit is from Welford Church, Berkshire. These elevations are taken from a print, and are both somewhat modified. In No. 1, the height of the tower and spire exactly coincides; in No. 2 it is different. Referring, in the next place, to the segments of the tower, we find them in No. 1 precisely equal; in No. 2, quite unequal. The uneducated, even, would, I imagine, see that No. 1 is superior in all respects to No. 2. Nor can I assign any reason for this superiority, unless it be the application of that law of variety which, as I apprehend, arises originally from the necessity of resorting to various means for various ends, as the teeth of the carnivora are for one purpose, those of the rodentia for another; but which becomes, secondarily, a principle or law of beauty, independently of any purpose which the Author of nature may have had in view. I exhibit a drawing of an arch in Canterbury Precincts. The point here is the exquisite manner in which vegetation accomodates itself to buildings. Architects are hardly sufficiently alive to this point. A grass lawn, such as England, and England alone, can boast, is the most beautiful platform from which any building can spring. Trees, shrubs, and ivy—even dangerous ivy—have their beauty, and are valuable adjuncts to architecture.

I would now, before concluding, call your attention to the diagram above my head, in which I have ventured to propound my general views on the subject of the arts and architecture particularly. You will observe, it is divided into three heads—form, height, and shadow and colour; or we may call them outline, substance, and colour, for light and shadow are the means of giving rounded form.

Under the head of "Form," you will observe that I have taken the Doric temple as the example of symmetry, and the Gothic cathedral as that of variety in form. They are perhaps as good as any we might chance to hit upon. I would observe, however, that the symmetry of the Doric column is diversified by an almost infinite variety, and that the variety of the Gothic minster is modified by a large share of symmetry. Perhaps it would be fair to assert, that in Gothic art the principle of exact correspondence of parts is changed for that of a general balance between "the two sides, so to say, of the picture." This is well exemplified by the position of the central tower in Canterbury and other cathedrals. To the east we always have the most interesting part of the building. Here, owing to its sacredness, the largest amount of decoration is always to be found, both externally and internally. Deep shadows throw out the surrounding chapels, and were terminated in a "chevet," this portion of the edifice is generally full of interest. To balance this mass of decoration, we have the great length and quiet stateliness of the nave; yet even these fail to give their due share of importance to the western parts of the building, for the typical completeness of which two western towers are an absolute necessity. I offer my humble adhesion to Mr. Fergusson's view, who calls Lichfield, with its central and two western spires, though small in size, a thoroughly artistic group. Canterbury, of which I exhibit a lithograph, only moderately well done, is a good deal too long.

If we recognise in any measure the truth of the principles developed in this lecture, we shall in some degree, at least, understand why we are greater and yet less, less and yet greater, than our ancestors. As has been most eloquently remarked by the Dean of Westminster, "We cannot dispense with the mighty past, even when we have shot far beyond it." Those who follow cannot be as those who went before. Mediæval days, with their exalted faith, their noble chivalry, their rude violence, have gone, and cannot return; yet they have left a legacy of enduring value. Their castles, cathedrals, and abbeys come down to our days, and preach to us in stones the best of sermons. Truly it may be said of those grand old monks that they laboured, and we have entered into their labours. The comparison instituted by the eloquent writer alluded to, between Elijah and Elisha, is not inapposite. The rude vigour of primitive times gave way in the latter to winning arts and healing arts, and gentle words of social and peaceful intercourse." The stream no longer bounds from rock to rock, but flows on in tame fields,—in a channel, if less ruggedly beautiful, wider, and perhaps more beneficent. It is the same with regard to the arts. Our great works are few. Be it so; but do not these very great and magnificent buildings of former ages tell another tale, viz., of labour unremunerated; of large populations pressed down by serfdom; of education little spread; of one order, and one order alone, that of the clergy, absorbing in itself, not merely all that was spiritually good and great, but even all that comes under the term of temporal prosperity? Let us hope, then, that the work of architecture, if carried on by men of inferior genius to those who decorated the Parthenon, or raised to the skies our noble minsters, may be practised in a spirit certainly of wider usefulness, and with aims not less beneficent.

INSTITUTION OF CIVIL ENGINEERS.

April 24th.—The first Paper read was "*On the Performance, Wear, and Cost of Maintenance of Rolling Stock.*" By T. A. Rochussen, Assoc. Inst. C.E.

This communication related to the statistics of three Prussian railways—the Cologne-Minden, the Bergish-Maerkish, and the Rhenish—the general circumstances of which were stated to be somewhat similar. The tables embraced the particulars of the engines, and of the carriages and waggons, with the expense of repairs and renewals, the work done by the engines in 1864, the cost of motive power, the repairs and renewals of engine-tyres, and the commercial results. Also the experience of the wear of tyres on the Cologne-Minden Railway for the twenty years from 1845 to 1864 inclusive, embracing the results of observations upon about twenty-five thousand tyres, of different makes and of different materials.

It was stated that, on the Prussian railways, the iron-spoke wheels were gradually replaced by disc wheels, which at first were of wood, but latterly they were entirely of iron. The first form of iron disc, adopted in 1848, was that of a bulged star; a wrought-iron plate, flanged to form the periphery of the wheel, was indented with five triangular bulges from the boss, which was cast on the plate forming the disc. This wheel had proved to be very durable, but it was noisy, and, the boss being 11½ inches in diameter, the structure was heavy. It, however, supported the tyre evenly and well, and reference was made to a pair of these wheels with iron tyres, which had run 116,000 miles without requiring turning, and being still 1⅜ inch thick, it was thought they would last up to 250,000 miles. In 1862, a dished wrought-iron disc wheel was introduced, the manufacture of which was both cheap and expeditious. But the fine grain iron necessary to insure a sound flanging for the periphery of the wheel made it too rigid. Attention was then directed to the means of obtaining elasticity both in the form of the disc and in the material used. Accordingly fibrous iron was employed, and the flat, or dished disc, was corrugated, the periphery being formed by a rim of fine grain angle-iron, rivetted to the disc plate. Subsequently the disc and the rim were welded together, and about the same time the Bochum Company introduced steel castings, in the corrugated form, of combined disc and tyre. In the improved form of the corrugated wrought-iron disc, brought out in 1864, the iron used was highly fibrous. Several slabs were forged to the shape of a double cardinal's hat. This bloom was re-heated twice, and by frequent and quick rolling was enlarged to about 3 feet in diameter. The rim was welded on under the steam hammer, which at the same time punched the hole in the boss for the axle, and gave the form of the wave to the disc plate. After turning up the rim, the tyre was shrunk on and bolted. Since 1864, the tyre, whether of steel or of iron, had been welded on to the disc wheel by hydraulic pressure. In this form, it was believed, the disc wheel offered the greatest amount of strength: the fibrous iron gave elasticity, the tyre was supported in every part, there were no joints, bolts, or rivets to wear loose, and after the tyre had been worn out, it was simply necessary to turn it down to the thickness of an ordinary wheel rim, and to shrink on another tyre. It was asserted that, with steel tyres, these wheels would run from 300,000 to 500,000 miles before requiring a new tyre; and that by grinding the tyres instead of turning them their life would be prolonged from 50,000 to 60,000 miles.

The second Paper read was "*On the Results of a series of Observations on the Flow of Water off the Ground, in the Woodburn district, near Carrickfergus, Ireland*; with accurately recorded rain-gauge registries in the same locality, for a period of twelve months ending 30th June, 1865." By Robert Manning, M. Inst. C.E.

It was stated that the surface of the ground was chiefly composed of bare mountain pasture and grazing land, the surface rock being almost entirely tabular trap, overlying the chalk, with here and there patches of green sand. Three rain gauges were placed at the respective elevations of 300 feet, 750 feet, and 900 feet above the level of the sea; and two stream gauges were erected, one on the southern branch of the river, which received the drainage of 2076 acres, and the other on the northern branch 1329 acres. The stream gauges were rectangular notches with sharp edges, such as were used by Mr. Francis, at Lowell, and the formula for calculating the discharge was that deduced from those well-known experiments. The observations were nearly eight hundred in number, and were recorded in an Appendix. From a summary of the results it appeared that the rainfall for the year was 35·867 inches, or nearly 18 per cent. above that of Belfast. For the six months from November to May the rain was 14·766 inches, producing a flow of 14·351 inches, while from May to November these quantities were 21·101 inches and 7·357 inches. The minimum flow off 1000 acres occurred in August, and amounted to 11 cubic feet per minute; the maximum, in September, to 3180 cubic feet per minute; and the mean monthly flow was at its minimum in July, and was 29 cubic feet per minute.

The particulars of one year's rain having been thus ascertained, it was assumed that the rainfall on the Carrickfergus mountains bore a constant ratio to that at Queen's College, Belfast, where a daily register had been kept for fourteen years, and that it was the greater by 16 per cent. The results then arrived at were, that the maximum rainfall in 1852 was 47·71 inches, the mean for the fourteen years 1851-64 was 38·42 inches, the average of the three dry years 1855-6-7 was 32·76 inches, and the minimum in 1855 was 28·8 inches.

The question then remained, how much of this rainfall was available for water supply. Twenty or thirty years ago, the evaporation was taken as proportional to the rainfall, and was variously estimated at one-sixth, one-third, and two-thirds of the mean annual rain, according to circumstances. Now the balance of opinion seemed to be, that the amount of evaporation was not proportional to the rainfall; that it was either constant, or within narrow limits, where there was an identity or similarity in the physical features of the districts compared; that it varied under different circumstances in this kingdom from 9 inches to 19 inches; and that its amount in any particular case must be left to the experience and judgment of the engineer.

The author calculated that the loss, or the difference between the rainfall and the supply, which was the resultant fact of greatest importance to the engineer, varied in the Woodburn district from 11·79 inches to 15·16 inches, the mean annual loss being 13·71 inches. The supply ranged from 14·57 inches to 35·37 inches, the mean annual supply being 24·71 inches. The years of maximum and minimum supply were also the years of maximum and minimum winter rain. In the years 1856 and 1857 in which the rainfall only differed by 0·41 inch, the difference in the loss was 3·22 inches, arising from the fact of there being a winter rainfall of 15·96 inches in the former, and of 22·03 inches in the latter year.

The particulars were then given of the storage required for all quantities from the mean annual supply down to that of the minimum year, from which it appeared that to store the whole rain yielded by the Woodburn district, 24·71 inches, a reservoir capable of containing 431 days' supply would be necessary; for the average of the three dry years, 18·28 inches, 132 days' would be required; while for the minimum, 14·57 inches, 119 days' would be sufficient. Diagrams were added showing the storage worked out for each month of the fourteen years, and for quantities of 24·72 inches, 20 inches, and 18 inches, and showing the state of the reservoir for a supply of 24 inches for eleven years, and 20 inches for the three dry years. It was remarked that, although the water in store attained its minimum in different years, that minimum invariably occurred in the month of October; and that, as regarded the economical supply of water from the district under consideration, it would not be prudent to attempt to store a greater quantity of rain than about 10 per cent. over the average supply of the three dry years, provided the extent of the gathering grounds could be increased.

The question of water power was then incidentally alluded to; and it was remarked that in dealing with useless and injurious floods, and in providing a town supply, care should be taken not to induce the destruction, by instalments, of the whole water power of the country, and injuriously to interfere with the natural regime of rivers. The proportion of the mean annual flow of both branches of the Woodburn River, from a rain basin of 4750 acres, applicable to the supply of Woodlawn Mills, was then determined, and the calculations and results were given in detail. The tables showed, that of the total flow off the ground, 21·71 inches, there was lost on Sundays and by floods 12·22 inches, leaving 9·49 inches, or nearly 44 per cent., available for the supply of the wheel, which was equivalent to 194 days full work during the year, or 1·78 times the mean flow of the stream. If the capacity of the wheel were reduced to 1·5 of the flow, it would work for 213 days, if to 1·25 of the flow for 218 days, and if just equal to the flow, it would work 243 days.

May 8.—The paper read was "*On the Water Supply of the City of Paris.*" By G. R. Burnell, M. Inst. C. E.

This communication was principally confined to the methods adopted for securing the quantity of water required, and for its distribution and delivery; and was founded upon information obtained from M. Belgrand, the engineer-in-chief, as well as from numerous official documents.

It appeared that when this subject was first seriously entertained by the municipality of the enlarged city, in the year 1860, the population of Paris amounted to upwards of 1,600,000, and the quantity of water available from various sources was only 32,563,028 gallons per day, or rather more than 20 gallons per head per diem; but a large portion of this was used for municipal purposes, and nearly the whole of it was objectionable in quality. A careful study of the Paris basin, with a view to ascertain its capacity for furnishing a water supply, as dependent upon the geological conditions of the district and upon its meteorology, that had been carried on since the year 1844, showed that the basin of the Seine was formed of a part of the granite eruption of the Morvan, succeeded by the Jurassic deposits, without the intervention of the old and new red sandstones, or any trace of the carboniferous formation; the Jurassic deposits being in their turn followed by the cretaceous formations, and the whole being covered with the tertiary strata around Paris itself. It was remarked that French engineers and chemists attached great importance to the presence of the bi-carbonate of lime in water for drinking purposes; and that they held that a proportion of that salt, about sufficient to produce 16° of Dr. Clark's scale of hardness, was positively beneficial. Accordingly, in selecting the source, M. Belgrand gave the preference to the waters that filtered through the calcareous formations that outcropped around the granite. The waters of the Dhuis and of the Surmellin were brought to Paris, from the plains of Champagne, by an aqueduct, along which they flowed by gravitation, reaching the city at a somewhat higher level than had been calculated upon. The authorities had also purchased the right to take a considerable quantity of water from the river Marne, at St. Maur, above its junction with the Seine; while the waters of the Somme Soude had been at present passed over, and were left for the future extension of the works.

The springs of the Dhuis had yielded, in the driest season of the last twenty-one years, 6,698,400 gallons per day, and those of the Surmellin from 450,000 to 670,000 gallons per day. It was however believed that, by a series of operations connected with the drainage of the head lands surrounding these springs, the quantity from both these sources might be increased to 9,000,000 gallons per day, even during periods of prolonged drought. These streams after being united were led to Paris, in an aqueduct of masonry, that was never less than 4 ft. 6 in. high, and was at times increased to 5 feet. It was carried on arches in those positions where the depression of the valleys did not exceed 33 feet, and where greater, a cast-iron syphon, 3 ft. 4 in. or 3 ft. 8 in. internal diameter, was substituted. The section of the aqueduct was in general ovoidal, but in places the sides had a curvilinear batter, according to the nature of the strata traversed. Its inclination was as a rule $\frac{1}{10000}$, but that of the syphons was $\frac{55}{100000}$, in order to accelerate the discharge through them. It was calculated to deliver 9,810,476 gallons per day, when running to within 1 foot of the crown of the arch, into the reservoirs lately built at Menilmontant, at a height of 301 feet above the level of the Seine. The materials employed in the execution of the masonry were "pierre meuliere" set in the cement of Vassy; the whole of the interior and of the outside of the arches being "rendered," to avoid interference with the flow from the roughness of the surface, and to prevent the infiltration of the land waters.

The quantity of water obtained from the river Marne, at St. Maur, was about 9,000,000 gallons per day, when all the water wheels were at work. This was pumped into a second story of the reservoir of Menilmontant, at a height of 287 ft. 7 in. above the Seine. This water was tolerably pure and limpid, but it was rather hard, containing a considerable proportion of bicarbonate of lime, in conjunction with a sensible quantity of the carbonate of magnesia.

From the several sources which had been described, it was believed that a supply of 15 million gallons per day would be obtained in the course of this year, or, together with the existing supply, a total of upwards of 47 million gallons per day for a population of 1,667,841.

On the left bank of the Seine there had recently been purchased a series of springs rising from the chalk formation, at Armentieres, in the valley of the Vanne, and their volume would be increased by the springs of Chigy, St. Philbert, Malhortie, Theil, Noe, &c. These waters would be led to Paris by an aqueduct 104 miles in length, and it was calculated that the quantity that would be so delivered would be equal to 22,328,000 gallons per day. When all the works for improving the water supply were completed, including the supply derived from the Marne, the Canal de l'Ourc and its increase, the Artesian wells about to be sunk in various parts of the city, &c., it was estimated that there would be a gross total of 105,388,160 gallons per day, a quantity more than ample for a much larger population than that of Paris was likely to become. But it must be borne in mind that the waters of the Canal de l'Ourc would still constitute more than one-half of the whole quantity, and as this canal was navigable it was exposed to various sources of impurity. In future two sets of pipes were to be established; one to supply spring water from the Dhuis, the Marne, and the Vanne, the other to supply the waters of the Ourc and the Seine for the services of the street washing, for the monumental fountains, and for other purposes of municipality. The water now taken from the Seine was distributed with all the impurities it might contract during either seasons of flood or of drought. An inconsiderable quantity was filtered, in the interior of the town, at the "fontaines marchandes," but the revenue derived from this was equal to about one-seventh of the total sum received for the sale of water in the course of last year.

Fourteen reservoirs were at present in use, of which four were reserved for the waters of the Ourc, nine for those of the Seine, and one for those of the aqueduct of Arceuil. Of these the last, and two which now distributed the waters of the Seine, were to be abandoned on the completion of the new works. The reservoirs at Menilmontant and at the telegraph of Belleville, lately constructed, were intended to receive the waters of the Dhuis and of the Marne; and they were calculated to contain together, in the two stories of arches of which they were composed, about 29½ million gallons. The cubical contents of the existing reservoirs, without including that of the Basin de la Vilette, at the extremity of the Canal de l'Ourc, amounted to nearly 23 million gallons. A description was then given of the reservoirs of Passey and Menilmontant; and with regard to the former it was remarked, that all the skill and attention of the French engineers had been employed in vain, in the attempt to prevent the action of atmospheric causes upon the masonry, which had given serious grounds for uneasiness, owing to the contraction and expansion of the masonry. It might be that the perfection of the setting of the cement upon the masonry had something to do with this effect, for it could not yield, like an elastic substance, such as mortar of the proper quality of hydraulic lime. In the construction of the reservoir at Menilmontant, the surface of the excavation in the gypseous marls, which were hard when originally cut, but which yielded under the influence of the atmosphere, had been "rendered" with a coating of plaster of Paris 1½ inch or 2 inches in thickness. This had been found to be an efficient temporary protection from disintegration under the effects of rain and of frosts.

The appliances for securing the effectual distribution of the water brought into Paris, and the quantities required for the different services, were then detailed; and it was stated that the authorities undertook to deliver, when all the works were completed, gratuitously to the citizens a total quantity of 54 million gallons per day. The execution of the works required for the distribution of the water to private houses and factories has been undertaken by a company, under an agreement with the town, for fifty years, during which time it was to collect the water rates, and at the expiration of that period, the whole of the estate was to become the property of the city. The profit arising from the execution of these works, at a fixed schedule of prices, and a sum agreed upon as a remuneration for the risk and trouble undertaken by the company, were the first charges upon the revenue, and the excess beyond these amounts was shared in the proportion of 75 per cent. to the town and 25 per cent. to the company. In this way it had been estimated, by M. Belgrand, that during the year 1863, 17 million gallons of water had been delivered. The receipts for the private supply in 1864 amounted to 3,822,760 francs from 23,074 subscribers, a number which, it was calculated, would be increased by 2000 in twelve months. Considering that there were upwards of fifty thousand houses in Paris, this might be cited as a proof, if such were wanting, of the bad effects that must always attend the gratuitous supply of water upon the habits of daily life of the citizens. It might be added, that the price charged to the water-carriers at the filtering fountains was ninepence for 230 gallons, and this quantity was retailed for four shillings. This increase in the price was one of the principal reasons brought forward to justify the great outlay incurred in leading to Paris the spring water from the Dhuis and the Vanne.

In conclusion, the author thought, upon a review of all the conditions of the Paris water supply, that it must be regarded as a commercial failure; for while the town paid 2,060,000 francs for salaries and repairs, it derived only 4,750,000 francs from every source of revenue, including interest and sinking fund. It might, however, fairly admit of doubt, whether the system had been a failure, if considered as a means of meeting the wants of the inhabitants, who were themselves too poor to pay the rates that would be required to defray the expense of conducting the water to their houses. But the system was believed to be wrong, inasmuch as it entailed upon the city a heavy burden for the water supply, which no one had a direct interest in checking, because it was paid for out of the town dues, instead of being made a separate charge upon the funds of the city.

COMPETITIONS, THEIR PRESENT BEARING ON THE ARCHITECTURAL PROFESSION AND THE PUBLIC, AND WHAT THEY SHOULD BE.*

By John Lanyon.

In treating of the present subject I feel I am treading on what some people would call dangerous ground; and, therefore, ere I begin I must beg of all those whom I address, as well as of those who may in any way come across this paper, to believe me to be perfectly sincere when I say I am in no way actuated by personal or petty motives, and in penning the following lines individual prejudice and spite are absent from my thoughts. The matter I would wish to deal with is one in which I feel our profession as a body requires and demands reform, and it is on this broad basis that I propose to take it up, in hopes that I may draw from this Institute an expression of opinion, followed by action so united and decided as may show to the public at large and the profession elsewhere, that, though Irishmen, we can do something to grapple with what we believe to be an evil, even though that evil be great, and have a strong hold upon the public.

To begin a paper on such a subject as the present one, I should, perhaps, first treat, of "Competitions" as a whole, and then proceed to deal with the pros and cons incident to my subject; but I should be only wasting time and insulting your common sense if I were to linger over mere definitions. I accordingly pass on to the pros and cons. I beg of you to remember that I treat of competitions as they are, and what they should be, according to my own ideas of the subject only, and I throw out my remarks to provoke discussion, and leave the verification of them in your hands. Competition, I cannot but think, as it is at present, is a great and grievous ailment under which we suffer—not quite so bad in its way as the rinderpest, which knows no anodyne, for I sincerely believe the cure of our disease lies in our own hands; so I must beg of you to be more than patient with me while I urge on you the great magnitude of the question.

The great points in favour of competition, so far as I have been able to glean them, are—the benefit to be derived by the young or unknown architect in the field open to all, and the necessity that this gives for the elder and recognised practitioner to keep himself up to the mark, and even with the times; and there can be no question but that these two points are most essential, and would be productive of the greatest benefit to the profession and public, if competitions were but fairly and honestly carried out. You may observe that I invariably class the profession and the public together, and I do so advisedly, for I cannot but feel that the interests of one and both are identical, so far as they relate to matters of competition.

The pros thus easily and quickly disposed of—for I think we must all acknowledge the truth of them in abstract principle, and there is no use in wasting time over details—you must permit me to deal with the cons in my own way. I accordingly begin by asserting—and that very unhesitatingly—that the system of competition as it at present exists, in every way you look at it, is practically in opposition to all the arguments in its favour. What system, I ask, could contain more abuses or hide a more iniquitous trade in underhand dealing and jobbing? You must understand me that I am speaking of the system generally, and have not in my mind any thought of individual competitions, competitors, or judges. On this last word "judges" I pause, for I feel that under this head will be found the most vital of the ills that competition is heir to.

As professional men, are we not led to believe—nay, is it not forced on us—that it is our duty to lead the public mind on such points as these, what are true principles in art? what is in true taste, and what is not?—else, where is the use of our expensive special education, of our lives given to the study of the adaptabilities of all arts, of truth and stability in architectural art? I ask you, do we do so under the present system of competition? and I know your answer must be, "we cannot;" and wherefore?—because naturally it is success over our fellows we look to, and to ride the winning horse in our field we must pander to the vitiated taste of those in whose hands the crowning of our success lies, our "judges." After you I would ask "the public" to say if, as a general rule, our "judges" are the right men in the right place? My answer is, no. And it is really expecting more than human nature is capable of to suppose that they can be. How are they educated to fill such a post? do they lay themselves out to gain such a knowledge on the subject as would warrant them in undertaking to adjudicate? does a mere smattering of art make them masters of their position? or does it not on the other hand make them all the more dangerous, as liable, from their much talking, to mislead others? Which of us has not come across that pest of our profession, the amateur architect, the man who considers he knows everything and can do everything, and therefore, when he tries it on, spoils everything? Such a man is often to be met on competition committees; and woe to the committee who has such a one for its guide to architectural knowledge. It would be far better for that committee it had never been formed. It contains in itself the elements of all discord and all abuses; for at what will the amateur stop? at nothing, no matter how underhand or discreditable, to carry his point, and show his supposed knowledge. But this, you will say, is after all but natural: granted it is; but is it, therefore, fair play to us? I might go on, and further pull to pieces and show up the composition of our committees of "judges," but for

* Paper read at the Royal Institute of Architects of Ireland.

my present purpose it is enough that we should agree on the point that they are not as they should be; therefore be it our duty to aid to them, and if they do not avail themselves of our advice, they are to blame. I now come to competitors, and under that head we all, in a great measure, stand. Gentlemen, I must be fair and I must candid, and in answer to the question, How do competitors come out of competitions? I reply, not always with clean hands. Now I can imagine indignant "judges" throwing the taunt back in our teeth, and saying, "Physician, heal thyself." Well, let us accept it, and be that also a part of our task. In all communities and professions I suppose there will be "black sheep," and these we can never hope to cure absolutely; but we may shame them into a change for the better, I take it, and in more ways than one. A friend said to me the other evening, hearing I was about to read this paper, "Competitions, to our profession, meant, Who has the most friends." This, I am sorry to say, is only too true; which of us has not been told, before sending in competition designs, that we were wasting our time; that So-and-so was too strong for us on the committee; which of us has not known of canvassing for votes among the judges by competitors, and that not always *sub rosa*, but with a sufficient amount of concealment to make it a matter next to impossible to bring before this Institute? To go further; which of us has not heard and read of even graver charges made against members of our profession? of base and low tricking being resorted to for the purpose of ensuring success? Gentlemen, this disgraceful system of favouritism and incompetency on the part of our judges, and of dodging on the part of our competitors, must have, in combination with the utter want of knowledge of their duties on the part of both judges and competitors, a damaging effect on competitions, and a demoralising and degrading effect on the tone of the profession, and on the mind of the public.

This is but a faint outline of some of the evils of the system of present-day competitions; and with these remarks I close competitions as they are, and proceed to what they should be; though under this division I will also treat of many existing evils, but more especially in regard to their cure. First come in, all their majesty, our "judges;" and under this head an inherent difficulty presents itself in their selection, for, although our judges may be persons of unimpeachable integrity, they are rarely, if ever, chosen as men competent from having had their attention previously directed to the acquirements of the necessary knowledge which would enable them rightly to adjudicate on, much less to understand, the points and beauties of the plans submitted to them; indeed, in most cases our "judges" are at sea from the very beginning, and therefore, not knowing what they want, how can they attempt to decide, or say which plan is what is wanted or which the best. To meet this difficulty, I would propose that in each competition our judges should avail themselves of the services of an architect, who would be neutral in the competition, and whose duties would be, first of all, to put in order what is required by our "judges," so as to be clearly understood by those about to compete; and then, when the plans are submitted, carefully to go over, and read them with him, and explain to the committee, the "ins and outs" of the various plans. As I take it, it is quite impossible for any one, without a very large amount of experience, to read a plan, or follow out arrangements and economy of space, combined with convenience, beauty, suitability and stability. In the foregoing passage I have spoken altogether of "plans," and I feel very confident that if in competitions plans were all that were sought for in the first instance, the arrangements would work much more satisfactory than at first glance it may appear, as I think we may take it for granted that the man who can make a good plan can make a good elevation; but even supposing such was not the case, and that it did not follow, then let there be either a second competition for an elevation to the accepted plan, or let the consulting architect be employed to carry out the work. The adoption of the above suggestion would quite upset that abominable and unfair system of choosing a design in consequence of its elevation being pretty or of a particular style, which, when it is about to be carried into execution, from its excessive cost has to be stripped of every thing which in the first place recommended it, and on the completion of the work it stands a disgrace to all concerned, and a monument of a flagrant injustice to other competitors, who honestly "cut their coats according to their cloth." Our judges should further remember that the agreement by architects to compete on the certain terms laid down, if acted up to by the architects, becomes a mutual contract, which is morally, and I even believe, legally binding on our "judges;" and I would go so far as to say that, in not carrying out the terms of their agreement to the letter, our judges in many cases leave themselves open to actions at law. As an institute I think we should be very glad to give assistance to wronged competitors in some of the very glaring cases of dishonesty and jobbing that unfortunately do occur. Our "judges" once made answerable, such a case would have a more wholesome effect in checking the evil than any other remedy. Strong measures are necessary to eradicate deep evils. In a former passage I recommended that the services of an architect should be had in all cases, but I also think it would be most desirable, in cases when other professional knowledge would be of use, that the services of members of other professions should also be called into requisition, and for this purpose—that the instructions as to what is required should be as clear and concise as possible, but at the same time in no way confining or restricting architects to any particular arrangement, except where the same is necessary, and then it cannot be too distinctly stated; if rooms of a certain shape or size are desirable or necessary, this should be specified; as also if there be a preference for, or a leaning to, any particular style. We all know that in many cases our "judges" confess their inability, and are very glad of any suggestions that may be made to aid them in their, at all times, if fairly and honestly carried out, most arduous task; who are, therefore, so fit to make these suggestions as the members of our profession, or who have a better right or should more thoroughly understand the subject? Therefore, as I feel it is just as much for the interests of the public and the profession, I submit for your consideration whether it is not most desirable that we should now take some steps for the better regulation of competitions; and, as a stepping-stone in the right direction, I shall submit to this meeting a few heads to be discussed, that, when whipped into shape and worked out in detail, may form a basis for future competitions. Before doing so, however, and leaving our "judges," I will give them a hint, by the way, that although they cannot premiate all the designs submitted, good manners might suggest to them sometimes the propriety of at least thanking the unsuccessful competitors for their trouble, expense, and loss of time.

1. Inasmuch as it is absurd of our "judges" to state the amount of accommodation required, and then to say it must be done for such a sum—in other words, insisting upon having a quart and paying for a pint—it is desirable, if they specify the accommodation, they should give only an approximate idea of the cost, to be kept in view as much as possible by the competitors; otherwise, if they give the exact amount of outlay, it is desirable that the required accommodation should be only approximately stated.

2. In cases where the outlay is distinctly stated, inasmuch as it is most difficult to come to a true decision as to the cost of the proposed building, an approximate estimate on some general system is desirable. I would, therefore, suggest that our "judges," with professional assistance, should find out a fair average price per cube foot for executing works in the locality of the proposed building; that a margin of 10 per cent. should be allowed to cover difference in ornament, &c., and that one of the first steps taken by the committee, through their professional adviser or surveyor, should be to cube the various buildings, and set aside at once any that came above the mark.

3. That, inasmuch as the present ratio of premiums is not a sufficient or a fair remuneration, and therefore cannot command the attention of first-class men, premiums should bear a direct ratio to the value of the work, and be at $1\frac{1}{4}$ per cent.

4. That, inasmuch as 5 per cent. is not sufficient remuneration in cases where the architect has been successful in competition, the full amount of the premium that he may be entitled to should be paid in addition to the usual fees.

ON GRANITE WORKING.*

By George W. Muir.

It is not my intention to attempt a scientific account of the origin, composition, and geological place of granite. It is intended chiefly to exhibit granite as it is in the rough, show what can be done with it by art, and state how and where it may be procured.

* Read to the Society of Arts.

The districts in Scotland from which granite is chiefly obtained are Aberdeenshire, Argyllshire, Dumfriesshire, and the stewartry of Kirkcudbright. In Aberdeenshire and Argyllshire the grey and red varities are found, but in the south of Scotland the grey only, and that generally of a very light shade.

Although Aberdeen has acquired the reputation of being the source of the granite now so much used for architectural and monumental purposes, very little of the finer qualities can be had from the immediate neighbourhood of that city. The quarries from which the granites worked in Aberdeen are chiefly obtained are situated at distances varying from thirty to fifty miles to the north and west.

The red-coloured granite is quarried at Peterhead, 45 miles by rail to the north of Aberdeen, and the finest of the blue grey at Cairnegall, about seven miles south-west of Peterhead. A very fine black grey has also been found near Alford, on the line of rail from Aberdeen to that town. The old quarry of Rubislaw, near to Aberdeen, and from which the stone used in building one-half of the city has been obtained, supplies a granite which, when polished, exhibits a fine dark blue colour and well-marked grain. It has hitherto been a favourite for monumental purposes, but of late the quarry has been in a condition unfavourable for the production of pieces of a large size.

The granites of Argyllshire, and especially the red and pink varieties from the Island of Mull, are becoming favourites for all purposes, architectural and monumental. These fine granites are quarried on the west side of the Island of Mull, on the eastern side of the Sound of Iona. The Tormor quarry, from which the darker reds are taken, is within a mile of the venerable cathedral of Iona. The pink variety is got at North Bay, a few miles to the north of Tormor. These quarries are worked by the Scottish Granite Company, and from them stones of any practical dimensions may be readily obtained at any time. Notwithstanding the great beauty of the colour and grain, and the large size of the stones which may be there obtained, the Mull granites are comparatively unknown in London. Mr. Gilbert Scott is the first architect who has appreciated their value, and he has used them extensively in the beautiful memorial now rising in Hyde-park to the memory of the late Prince Consort.

Very fine granites are obtained in the south of Scotland. The quarries at Kirkmabreck, belonging to the Liverpool Dock Trustees, are among the finest in the kingdom, but they are almost altogether employed for engineering purposes, not being suitable for polishing, on account of the light colour. The granites best suited for polishing, for monumental purposes, are those in which the colour, when polished, is darker than when only fine axed or worked with the chisel. The Dumfriesshire granites do not rank high for this quality, and are not used except in combination with the darker coloured stone. They are also very full of the ugly black spots which so disfigure a polished stone. From these spots, the Mull red and pink varieties are very free, compared with the red granite from Peterhead. A granite of somewhat better quality is had from Craignar, a wooded hill near Dalbeattie, a village about thirty miles eastward of the Liverpool quarries. From Craignar a considerable quantity of the stone used in the construction of the north side Thames embankment has been drawn. Nearly all the quarries in the kingdom have been drawn upon to supply stone for that great work, and considerable difficulty has been felt in meeting the demand. The Mull quarries supplied a portion previous to the erection of polishing works by the company. The product of the quarries is now consumed for the most part in the manufacture of monuments, columns, &c., for ornamental purposes.

It is remarkable that granite is obtained from places so few in number, and so far apart as Peterhead, Aberdeen, Iona, Dumfries, and Glasgow, but such is the fact. It is very difficult to get a supply of stone of good quality, and considerable expense has to be incurred, in the removal of superincumbent soil or worthless rock, before stone of a quality that can be profitably worked is obtained. The profitableness of a granite quarry depends in a great measure upon contiguity to a general market, where the smaller stone, resulting from the quarrying of large blocks, can be readily disposed of. In some quarries rubble is sold at the low rate of one shilling per ton weight; in others, where even that price cannot be got, it is thrown into the sea or into a waste heap. The quarries in Aberdeen derive a great portion of their profit from the sale of stone used in building there, and the manufacture of paving sets for the London market. The price or value of granite varies greatly; for while rubble is sold at a shilling per ton, ten shillings per cube foot, or one hundred and forty times the price of rubble, is cheerfully paid for a finer block.

In quarrying granite, or in the selection of a point in a mass of granite to be quarried, attention has to be paid to the lay of the rock. In the Cairngall quarry, belonging to the Messrs. MacDonald, the stone lies from east to west. The east side of the hill is therefore that on which their quarry is situated. Another firm who opened a quarry on the same hill, but on the west side, had to abandon the working. The posts of granite, by which we mean the masses that stand separated from each other by dries or natural divisions, were the quarry worked on the side to which they incline, would fall upon the workmen engaged beneath them.

The forces employed in breaking the masses of rock into the dimensions desired are powder and the wedge. In using powder, a hole is "jumped" to the depth required, and being filled with powder and closed at top, it is fired with a fuse, timed to allow the workmen to retire to a safe distance.

The first shot generally does no more than shake the rock round the hole, and make a number of cracks. The hole is again charged, and these cracks become filled with powder. The greater quantity of powder produces a greater effect, and the rock is further shaken and opened up. A third shot generally brings down the mass, and makes it available for the cutters to shape into blocks. This is done by wedging, or the "plug and feather," the latter being a short piece of steel inserted in a hole in the stone between two thin pieces of iron. By striking the plug with a heavy hammer the stone is split into pieces of the size desired. At the Kirkmabreck quarries no powder is ever used, but the stone lies in the most favourable position for detaching. It is desirable to use as little powder as possible, as otherwise the rock is frequently shattered in a way not intended, but it is not possible in every quarry to dispense entirely with its use.

No material is to be compared with granite for monumental purposes. Besides the beauty of the stone, it possesses the great recommendation of durability. Of what service is a monument of freestone, the inscription upon which will last possibly during the lifetime of those by whom it has been erected, and perish just at the time when it was expected to inform a succeeding generation of the virtues of the person whose memory it was intended to perpetuate? We frequently are employed to renew, in granite, tablets of freestone that have been fixed in church and church-yard walls, and which, from decay, can no longer serve the object for which they were originally designed.

Granite is now being very largely used for ornamental purposes in buildings, and I do not doubt that its use will very greatly increase, and that it will come to be used with greater skill and discrimination than it now is. The sameness of the colour of, say thirty, forty, or more columns on the front of a bank or other building, when all are of one colour, is not pleasing. Would it not be better to employ a variety of colours, or a variety of shades of the same colour.

Take any of the colours of the specimens now before you on the table. Let it be the dull, flesh-coloured red of Peterhead, or the livelier hues of Tormor from Mull; the light grey from Kirkmabreck, or the dark from Rubislaw; or even the unique and delicate pink from the north Bay of Mull, and it is impossible to come to any other conclusion than this, that the front of any building constructed wholly of any one of these colours will not be so beautiful as it would be if their varied colours had been judiciously combined. Great variety and beauty may be produced also by varying the style of work. Let the base be rough rock, the first courses above rustic, the next single-axed, and the highest fine-axed, and let their dull, solid surfaces be varied by polished columns, pilasters, lintels, and string-courses, and a building worthy of the greatest name in architecture, or the most honourable purposes to which any building can be applied, would be the result.

In selecting granite it is advisable to consider the purpose to which it has to be applied. The stone best suited for a monument or a column in a position where it can be closely inspected, may be of a finer grain than if it has to be placed at a higher elevation. I have seen buildings with very fine columns of grey granite, so small in the grain, that at the distance from which they could be seen the effect was no better than if they had been so many cylinders of zinc.

Apart from all commercial considerations, which may be suspected to influence one engaged in the granite trade, I should like to see granite used for the external front walls of buildings. Which company will be the first to have an office of which the front shall be wholly of polished granite? The cost would not be so great as may be supposed. The more extensively granite is employed the cheaper can it be supplied.

Granite may also with advantage be more largely used for interiors. A polished granite stair and staircase would be a very beautiful thing, and granite columns form a beautiful feature in a hall or corridor. By the combination of various colours a composition of great beauty can be produced.

It may be interesting to notice shortly the manner in which the stone is changed from the rough to the smoothly-polished surface. The form is given to the stone by the hands of skilled masons, in much the same way as is done with other stones of a softer nature. Of course the time required is considerably greater in the case of granite as compared with other stones. If the surface is not to be polished, but only fine-axed, as it is called, that is done by the use of a hammer composed of a number of slips of steel about a sixteenth of an inch thick, which are tightly bound together, the edges being placed on the same plane. With this tool the workman smooths the surface of the stone by a series of taps or blows, given at a right angle to the surface operated upon. By this means the marks of the single axe, by which the blows are given obliquely on the surface of the stone, are obliterated, and a smooth face produced.

Polishing is performed by rubbing, in the first place with an iron tool, and with sand and water. Emery is next applied, then putty with flannel. All plain surfaces and mouldings can be done by machinery, but all carvings, or surfaces broken into small portions of various elevations, are done by the hands of the patient hand polishers. The operation of sawing a block of granite into slabs for panels, tables, or chimney-pieces, is a very slow process, the rate of progress being about half an inch per day of ten hours.

The machines employed are few and simple. They are technically called lathes, waggons, and pendulums or rubbers. The lathes are employed for the polishing of columns, the waggons for flat surfaces, and the pendulums for mouldings and such flat work as is not suitable for the waggons. In the lathes the column is placed, and supported at each end by points, upon which it revolves. On the upper surface of the column there are laid pieces of iron, segments of the circumference of the column, The weight of these pieces of iron lying upon the column, and the constant supply by the lathe attendant of sand and water, emery, or putty, according to the state of finish to which the column has been brought, constitute the whole operation. While sand is used during the rougher stage of the process these irons are bare, but when using emery and putty, the surface of the iron next to the stone is covered with thick flannel.

The waggon is a carriage running upon rails, in which the pieces of stone to be polished are fixed, having uppermost the surface to be operated on. Above this surface there are shafts placed perpendicularly, on the lower end of which are fixed rings of iron. These rings rest upon the stone, and when the shaft revolves these rings rub the surface of the stone. At the same time the waggon travels backward and forward upon the rails, so as to expose the whole surface of the stone to the action of the ring.

The pendulum is a frame hung upon hinges from the roof of the workshop. To this frame are attached iron rods, moving in a horizontal direction. In the line upon which these rods move, and under them, the stone is firmly placed upon the floor. Pieces of iron are then loosely attached to the rods, and allowed to rest upon the surface of the stone. When the whole is set in motion, these irons are dragged backwards and forwards over the surface of the stone, and so it is polished. When polishing plain surfaces, such as the needle of an obelisk, the pieces of iron are of course flat, but when we have to polish a moulding we make an exact pattern of its form, and have the irons cast from that pattern.

I have thus described the established modes of working granite. A Frenchman has lately introduced machinery by which he professes to work and polish granite by very much the same means as is used by mechanical engineers for the cutting and polishing of iron; but as yet, so far as is known to me, this new apparatus has not been found effective.

The demand for polished granite comes from all parts of the world. It is sent to every British colony, and to many parts of the continent of Europe.

To show the rise and present extent of the polished granite trade, one fact will be enough:—thirty years since, the late Mr. Macdonald had but four men in his employment, now his successors employ fifty times that number. I will not boast of the progress of the Scottish Granite Company, but we began a year since with an engine of six-horse power, and I hope soon to start another of thirty-horse. I can also say that we are now engaged in polishing the heaviest columns ever made in Scotland. They will weigh about forty tons each, and I hope you will all live to see them on the new bridge at Blackfriars.

These columns we have been very reluctantly obliged to make in sections. This has arisen, not from the quarries failing to produce blocks of sufficient size, or our machinery being unable to handle them, but from the difficulty and risk of the transport from the polishing works to their intended position on the piers of the new bridge.

Now that the granites of the west of Scotland are becoming known and estimated at their proper value, and that Glasgow, the commercial metropolis of Scotland, with all the advantage of ready communication by sea and land, has entered into competition with Aberdeen in a line of business hitherto considered peculiar to the "granite city," the art of working granite will receive an impetus greater than any yet given, and this beautiful and most durable of materials will be applied to purposes for which it has not yet been considered suitable.

In the discussion on the foregoing paper,

Mr. Botley, in reference to the beautiful effects alluded to of polished granite of different colours for the pavement of entrance halls of private residences, inquired what would be about the cost of so paving a hall, say 10 feet wide and 20 feet long.

Mr. Muir replied, that would be a superficial area of 200 feet, and would cost from £120 to £130, or about 12*s.* 6*d.* per square foot. That would include slabs of various colours. A portion of the floor of Norwich Cathedral had been paved with polished granite, and the effect was very beautiful. The thickness of the granite made but little difference in expense, which would be the same whether the slabs were two inches thick or one foot; the cost being not so much in the material itself as in the cutting and polishing. The most practical thickness for pavement was 2¼ to 3 inches. With regard to the alleged difficulty in the transport of large blocks, he might mention that the Scottish Granite Company had furnished four blocks for the Albert Memorial in Hyde-park, weighing 60 tons each. On the subject of accidents from blasting in the quarries, they were not unfrequent, but for the most part they arose from want of due care on the part of the workmen themselves and a disregard of danger, which was engendered by habit, much the same as in coal mines.

Mr. Campin gathered from the paper that the working of granite was essentially a manual process, and that labour-saving machinery had not been nor was capable of being introduced to any great extent into this operation. [Mr. Muir said, except for polishing.] He believed some twenty years ago machinery for the working of granite was proposed by a person named Hunter, with the view of saving labour in the primary operations, and he had hoped to have heard this evening whether any practical results had attended that attempt.

Mr. Muir replied that all the machinery yet invented for that purpose had failed.

Mr. Bishop regretted to hear that the granite columns for the new bridge at Blackfriars were intended to be made in sections. He had hoped that, in that instance, an opportunity would have been afforded of erecting monoliths which would bear comparison, to some extent, with those which were met with amongst the ancient remains of eastern grandeur. No doubt the practical difficulty in the way of monoliths was the great expense of transport. There were many large monoliths of polished granite met with in Egypt, amongst which the obelisk of Heliopolis was remarkable. That was supposed to have been floated down the Nile. He had also noticed some very large blocks of granite in the ruins of Baalbec. There were in particular three blocks in the walls of one of the ancient temples, placed at a height of about 20 feet each, which were about 64 feet long and 12 to 14 feet thick. We had nothing in this country to compare with these, and they must necessarily have been transported by land carriage. The quarry from which those blocks were obtained was situated about two miles from Baalbec, and there still remained there a similar block, almost ready for transport. The weight of this block was, of course, enormous, and it was lying some 12 or 14 feet below the surface of the surrounding country; but, if it were once raised, an almost level surface would be presented for its transport. But those blocks in the temple had been elevated 20 feet in the wall; if, therefore, the ancients were able to accomplish such a feat, with their rude mechanical appliances, there ought to be no difficulty in the management of monoliths in the present day.

Mr. Muir remarked that the difficulty of transport was solely of a financial nature, and this was the most troublesome one to be got over. It was proposed to bring from the Mull quarry a block, estimated at 700 tons, for the Albert memorial. That block was 150 feet long, without a crack, and he believed it to be solid to a depth of 15 feet; but the whole difficulty of transporting it to London consisted in the very great expense this would involve. It had even been suggested to take it to America, for a memorial of Abraham Lincoln. In the case of the large blocks to which he had alluded as supplied for the Albert Memorial, the cost of the crane alone for lifting them was about £650, and the whole mechanical arrangements were provided at a total cost of about £1500. Therefore, unless the company had a succession of orders for these large blocks, they could not be supplied, except at a very high cost.

Mr. STREET said, in reference to the more general application of granite for building purposes, it would be satisfactory to hear from Mr. Muir what was the cost of this material as compared with other stone. He presumed the great expense consisted in the dressing; and he apprehended it would have been a very costly affair to have constructed the façade of the Houses of Parliament in polished granite. He would be glad to hear what was the expense of dressed granite for building purposes as compared with other descriptions of stone.

Mr. [illegible] would add to that inquiry, whether the polishing rendered the granite more susceptible to atmospheric influences than when the surface was rough? It had been found that the small polished granite columns in Salisbury Cathedral had been subject to scaling, which was attributed to the high degree to which they were polished.

Mr. MUIR replied that the result of twenty years' experience with granite, which was a very short time in connection with such a material was that, in the case of a granite obtained from one quarry in Aberdeenshire, a certain amount of rust had taken place in that time, and a good deal of the original high polish had been lost, but nothing to which the word "scaling" could be justly applied had taken place. The decay of the granite in the Mull quarries was wholly inappreciable; the surface which had been exposed thousands of years was wholly undeteriorated. He believed the effect of polishing was in most cases to increase the durability of the stone, but any atmospheric action was more readily observable on a polished than on a rough surface. With regard to the cost of granite for building purposes, he believed it could be delivered in London at a price not exceeding that of some kinds of Portland stone. Taking the case of a building with a frontage of forty feet, and fifty feet high, which would comprise a superficial area of 2000 feet, using tooled granite in the main portions, with polished lintels, columns, and architraves, the cost would be from £[illegible]000 to £2500. That was for stone of two feet thickness.

Professor TENNANT, having called attention to a paper on the "Art treatment of granitic surfaces," read by Mr. John Bell in the session of 1859-60, which he said elicited a very valuable practical discussion, remarked that much might be said on the subject of granites—not only of the Scotch, but also the Cornish and Devonshire, and Irish granites; and he was happy to find the subject was now exciting the attention of the public; because it was a material which was undoubtedly capable of greatly extended application. A striking instance of this was afforded in the works of the Thames Embankment, in which several descriptions of granite had been employed, and there were others as well adapted for the purpose as those which had already been used. On a former occasion he alluded to that class of granites termed syenites, differing from the ordinary kind which contained quartz, felspar, and mica, while syenite was composed of quartz, hornblende, and felspar. The latter was used by the Egyptians, and some beautiful specimens were to be seen in the British Museum. There were in the Museum of Oxford the finest illustrations of granites that could be met with anywhere, and Prof. Phillips had there shown the applicability of many of those varieties of granite which were little known at present. With regard to the so-called scaling of the surface of granite, he believed that to be due to the process of dressing. When the stone had been "starred" in the operation of tooling, and was afterwards exposed to the weather, the portion that was starred became liable to peel off. This was shown to be the case in one specimen of Egyptian granite in the British Museum, the arm of a figure, where it peeled off like the outer portions of an onion, showing where the axe or pick had bruised the stone, in some cases to the extent of half an inch. In other instances the pressure of iron pyrites on the stone was a cause of decomposition: the oxide of iron expanded, and burst the stone. In other cases there were large crystals of felspar, and in different granites these felspars varied in their composition. In one case there was potash felspar, and in another soda felspar. All these were points of great interest, and here was an opportunity of examining them in the different qualities of granite now being used in the works of the Thames embankment. In fact, he knew no city which better illustrated the varieties of granite than did the city of London at present.

Mr. MUIR remarked that the starring to which Professor Tennant alluded was done prior to the polishing, and a slight starring might be taken off by the process of polishing. He believed the use of the new tool (described in his paper), which they could hardly suppose to have been employed by the Egyptians, would obviate the starring [illegible] its effects were not produced by heavy blows upon the stone, but rather by oft-repeated gentle taps, which were not likely to produce starring. He should be glad to hear from Professor Tennant to what extent he considered the granite in the parapets of London-bridge, which had been erected forty years, had decayed from starring.

Professor TENNANT believed that the foot pavement of London-bridge did not wear away to the extent of more than one-eighth of an inch in four years. With regard to the effect on the parapets he would refer to Waterloo-bridge, where the decay was very trifling indeed. About fifteen years ago an alarm was raised that the granite of Waterloo-bridge had decomposed to such an extent as to make the bridge unsafe, and the same was said about several other public buildings, but after a time those alarms subsided, and the structures were standing, and were likely to continue to do so. If they went back to the works of ancient art, the obelisk of Heliopolis, which had been erected 3000 years, was still in good condition; and the same might be said of the obelisk brought over by Belzoni for Mr. Banks, at an expense of £2000, and which had been erected in front of that gentleman's residence in Dorsetshire.

Mr. MUIR said that as the paving-stones of London-bridge wore away only to the extent of one-eighth of an inch in four years, it was easy to estimate how slight would be the deterioration where the material was not exposed to any traffic at all.

Mr. BISHOP mentioned the great amount of granite dust which was observable in the galleries of the Escurial, which no doubt fell from the walls, and was undoubtedly powdered granite.

Professor TENNANT remarked that some qualities of granite decayed very much, especially some of the Cornish and Devonshire descriptions, from the decomposition of which had been produced the porcelain clay, or kaolin, which was so extensively used. The late Mr. Minton entertained the fallacious idea that the supply of that material would soon be exhausted; but there was no ground for this fear. This decay arose, he believed, from an excess of alkali in the granite, for when that was present beyond a certain amount, decomposition went on very rapidly. In the different granites there were two kinds of felspar: in fact, they had in granite four different ingredients; they had potash felspar in the white granite, and soda felspar in the red, with quartz and mica in addition. In the Scotch granite, and in that from Dartmoor, they had a form of tourmaline, which made it extremely brittle, and if it was employed for macadamising roads it was very soon reduced to dust.

The CHAIRMAN stated that there was great interest connected with the working of a material which had been supposed to be the earliest formation of which this world was composed; and when properly selected it was no doubt the most durable of all materials, but he was afraid the cost would preclude any very general use of it on the streets of London, until cheaper modes of manipulation, by machinery or otherwise, were discovered. With regard to the natural decay of this stone, it was not necessary to say one word after the able remarks on that subject which had been made by Professor Tennant, but all travellers in Switzerland must have noticed the very rapid decomposition of the granite which went on, especially in the district of Chamounix. There could be no doubt that an enormous quantity of this *debris* was brought down from the upper granite formations by the action of the weather; but the surface over which this action took place was so large, that the extent of decay at any one point was very slight indeed. The light-coloured earthy masses that were brought down by the Aar and other rivers were in fact powdered granite. With regard to the cost of working granite for building purposes, as compared with other descriptions of stone, looking to the Houses of Parliament, he thought if the expense of facing that great structure had been double what it was, it might very possibly have been true economy; for that vast expenditure seemed likely to be wasted, inasmuch as the ornamental work was rapidly decaying. It was a melancholy fact that the material of many of our modern buildings was crumbling away even during the lives of those who had constructed them. Another interesting point was with reference to the starring. No doubt the theory of Professor Tennant on this subject was correct. If the starring was so deep as not to be removed by the after process of polishing, the effect would be apparent upon the column after a time, and that, no doubt, was the cause of the peeling, which had been alluded to. Aberdeen had been referred to as the "granite city." It might have merits in the solidity of its granite houses, but it had the demerit of great monotony and coldness of colour, and the hardness of the material was such that there was not only monotony of colour but absence of ornamentation; so that, whatever other merits granite might possess, it could lay no claim to the promotion of florid ornament in architecture.

ARCHITECTURAL ASSOCIATION.

THE annual business meeting of this society was held on the 4th of last month, Mr. R. W. Edis, President, in the chair. The alterations of Rules 4 and 5, of which notice had been given as mentioned in our last, were carried. The amendment on the proposed alteration of Rule 5 was lost on division. In considering the annual report of the Architectural Alliance, the paper by Mr. Hine of Nottingham, setting forth the propriety of making the bills of quantities a part of the basis of contract in building works, was read by the Secretary, after which the Chairman requested Mr. Rickman to open a discussion thereon.

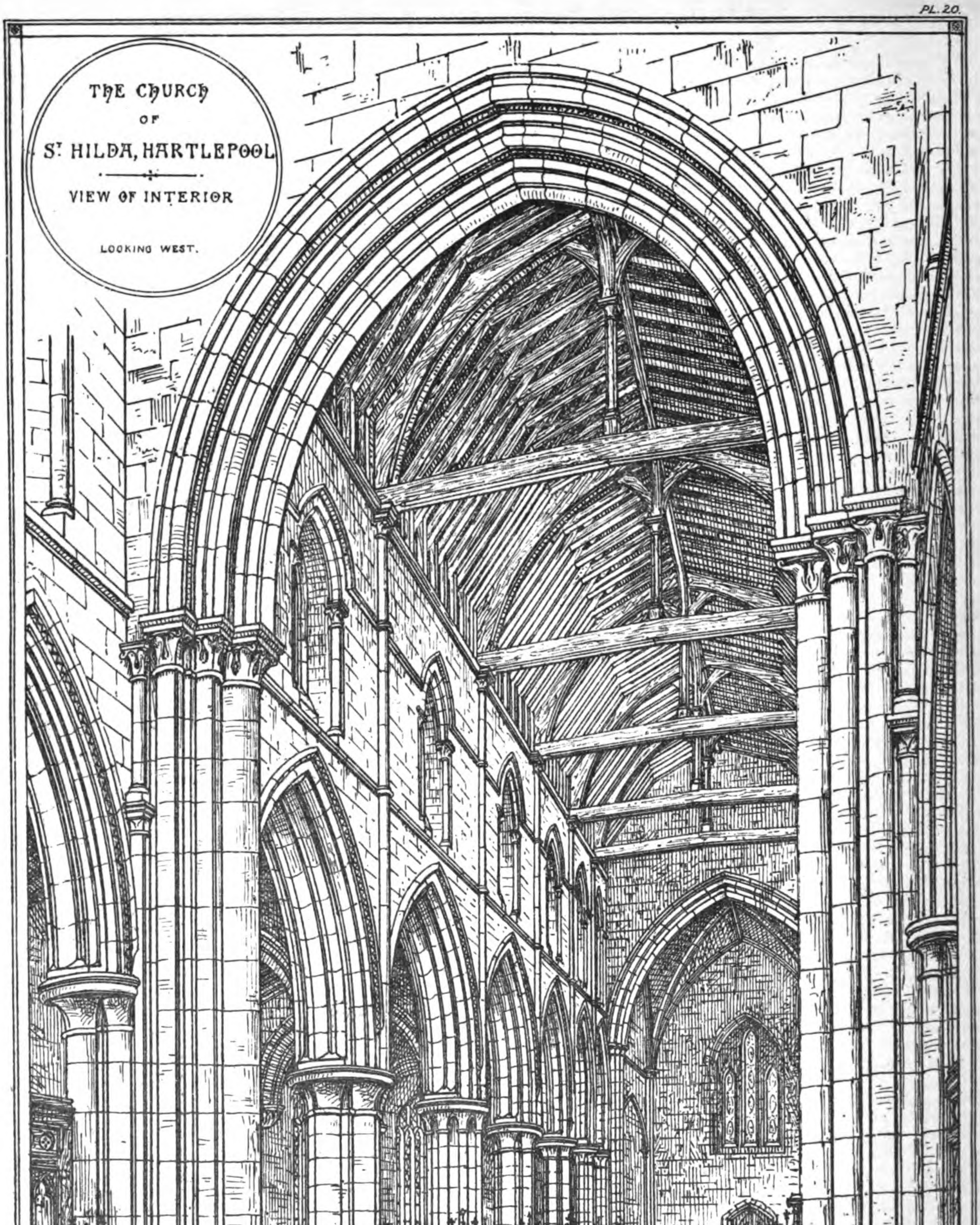
Mr. Rickman said that this subject had been brought forward by Mr. Hine, who was a man of very large experience. The subject matter of his paper was increasing in importance to the profession, as standing between clients and builders. The position of the measurer was also becoming every day more and more important, because to a certain extent the architects who are now engaged in large practice have not the thorough business habits or training which men of equal standing formerly had; while the class of builders with whom they have to transact business, if their business is of any extent, is as much higher than it was. The builders of the present day were men of greater knowledge than those with whom architects had to deal years ago. The number of architects who looked solely at the interests of their client, without also looking at what was due to the builder, was increasing. It thus became of greater importance, for the satisfactory settlement of every building contract, to have all matters of detail fully cleared up before the work was commenced. Throughout the country the custom of making the quantities the basis of the contract was coming more and more into use, so much so that with many clients of experience in building they would not allow an architect to carry out works for them, unless he himself provided the quantities, so that it might be known that the drawings and specifications really agreed, and that the quantities were based upon them. Supposing a contractor undertook to do certain work on the representation of the bill of quantities, he was not bound to do more works than were enumerated in that bill of quantities. The reason that questions relating to works to be executed, had been so often referred, was the result to a great extent of the lax manner in which working drawings and specifications are got up at the present time. Specifications here and there went into minute particulars, intimating work sometimes of a very expensive character, while other portions were not so minutely, if at all, referred to. The drawings here and there went into great detail. At other places construction and important features were neglected or ignored, and their details were required by the architect to be executed totally at variance with what any man of standing would expect, when compared the original drawings. These were things which occurred day after day, and were proofs of the lax and inefficient principles which guided many professional men at the present time. In many cases the quantities that were prepared by the surveyor for work proposed to be executed were considerably in excess of what appeared from the drawings and specifications. This was done because it was found by experience that when the drawings and specifications were utterly inefficient, the architects would still persist in introducing a great variety of work into the building which had not been orgiually mentioned. This may be seldom done with wrong intention on the part of the architects, but they have come to think too exclusively of their clients' interest. It was quite true that the surveyor did leave a margin, but from experience he was of opinion that this margin arose not from taking work too fully (for a surveyor would take work more closely than a builder dared to take it), but from the fact that the original documents placed before him were insufficient for the purpose, and there were architects who were unwilling to have them rectified. Under such circumstances, should errors of omission appear in the quantities, some work must be omitted from the contract, in order to make up for the deficiences which had been found. That was not precisely a loss on the part of the client, because he must not expect to get more than he pays for. Some architects thought they could get more out of the builder than they paid for; they thought they could get a rod of brickwork for less money than others. Those who endeavoured to carry out such a practical object would find that they would not get contractors to work for them a second time. There were architects of standing—nominally of standing—in the profession who had gone the round of all the respectable contractors, but no man who had once carried out a considerable work for them would do so again, unless a clause was introduced that quantities should form part of the contract. That is to say, that the measure of what the builder had to do should be the very schedule of works on which the builder originally contracted, and not the pleasure or whim of the architect as to what should be introduced into the building. It was true that a second surveyor was sometimes employed. This was however on large buildings exclusively. The great bulk of the work done by architects was work costing from £1000 to £5000, or £6000. It did not pay to have two surveyors for this class of work, and one surveyor must go through the whole work. It was much to the advantage of the architect that a surveyor should do so. The specification, after it has passed through the working surveyor's hands, is generally greatly benefited. There were solicitors in London, of large experience in building operations, who would not allow any contract to be signed by their clients, unless the bill of quantities formed part of the contract. These were the practical points which Mr. Hine had pointed out in his paper, and were of the utmost importance to members of the Association. Mr. Hine had not dealt with the other question as one of the faults of the architects of the present day. That was not his business. At the same time, he (Mr. Rickman) thought that young architects ought to look the matter most fully in the face; unless they made a contract with a builder for certain work, with a clear understanding of what the work was and the rate at which it was to be paid for, they would not get their accounts through without some great difficulty. Builders would know, in the second contract which they undertook, what allowance to make for the caprices of the architect. The architect had no advantage in ignoring the bill of quantities. Reference to it would greatly assist him in preparing detail drawings, and it would make architects more men of business to recognise and prepare the quantities. They would learn to look at things in a business way, and not merely in a *quasi* artistic manner. Mr. Rickman concluded by expressing the hope that the necessity of including bills of quantities in the contract would be urged most strongly upon the profession through the Alliance.

Mr. T. Roger Smith said he rose with views upon the subject which were very far from defined. A good many of the arguments which had been used might be summed up by this, that there was a great deal of imperfection in the manner in which some architects prepared their documents; while those prepared by surveyors were supposed to be more accurate, and therefore it was desirable the two should be embodied together. He wished to ask Mr. Rickman how far the arguments for the system which he advocated would apply to those cases where the architect does his duty, and prepares the specifications and drawings accurately and carefully? The theory of London practice was, that the drawings and specifications represented what the architect desired to have built, and that the drawings showed almost everything, and the specification together with the drawings included or implied everything. That the architect having thus provided for all requirements, he made an agreement with the builder to carry out the work; and the means of arriving at the expense which would be incurred was by the use of an instrument called the bill of quantities, which the contractor was supposed to prepare for his own use, and to get at in his own way. Several contractors were commonly asked to give prices, and therefore to save trouble some professional surveyor prepared this bill of quantities, in blank, and the builders filled in the prices at which they respectively thought they could carry out the work. It depended upon their prices affixed to the separate items what the sum total of each tender would be. This document had ordinarily not been recognised by the architect or prepared by him, and was not under his supervision. The architect chose customarily to ignore the bill of quantities, and the agreement between the builder and the employer was that the work represented by the drawings and specifications should be built. If there were omissions in the drawings or specifications they were considered as extras. There was the advantage in this, that if an architect was thoroughly sure of his own work, he was independent of the mistakes that any other person might make, except so far as they might influence the amount of the tenders. At the same time, the architect was perfectly well aware what the system was; he knew that there was a bill of quantities, and that indeed it was ordinarily an absolute necessity such a document should be prepared in order to obtain tenders. It was therefore really the architect's interest to have a surveyor, upon whose judgment he could rely. It had always seemed to him (Mr. Smith) that it was rather a weak point in our arrangements for the architect to know that there existed a formal document, and to even have appointed the man to prepare that document, and yet to ignore it, and not allow it to enter into the agreement which subsisted between the employer and the builder. There were, however, objections to its being introduced and he (Mr. Smith) was far from being prepared to say that these objections were not weighty. The experience of those who had determined the present system of things was so great that such a society as this Association ought to hesitate in adopting any resolution which might seem to go against it. But at the same time he (Mr. Smith) was aware that the practice he had described was not even in London universal; a London architect, from whom he had learnt much of what he knew of architectural practice, had told him that his uniform custom was to consider that plans and specifications, and bills of quantities together, formed the basis of his contracts with builders, and this gentleman was one of the most experienced architects in London. If an architect were sure of his surveyor, the advantage of having the surveyor's careful scrutiny added to his own careful work, would usually outweigh most disadvantages, such as those which might arise from the architect meeting some things in the bill of quantities which he was not prepared for. It was in his opinion most desirable for architects entering practice to learn the ordinary routine of taking out quantities, and even occasionally to practice it. He (Mr. Smith) thought, if artistic men could go through such work without damaging their artistic faculties, it was a misfortune if this portion of the architect's practice were never carried out by the man who was supposed to be responsible for the whole building; and if architects prepared their own quantities, most of the objections which lay against the proposal to make the quantities part of the contract would fall to the ground. There need be no specification at all under such circumstances, and the bill of quantities would take its place. The entire subject required careful consideration; and it was a point, he begged to repeat, on which his judgment was not fixed.

Mr. Christian said, the Association owed Mr. Smith thanks for placing the relative positions of the architect, surveyor, and builder so clearly before the meeting. He (Mr. Christian) did not quite agree with Mr. Smith in all the deductions he drew from the position of the three employments, though he agreed with most of them. He did not agree with the tenor of Mr. Hines's paper. From that paper and from Mr. Rickman's speech one would infer that their arguments were based upon the supposition that architects were incapable, and surveyors dishonest. He should be sorry to think this true in either case. If he could believe that the majority of architects were incapable of doing their duty, he should advocate including the bill of quantities in the contract. But he considered that the position of those architects was by far the strongest who refused to have anything to do with the bill of quantities. He had found in his own experience that builders often, when required to perform work which clearly formed part of a contract, demurred under the plea that it was not in the bill of quantities. In such a case, if the architect could say, "I have nothing to do with the bill of quantities: is it expressed in the drawings or specifications?" he was delivered from all difficulty. If he could show that the specifications and drawings were complete, then he could silence the builder at once. He felt very strongly that the architect was not employed solely for the benefit of either the client or the builder, and that he has no more right to allow his client to pay for one rod of work more than had been done, than he had to insist on the builder doing a rod of work for nothing. He (Mr. Christian) did not in the least desire personally to object to what Mr. Rickman had said, but he thought that Mr. Rickman had dwelt somewhat too strongly on the imperfection and ignorance of men in the profession. He did not think there were so many incapable architects as Mr. Rickman had led them to infer, and he was sorry if that gentleman's experience had led him to such conclusions. According to Mr. Rickman's views, such men were not competent to make out drawings and specifications; and the surveyor who supplies their deficiencies ought to have part of the five per cent. allowed to the architect. Were the bill of quantities made part of the contract, the surveyor would stand in a position superior to the architect, which he (Mr. Christian) thought was wrong. The surveyor in taking out the quantities for the builder ought not to be depended on for correcting the architect's specifications and drawings. He hoped that no motion making bills of quantities part of the contract would be carried at that meeting. He did not wish to follow Mr. Rickman in throwing blame on any part of the profession, yet it would be found that bills of quantities were not always faultless. If bills of quantities did form part of the contract, the result would be, that the bill of quantities would be brought up against the architect and his client's interests, under all circumstances where anything was omitted; but if there was a surplusage nothing would be said, and it would go into the builder's pocket, and the client would get no benefit. If the present system was unsatisfactory it would be better to try another scheme altogether, such as that of priced schedules, as used largely by the Government. However experienced and well-intending a surveyor may be, there would always be a margin, either too much or too little, at which he could not arrive. A better plan was to get a good schedule drawn up, and fairly priced by competition. By this means the difficulties of alterations and extras would be avoided, and the architect, builder, and client would arrive at a truer understanding of their relative positions than by any other possible means. If they could be sure that all men employed on the building were neither rogues nor fools, the simplest and perhaps the best system would be that of day-work under a good clerk of works. But as they could not always ensure honesty and common sense they must adopt some other plan: architects ought not to give up their position and authority in the matter under discussion. He was a conservative, and should prefer things to remain as they were. He had not been able to examine or discuss Mr. Hines's paper in detail, but if they were to take it clause by clause, he was sure that the result at which they would arrive was, that the adoption of the system recommended would be injudicious and unwise.

Mr. Blashill said that some years ago he had been a member of a committee which had the matter now being discussed under consideration, and a point which occurred to him at that time had been forgotten in the present discussion. Mr. Christian had said that taking out the quantities was work done for the builder. In the olden time there was not only competition as to prices, but also as to the skill of the builders in taking quantities with closeness to the drawings. By the present system that guarantee was lost altogether. The only competition now was as to prices, and quantities were matters about which the architect could not be sure at all. There might be considerably more or less work than appeared in the quantities, but at all events the builder must do the work, and the client must pay the contract price, without any real remedy for excess or deficiency. If any alteration were made, it might be worth considering whether the contract should not be based upon the quantities alone. For the quantity and quality of the labour and materials, together with the site, were the only matters of importance to the builder in forming his tender. The design and arrangement of these materials are chiefly of importance as between the architect and his client, and they would be shown by the drawings and specifications, which under such a system would show the builder how and where to place the work he had contracted to do. The objections to this system would be the expense of measuring up every work for extras and omissions, and the uncertainty as to the ultimate cost, but from these very grave objections the present system was not wholly free. To make the quantities a part of the contract, retaining the other documents, would tend to produce disputes by increasing the chance of discrepancy.

Mr. R. O. Harris said, in making bills of quantities part of the contract, the whole of the surveyor's responsibility was at once thrown upon the architect or his client, who had to depend upon the ability of the surveyor employed, a liability which few architects would care to accept. He did not think that architects—though they were expected to know a little of everything—could be expected to take out bills of quantities with the precision and accuracy modern builders require for a large building. The state of affairs had better remain as at present. It frequently happened, that all a surveyor had to guide him in taking quantities was a simple pencil drawing, and a few pages of written specifications, mere notes in fact, for a whole building. Such cases occurred to his (Mr. Harris's) certain knowledge. The surveyor, wishing not to lose the job, takes out his quantities on the safe side, being responsible for them to the builder. He very naturally guards against loss to the builder, as he (the surveyor) would have to make it good. I shall support those members wh› vote for quantities not being part of the contract. Including them in it might be very desirable for surveyors, but, I think, it would be otherwise as regards architects.



C. HODGSON FOWLER ARCH^T

Mr. MATHEWS begged to propose that the Association, having discussed Mr. Hines's paper, should give it their cordial assent. In so doing, he said, from the statements which had been put forth by Mr. Hine and the gentlemen who had spoken, it seemed that architects did not know their business thoroughly. Why should they as a rule give their drawings and specifications to a second person to go through to correct faults in them? Why should he have to re-write specifications and get over difficult points? He (Mr. Mathews) thought it was most desirable that bills of quantities should be the basis of the contract; and, in cases where architects could find time to take out their own quantities, he considered they ought to do so. There was no better means of instructing a young man in the practical part of the profession than by so doing. It would greatly help to make an architect's building more satisfactory to himself, and to remove many difficulties that would otherwise arise in carrying them out. It would be more just to the employer, as he would only have to pay for what he really had; and it would place the architect in a right position between his client and builder.

Mr. LACY W. RIDGE said it was scarcely wise, at so late a period of the evening, to pass such a strong resolution as Mr. Mathews proposed, because it was a very important question, and required more discussion and consideration, though his own feeling was in favour of the motion. Most of the arguments which had been used had, however, been grounded on the incompetency of architects. If, however, the drawings and specifications were properly made, and the quantities fairly taken out, there was a reasonable prospect of their agreeing. They might then be made part of one and the same contract to the advantage of everybody. When the time came for settling the accounts, the extras and omissions might be set against each other. The great defect of the present system was, that even when a surveyor was appointed by the architect, he was in a second degree only responsible to the architect, whereas he was pecuniarily responsible to the builder, so that in self-defence he took the side of the builder. As a protection to the surveyor, and as leading to the quantities being taken out in more strict accordance with the drawings, he (Mr. Ridge) thought it would be better to make the quantities part of the contract.

Mr. SMITH said, he begged to move an amendment to Mr. Mathews's motion, "that in the opinion of this Association the proposal for making the quantities part of the contract deserves consideration; but, as a matter of fact, it is not the most usual course in London contracts." In moving the amendment, Mr. Smith said that one great difficulty in the way of making the quantities part of the contract was the incompetence of certain surveyors. He had very little personal knowledge of such surveyors, but there did exist a considerable number of surveyors who took quantities out in a very loose manner indeed.

Mr. CHRISTIAN seconded the amendment.

The PRESIDENT said he thought it would be very unwise to carry Mr. Mathews's resolution. He thought it was absurd that an architect should be fettered in any way by the work of a surveyor over whom he really could have no control. Such would be the result where bills of quantities were made the foundation or a part of a contract, unless such bills of quantities were taken out by the architect himself or under his immediate supervision; but if they were taken out by an entirely independent surveyor, and were then made to form part of the contract, should there be any mistake in the bills, the result would be in most cases very troublesome and unsatisfactory to the architect, and probably also to his client; and, at the end of the work, it might be necessary to have a re-measurement of the whole building, which would be likely to lead to much annoyance and expense on all sides; the architect would perhaps be overthrown, and the client have to pay considerably more than the contract. If, as had been insinuated, an architect could not make out fair and proper drawings and specifications, sufficient for a fair and equitable contract, without quantities, he had better have left architecture alone altogether. Some remarks had been made as to architects being a lower business class of men than formerly. His (the President's) impression was that the architects of the present day had not only considerably improved in the art, but also in the business portion of their profession, and that it was most undesirable for many reasons, which time would not now allow him to enter upon, for an architect to allow the bills of quantities—unless taken out in his own office—to form any part of the contract.

Mr. RICKMAN begged leave to say a few words in reply: Mr. Smith had asked him how he would apply bills of quantities in cases where the specifications and drawings were fairly made out. He was happy to say a very large number of the drawings and specifications were properly made out. In these cases the quantities were just as valuable as in the other cases. The necessity of pricing and forming an estimate involved that somebody should transfer the form of the work from drawings and specifications into the shape of a bill of quantities, unless a mere shot at the value of the work was taken. The bill of quantities must be referred to in some way or other for the purpose of any variation which it might be desired to have carried out. There were quite as strong reasons at work to make the surveyor take out quantities closely, as there were to make him take them out liberally. The surveyor only took out quantities liberally in cases where he suspected the architect of carelessness, and where he feared the builder would be down upon him for the sins of the architect.

The amendment, as proposed by Mr. Smith, was put to the meeting, and on a division was carried.

The SECRETARY moved, and Mr. Harris seconded, that Messrs. T. R. Smith, Rickman, Edis, and Christian be re-elected delegates from the Association for the next meeting of the Architectural Alliance, which was carried unanimously.

THE CHURCH OF ST. HILDA, HARTLEPOOL.

(With an Engraving.)

The accompanying plate illustrates the restoration about to be carried out in the ancient parish church of St. Hilda, Hartlepool, Durham. Happily, it is now rare to find a church of such original magnificence in so lamentable a state of repair. Both in its grand massiveness of effect, and its chaste ornamentation, it is considered to surpass all other churches of the county of the same period. The tower-buttresses are unique; and the piers and arches of its nave, the clerestory, both internally and externally, and its beautifully proportioned and simply adorned chancel-arch, are also justly admired.

The church was principally erected during the latter part of the twelfth century (the tower being probably a few years later than the nave), whilst the south door is of the eleventh, and the aisle windows of the fifteenth, centuries. Its style is mainly of the earliest period of pointed architecture. Its massive tower is cracked in all directions, and has a considerable inclination to the north-east; and almost every other part of the church is in want of repair. In the year 1721, during extensive alterations, not only were the buttresses taken away from the north side, and the windows modernised in the north aisle, but the noble chancel was curtailed to one-fourth its original length; and the present arrangement of ugly, uncomfortable pews adopted, throwing away a large number of sittings.

"This once magnificent building is marked by peculiarities of a perplexing description, and it is no easy task to decipher the intention of its architect. Especially singular are the enormously massive buttresses jutting from the tower. Those at the west end project above 26 feet from the tower, and the walls of each are respectively 3 ft. 9 in. and 3 ft. 2 in. thick. Whence this difference of substance arises has yet to be explained. Looking at their extraordinary form, we might fancy the original design had for its object a cross church, consisting of nave, transepts, choir, and chancel, and that, this intention being altered, the buttresses were placed against the tower to compensate for the loss of support which the complete members would have given it; but on a closer inspection of the masonry we discover portions of the walls, windows, and (upon the buttress sides) the coping stones of the roofs of three small chapels, attached to the west, north, and south of the tower, and all of the Early English period when the church was first built. The southern chapel, indeed, still exists. A survey of the interior of the tower satisfies us of the necessity of large buttresses, for they sustain the lateral pressure of a lofty and heavy stone-ribbed groining, which is undoubtedly the best constructed specimen of the kind in the county. This vaulting with the clustered columns from which it springs once formed a fine addition to the interior of the church, from which it is now separated by a ponderous wall of later date.

The church of Hartlepool, before the demolition of its ancient chancel, must have far excelled any of the churches in the county. The eastern part of this edifice, most probably owing to the fact of its being the Bruce mausoleum, was a most remarkable building,—a second church of equal length to the nave, having its columns, arches, and aisles of the same dimensions as that part, and apparently more highly decorated. About half a century has elapsed since the repair of the chancel is said to have been seriously contemplated, but the consideration of the subject was soon ended by the destruction of the whole, save one small compartment.

In spite of the destruction of its chancel, and the introduction of modern framed windows into the aisles, this church is still a very interesting building. Its entrance doorway is a beautiful specimen of late Norman, and the whole exterior detail, especially of some of the clerestory capitals, is of very fine character. Internally there is not so much of elaborate execution, but the capitals supporting the chancel arch are decidedly good specimens of their style, and the small capital breaking the continuation of one of the thin shafts is a marked singularity. A specimen of the whimsical occurs in the zig-zag of the doorway, where (against the left capital) one of the pieces of stone is left uncarved. But the most remarkable oddity is the form of the south aisle arches, at first, they would be pronounced inaccurately drawn, or if not, deformed in consequence of extraordinary pressure, but the latter is certainly not the case, as the joints are perfect, and the superincumbent masonry regular, and because there is no lateral thrust to cause this most singular deformity. The last striking feature is the cushion of the capitals upon which the arches rest, but this is not peculiar to Hartlepool. Here the columns are attached alternately to octagonal and square shafts, and have circular bands or cushions enclosing the whole, both at the base and capitals. At Billingham, on the contrary, the columns are attached to a circular shaft, and the cushions are square. But Hexham Abbey, in Northumberland, offers the most important specimen, for the lofty tower piers are inclosed with a cushion similar to that of Hartlepool."*

It is proposed to carry out a thorough restoration of the church, with a view to bring this noble fabric to something of its ancient grandeur, and to provide increased accommodation for the worshippers. In the nave, it is intended to take out all the present fittings and the unsightly gallery, to relay the floor at its proper level, to raise the roof to its proper pitch, to re-roof the aisles, and restore the windows both in the north and south aisles. The tower will require to be treated with the greatest care. The whole of the foundations will require to be under-pinned; parts of the walls rebuilt and restored to their original design; other parts of the tower thoroughly repaired and banded together (iron ties being used when required); and the vaulting and arches thoroughly restored. It is intended, if practicable, that the large arch into the nave should be open. These works, from their nature, must be costly; for the work will have to be carried on with every possible precaution—stone after stone being taken out and replaced in a gradual manner; as it is considered most desirable to retain as many of the original features of the fabric as possible. The chancel it can scarcely be hoped, perhaps, to restore to its original length; but it is purposed to rebuild it of such a size, that, while being sufficient for the due performance of Divine service, it may form a termination not unworthy of the splendid nave. The estimated cost of the restoration is £3500. The committee have secured the services of Mr. C. Hodgson Fowler, the architect to the Dean and Chapter of Durham.

Reviews.

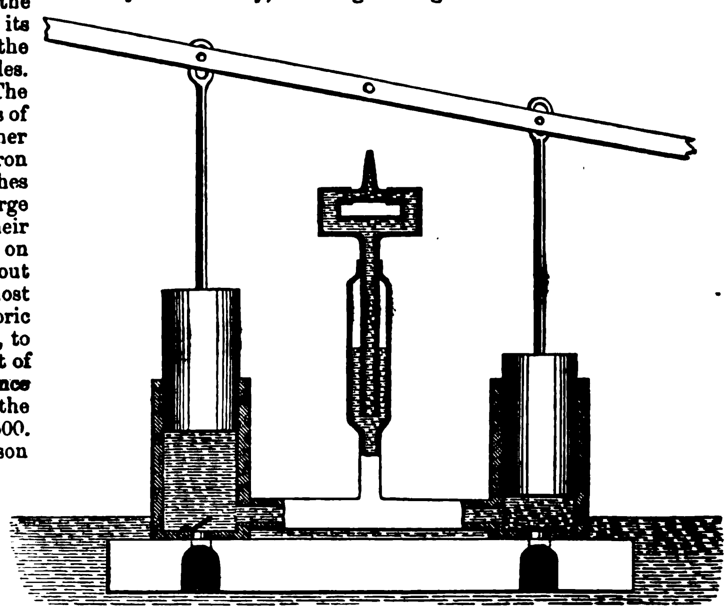
Fires, Fire Engines, and Fire Brigades. By Charles F. T. Young, C.E., Mem. Soc. Engineers, Author of "The Economy of Steam Power on Common Roads," &c. &c. London: Lockwood and Co.

Who that has lived in a large city has not been startled by the ominous cry of "Fire"—and who that has witnessed the disastrous effects of a large conflagration, can fail to recognise the importance of any investigation tending to prevent the recurrence of such calamities?

The title of the work before us, embracing as it does almost the entire subject of fires and their prevention, evidently requires from its author not only the most careful and studious research and examination of facts, but also the yet higher qualities of unflinching truthfulness, and a determination to maintain whatever shall conduce to prevent the continual reappearance of that now almost stereotyped form of report, "Totally destroyed," or "Considerably damaged"—a form, by the way, which throws a convenient veil over the proportion of fires which result in total loss, and, as Mr. Young remarks, contrasts unfavourably with the distinct classification adopted in the reports of the Parisian fire establishment. In a matter involving the efficiency and management of men and appliances for the extinction of fire, too much regard cannot be paid to care and exactitude in the preparation of statements which by their bearing may tend to show where faults exist, and in what direction amendment may be looked for. There is evidently at present much room for improvement, and it is apparent that any work which, like Mr. Young's, brings together the available history and experience of fires and fire prevention from all parts of the globe, must be of essential service. The time was in our own country when occasional fires in large towns were almost necessary evils, and were to be viewed much in the same light as we look upon the loss of a limb as being preferable to the destruction of the whole body.

Of this class was the Great Fire of London, which, terrible as it was, at once purified the atmosphere, and did away with many of those miserable streets and alleys which had formed the hotbeds and nurseries of fever and plague. Unfortunately, it cannot be said that we are yet entirely free from localities so built up, so filthy, so over-crowded, and so suited in every way to foster disease and death, that a clearance, even by fire, would not occasionally appear to be desirable; but at the same time let it be remembered, that in these days we have some idea of sanitary laws, and that localities such as we have named are precisely those in which fires of any extent are least frequent.

It is not then to fires that we ought to look for sanitary improvements, but rather to their prevention, as avoiding the ruinous destruction of piles of property, and the utter and unbalanced loss of hundreds of thousands, nay millions, of pounds, which might but for fire have remained available, either directly or indirectly, for the general good.

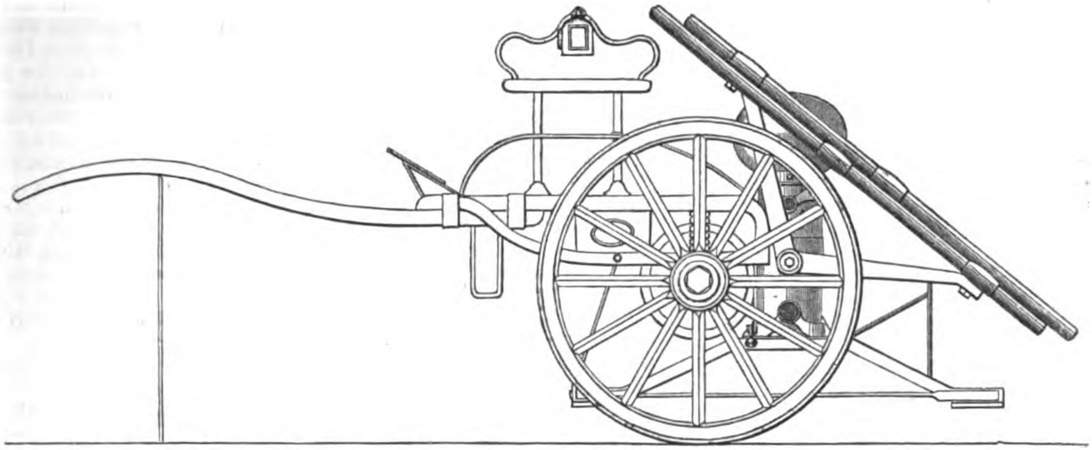


Hero's Engine, second century, B.C.

Mr. Young's work, which is written throughout with an evident desire to throw a clear light upon what has hitherto been but an imperfectly understood subject, commences with a chapter upon "Fires" generally, their causes, and hints most excellent in character for their prevention. This is followed by instances of large conflagrations, &c. We then have an excellent chapter upon Fire Brigades, including those of former as well as our own times, and pointing out existing defects. The succeeding chapter enters at considerable length into the means for subduing fires, and points out the weakness of the claims to originality of several so-called recent inventions. Fire-proof structures, which form the subject of the succeeding chapter, might advantageously, we think, have been treated at somewhat greater length; although, as it is, quite sufficient is said to show the fallacy of some commonly existing ideas, and to indicate the possibility of much improvement on present practice.

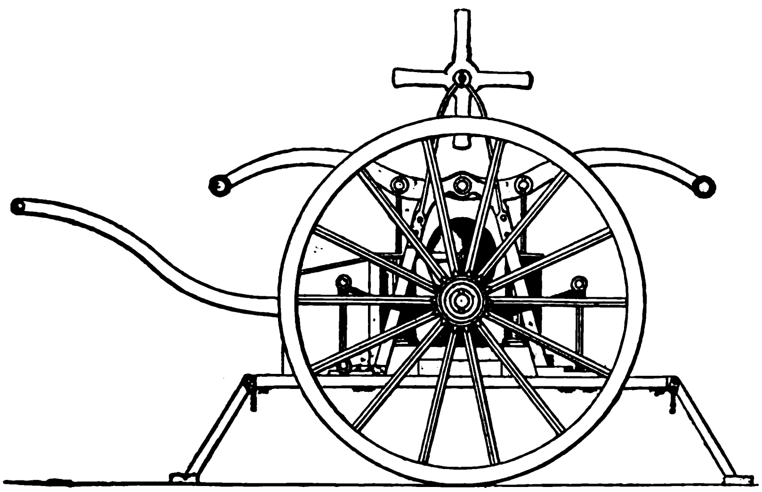
The succeeding chapter, devoted to the history of manual fire engines, reveals some very startling facts as to the antiquity of arrangements which we have been accustomed to look upon as being of comparatively modern origin. Of these instances the most notable is that of the air-vessel, the first use of which in connection with pumps, Mr. Young says, is usually ascribed to Leupold, in the year 1720, whereas, according to Vitruvius, the

* R. W. Billings' Illustrations of the Architectural Antiquities of the County of Durham.



Roberts' Gig Engine.

honour belongs in reality to Ctesibus, an engineer who flourished in the second century before the birth of Christ; and an illustration is given of a double-cylinder fire engine, described by Hero in his "Spiritalia," with which modern improvements are in principle almost identical. We reproduce this very curious proof of the mistake we should make in supposing that ancient records can show us nothing approaching in principle to the perfection of modern practice. The whole of this portion of the work, indeed, is highly interesting, and will well repay attentive perusal. It particularly struck us that engines of the small light class, such as Roberts' Gig Engine, and Merryweather's Small Manual Engine, were deserving of much more attention at the hands of fire brigades than they have as yet received, inasmuch as, from their lightness, and the small power required to work them, they would be frequently available long before ordinary brigade manuals could be brought to bear, and might thus be the means of effectually keeping in check, if not of entirely extinguishing, incipient conflagrations. At a certain stage, however, the larger manuals must of necessity be called into play, and of these two excellent examples, one by Messrs. Merryweather and Sons, and the other by Messrs. Shand and Mason, are given; Mr. Young aptly pointing out the fallacy of supposing that in cases of this sort a low priced, ill-made



Merryweather's Small Manual Engine.

machine can be cheap, where the greatest possible efficiency should at all times be maintained and available.

The subject of manual engines is throughout treated in a very complete manner, the progressive steps being well marked, and honour given to some who have hitherto scarcely received their due. Useful tabulated results of the performances of the principal engines at public competitions are given, and enable a clear idea to be formed of the capabilities of engines of this class, which however good, as they undoubtedly are, are after all secondary in interest for the engineer to the more effective and economical steam-power engines, to which a large proportion of Mr. Young's work is devoted, and which is of too much importance to be treated in the space available in our present number. We therefore propose to examine it at some length in our next.

THE INTERCOLONIAL EXHIBITION TO BE HELD AT MELBOURNE IN 1866.

The Colonial Government of Australia have issued a commission, under the presidency of Sir Redmond Barry, to take measures for conducting an Intercolonial Exhibition, to be held in Melbourne in 1866, and it is gratifying to find that the effort is receiving the well-merited support and co-operation of the governments of the various dependencies of the Crown in Australasia, and of friends and exhibitors in Europe and America.

The commissioners remark that, "although the contemplated display cannot vie with the splendour of those which excite the rivalry of nations, purposes of the highest utilitarian and social importance to those immediately concerned may be thereby served. A searching and penetrating attention may be concentrated on our mineral treasures, portions only of the boundless stores of which have been hitherto brought to light;—on improved economic methods of winning them from the earth, and applying them to the ends for which they are intended;—on the sources of wealth which, in their raw state, abound on the surface of our soils, in the rivers, and in the waters which encircle our coasts;—and on the rare excellencies and peculiar development in different latitudes, under different conditions of culture, of those products which successful enterprise has introduced amongst us, rendering us already independent of many countries, and enabling us to contribute to the necessities, the comforts, and luxuries of most. A deliberate comparative survey may be made of the results flowing from the adoption of the liberal arts happily domiciled in these climes, and the exercise of those useful manufactures which genius, self-reliance, and perseverance, have established in lands so suitable for their natural vigorous growth. A diligent compilation of the statistics of the actual products and of the productive capabilities of the different colonies will form a most valuable fund of information.

It is proposed to distribute the objects to be displayed into the following divisions:—Mineral products, animal products, vegetable products, manufactures and the useful arts, ornamental arts, machinery.

The commissioners particularly desire to induce patentees of mining machinery in Europe and America to forward, for exhibition, models of their working machinery. More especially that class coming under the head of Rock Boring, Tunnelling, and

Coal-Cutting Machines. The importance of the introduction of such machinery into the colony cannot be too highly rated, as it will render productive vast tracts of auriferous land now considered too poor to work. In quartz mining, which is daily affording instances of its permanent character, inventions of this sort would make such a reduction in the cost of sinking, driving, and stoping as would in many instances double the dividends to the proprietors. The coal-cutting machine would be admirably adapted to alluvial mining, and with slight modification might be used in almost every operation, it being especially suitable for breaking out loose and treacherous ground without risk to the men attending it. Another kind of machinery it would be desirable to have represented would comprise every invention more particularly used for hydraulic mining in California. The steps now being taken for supplying the goldfields with water will no doubt cause such machinery to be in great demand. Considering the probability of the exhibition attracting from the adjacent colonies a large number of visitors, more or less interested either practically or financially in mining pursuits, a more favourable opportunity could hardly be suggested for such a display.

The Juror's reports at the International Exhibition, London, 1862, directed particular attention to the great importance attached to Australian mineral products; and any who may have effected improvements in mining machinery are invited to the field which is here open for the disposal of really good workable appliances, especially those adapted for boring and tunnelling for gold, quartz, coal, copper, and other minerals. The Commissioners desire to exhibit all the mechanical improvements of this kind that can be gathered together, believing that by so doing the interests of the colonies, as well as those of the home manufacturers, will be materially promoted. Full-sized machinery or working models would be equally acceptable; and as the building in which the exhibition will be held is to become hereafter a public museum and department of industrial art, such mechanical illustrations could be made permanently accessible to the public, thus securing a publicity far beyond that of the few months during which the exhibition will be open. According to the wish of the exhibitors, the goods would be thus received for permanent exhibition, or at the close of the present one be handed over to any person authorised as agent.

Although the scheme of the Intercolonial Exhibition is strictly to encourage colonial productions, the importance of possessing the highest class machinery for mining purposes is a sufficient reason for inducing the Commissioners to make this branch an exception to the general rule. The models or machines can be received at Melbourne up to the end of September next.

The Secretary to the Commissioners is Mr. J. G. Knight, F.R.I.B.A., of Melbourne, who so ably represented the Australian Colonies at the London International Exhibition of 1862. The offices of the Commissioners are 64, Elizabeth-street, Melbourne.

JUDGMENT RESPECTING CERTIFICATES UNDER A CONTRACT.

The following report of a decision of the Court of Common Pleas, Dublin, on the 2nd ult., is of importance to members of both professions, engineers and architects, as well as contractors. The defendant was Mr. John Bower, C.E., Dublin. The case was tried before Chief Justice Monahan, Judge Keogh, and Judge Christian.

Murphy v. *Bower*.

Their lordships delivered judgment in this case, which was argued last term, and stood over. It came before the court upon a demurrer by the defendant to the summons and plaint. It was an action by the plaintiff, as assignee of Messrs. Edward, John, and Patrick Moore, railway contractors, against the defendant, who is a civil engineer, to recover damages for not giving certain certificates under a contract. The summons and plaint contained three counts. The first, after stating the pecuniary embarrassments of the Messrs. Moore, and the appointment of the plaintiff as their assignee, stated that the defendant was duly appointed civil engineer of "The Finn Valley Railway Company," in the north of Ireland, and, while so acting, a contract was entered into between the Messrs. Moore and the railway company for the construction of the railway, for a sum of £22,000, and further sums for extra works, payment to be made in monthly payments of not less than "nine-tenths" of the value of the work done, the balance to be paid on completion, on the production by the contractors to the railway company of proper certificates from their engineer that the work was all done and completed. That the defendant gave certificates to the extent of about £19,000, but declined and refused, when called on, to give further certificates, although the amount fairly due on foot of the contract and extra work was about £26,000, thereby leaving a balance of about £7000 due to the plaintiff as assignee of the contractors. The first count complained of simple neglect of duty on the part of the defendant; the second was similar, but, in addition, imputed fraud; and the third, which was also similar, charged collusion between the railway company and the defendant. The defendant demurred to the summons and plaint, on the ground that a contract in fact should be distinctly stated, and that it was not so stated that the duty was necessarily imposed on the defendant to grant a certificate, and that the defendant was no party to the contract, &c.—Their lordships allowed the demurrer, with costs. —*Carlow Sentinel.*

Railway Bridges in the Metropolis.—The question of noise from passing trains, so much complained of, was recently raised between Mr. Scholefield, chairman of one of the Commons railway committees, and Mr. Hawkshaw. Mr. Scholefield desired to know whether the noise consequent on the passing of trains over the railway bridges in London, could not in some way be obviated. Mr. Hawkshaw gave it as his opinion that this excessive noise was mainly due to the construction of these bridges being entirely of iron. He stated that this mode of construction was insisted on by the parochial authorities; but that if these bodies would allow the bridges to be made of brick or stone, as formerly, the noise caused by passing trains would be very little, and indeed, with proper precautions, might be almost entirely obviated.

New Iron-Preserving Agent.—Dr. Henry Edward Francis de Briou, a Parisian physician, who for many years has resided in England, has discovered and patented a process for preparing from india-rubber what may be designated an "enamel paint," which is said to be proof against the action of the atmosphere, as well as against the power of all liquids to affect iron. This enamel paint possesses all the remarkable qualities of india-rubber, without combining with them any other substance or element that is calculated in the slightest degree to counteract their thoroughly efficient operation. The preparation is applied cold and in a liquid state, and in consistency and general appearance it resembles such common oil-paint as is ordinarily used for iron-work. It may be applied with ease. The covering may be so thin that its presence cannot be detected; while it leaves the protected surfaces in all their original sharply-defined freshness. It hardens also at once, and immediately forms a smooth and lustrous enamel-like covering, air-proof, damp-proof, water-proof, and acid-proof. Thus protected the iron is safe. Rust cannot accumulate upon the surface of this enamel-paint, nor corrode beneath it.—*Art Journal.*

Archæological Discovery.—An important discovery has just been made in Egypt, at Chalouf, a station some leagues north of Suez, where a monument of Persian origin has long been known to exist. A copy of some cuneiform inscriptions found there having been sent to M. Mariette, that gentleman inferred from certain indications that a portion in hieroglyphics must still remain below the surface of the soil. He accordingly communicated his conjecture to M. de Lesseps, who ordered excavations to be made, which brought to light a translation of the cuneiform writing in Egyptian hieroglyphics. The stone bearing this bilingual inscription, which belongs to the reign of Darius, will shortly be conveyed to the museum of Boulac.

A Rotary Rock Boring Drill.—Among the patents recently issued at Washington is a rotary rock-boring machine, which consists of a drill composed of a number of scolloped cutting wheels, arranged in a common head, on axles passing through said wheels at right angles, in such a manner that by giving to the head a rapid rotary motion, the wheels will cut into the ground or rock and produce a clear hole. The dirt is raised by the action of a spiral flange, secured to the outside of the drill rod, guided by friction rollers. A stream of water is made to pass continually to the bottom of the hole through the drill rod, which is made hollow for that purpose. Much of the dirt is thus removed. The machine can be applied to ordinary rock drilling or well boring.

ARCHITECTURE AT THE ROYAL ACADEMY.

YEAR by year, the hold of architecture upon the Royal Academy, and upon its "Exhibition" in particular, appears to become gradually and hopelessly lessening. We have on many bygone occasions alluded to this fact, with the hope that, if the Academy as a body did not change its mode of proceeding, such of its members as belong to our profession might be stimulated to, at least, an open protest, which, backed as it would doubtless be by the efforts of less privileged men out of doors, could hardly fail to ensure some more worthy recognition of an art which, with sculpture and painting, has an equal claim to consideration, if only on the ground of the original Royal Charter to the Institution. Granted that the demand for, and interest in, historical pictures and landscapes is greater than for the more conventional and homely productions of sculpture or architecture; yet surely, after making every allowance, the preponderance is far too great when we find that, out of 1,053 subjects exhibited this year, 798 are devoted to painting, 214 to sculpture, and only 40 to architecture! We are quite aware of the difficulty as regards finding space in the already too crowded rooms, but we plead for a more just distribution of that space, and shall look forward with hope to the influence of the newly-elected "Professor" of Architecture, and the newly-elected "Associate," to bring about a better state of things for the future, be the ultimate destination of the Academy Burlington House or South Kensington.

The first architectural work in the catalogue (761) is "Hoddesdon Church," as proposed to be altered by Mr. J. Clarke, which will be quite deprived of its localism by the strange transformation in its appearance—not, to our mind, in the best of taste; and the pack-saddle roof to the stilted tower adds to the unsatisfactoriness of the composition. (762) deserves a better place on the walls; hung where it is, it is next to impossible to appreciate what evidently is a most painstaking drawing, well designed, and effectively finished in pen and ink, giving the "Proposed Improvements in the Chancel of a West-end Church," the architect being Mr. Charles Gray. It will be remembered that one of the memorials determined upon in honour of the late Lord Palmerston is the reproduction of the eastern chapel of Romsey Abbey, which is close to his late lordship's residence in Hampshire; and that this has been entrusted to Mr. Ferrey, who, in (763), gives a view of its intended external aspect. Inasmuch as the form of this addition was determined by the original foundations, and other features have been determined by "remains recently excavated," there is not much scope for remark. It may, however, be observed that the arrangement of the east end—two three-light windows, separated by a buttress, and under an almost flat-pitched roof—is peculiar; and the details appear very simple and homely throughout. Within the building is to be placed a recumbent figure of the late nobleman.

A "Memorial Window to His Royal Highness the Duke of Kent," now executing by command of Her Majesty the Queen (764), does not state its destination. The artist, Mr. Hughes, has adhered more to the pictorial style of treatment than legitimate glass painting admits of; hence breadth of effect and transparency are almost entirely wanting. The City Architect, Mr. Horace Jones, displays, in a beautiful drawing (765), an interior view of the renovated Guildhall, which in the catalogue is described as "restored." The chief new feature, indeed almost the only one, is the *roof*, of the Westminster Hall kind, and very good; but how far it is to be understood as following the design of the cotemporary roof of the building it might perhaps be hardly safe to inquire. Messrs. Belcher's "Royal Insurance Buildings" (766) are among the handsomest and most sensible of the many large buildings erected of late in the city. The style is Italian, freely treated, and well balanced in its parts. Advantage has been taken of its situation at the corner of a street to gain a noble entrance on the canted angle of the building. In odd contrast with this picture is the next (767), which bears the honoured name of "C. Barry," but is certainly not much like what *the* C. Barry would have produced. Who does not know the rural attractions of Dulwich, and the pictorial attractions of its "Gallery," in the architecture of which may be detected many of Soane's whimsical conceits?—but who would have supposed that the famed "Dulwich College" would ever give place to so shapeless and disproportioned a building as that "now in course of erection" by the architect we have just quoted? The detail, moreover, seems not a whit better than the outline, being of that peculiar kind once described by a well-known art writer as "pestilent." More satisfactory by far is Mr. E. M. Barry's design, submitted to Government, for the completion of the New Palace at Westminster, on the removal of the present Law Courts, and which is shown, in (768, 775), in plans, elevations, and sections, though, unfortunately, to a very small scale. It is apparent, however, that the general character of the late Sir Charles Barry's work will be conscientiously followed in these additions, which embrace, among other things, a large quadrangle between Bridge-street and New Palace-yard, also a subway from the House of Commons to the Thames Embankment, and to a new railway-station on the north side of Bridge-street. The latter is proposed to be Gothic, in harmony with the rest; but it would surely be allowable, if not desirable, to break this monotony by designing the station in an entirely different style, especially as the adjoining building already suffers much from over-repetition of parts.

Mr. W. White sends (769) the perspective view, which should have accompanied his geometrical drawings, of his "New Church, Aberdeen Park, Highbury," to the Architectural Exhibition. The grouped effect is quite what might be anticipated from the scale drawings, and we regret that, in the too great straining after novelty, so much that correct taste would have expunged has been permanently identified with the building. The largest and most important of the architectural pictures is (771) Mr. H. Currey's "Design for the New St. Thomas's Hospital," which is to be erected at Stangate, and on the banks of the river, facing the Houses of Parliament. This building will be remarkable for the extent of area occupied, and for the classification of its internal arrangements, in conformity with the most approved sanitary measures and complete system of ventilation, which give a distinctive character to the effect of the whole by no means unpleasing. The façade of the New Freemasons' Hall, now approaching completion, in Great Queen-street, and one of the most original as well as successful of the modern structures of London, is well shown in the drawing (773) exhibited by the architect, Mr. F. P. Cockerell. In its details a more purely classic type has been followed than is usual now-a-days, yet not without some judicious variations, especially in the introduction of various symbols and devices identified with the Masonic craft. (774) shows another of the many comprehensive schemes which have been before the public for a viaduct across the Holborn Valley. The design before us is by Mr. Horace Jones, and appears to have been studied with care and judgment. The question of cost might operate as a check to its being carried into execution, but it is high time that decisive steps were taken to improve the locality in some way or other. In (776) we can can hardly realise the "Parish Church, Leamington," as proposed to be altered by Mr. Street. The building, as it exists, was designed on an ambitious scale by the Vicar of Leamington—an amateur architect—and is based very much upon Continental examples. It has, however, never been finished, although suggestions innumerable have been sought and obtained for the purpose. A Palladian design, on an extensive scale (777), exhibits Mr. H. Jones's excellent design for the "Metropolitan Meat and Poultry Market," proposed to be erected at Smithfield, which we should be glad to see erected on the same site. Both the plan and the elevation (Palladian) are much to be commended. Mr. Marrable's "Chancel of St. Peter's Church, Deptford," (778) is, fortunately, hung so high that it might pass unnoticed but for its glaring colours, which show out sundry architectural features deserving more of the blame than the praise of novelty. It is a pity that such a drawing should have found a place here at all, when so many more meritorious works have been excluded for "want of room." "St. John's College, Hurstpierpoint," (779) by Messrs. Slater and Carpenter, is a fine interior view of a good building. The proportions generally are very satisfactory, and the fittings are designed in harmony and good keeping.

Views of the two chief designs for the "New Midland Railway Terminus and Hotel," to be erected in the Euston-road, St. Pancras, are exhibited side by side in (780, 789); the former being the one selected, and about to be carried out, "with some modifications," by Mr. Scott; and the latter, by Mr. G. S. Clarke, having received the second premium. There is, at first sight, a degree of similarity between these two designs, so far as the massing is concerned, and that each is treated as a mask or screen, which in no way identifies itself with the ordinary aspect or purposes of a railway; the buildings themselves being on so gigantic a scale that even the arched approaches to the terminus in the rear, though large in themselves, are comparatively lost in the composition, and we can simply wonder at the requirements of the tier after tier of windows, and lament over details repeated again and again with tiring monotony. In the absence of accompanying plans, we can make but this brief reference to general effect. Supposing that the geometrical drawings would have been inadmissible here, it is a pity that they were not forwarded to the Architectural Exhibition, where, in common with the others, they might have been studied with advantage. Mr. Norton has not been very felicitous in his "Imperial Hotel, Southampton" (782), which, though a large building, is poor in design throughout. Two mansions by Mr. Kerr, viz., "Ford, Surrey" (783), and "Bearwood, Berkshire" (799), are cleverly designed, though perhaps there is rather too much aiming at quaintness. They are chiefly in red brick, with stone dressings, and in the Elizabethan or Jacobæan style. "The New Chapel of St. John's College, Cambridge," now in course of erection from the designs of Mr. Scott, is shown by Mr. J. Drayton Wyatt in (788). A view of this building, as first designed, appeared in a former number of this Journal. There is now to be, in place of the small flèche at the intersection of the church with the ante-chapels, a large central tower, which will be carried up to a great height, and thus supply a feature hitherto almost altogether wanting among the edifices of Cambridge. "Scarisbrick Hall" (790) was erected partly by the late Welby Pugin, and has been completed in good taste by his son. The drawing in question hardly does it justice.

We next notice a beautiful little drawing by Mr. H. W. Brewer, of "St. Gereon's Church, Cologne" (794); while some careful views of "Peller's House at Nuremberg," the "Baptistry at Pisa," and the "Mittel Schloss, Marienburg," are contributed by Mr. Spiers. Miss G. Wilkinson, too, exhibits an elaborately finished interior (781) of the "Hall of Ambassadors at Alcazar, Seville." The "City Terminus Hotel and Railway Station in Cannon-street, London," by Mr. E. M. Barry, is merely a simplified version of his Charing-cross Hotel and Station, the arrangements appearing to be almost identical. In the Architectural Exhibition will be found geometrical drawings of Mr. A. M. Ridge's premiated "Design for a Hall of Science and Art," the perspective view of which is here given in (797). It is drawn very conscientiously in ink-etching, and is deserving of the distinction which it has gained.

In the Sculpture Room will be found a highly interesting model, to a large scale (one inch to a foot), representing the proposed embellishments to the apse of St. Paul's Cathedral, as designed by the surveyor to the fabric, Mr. Penrose, and executed by his pupil, Mr. R. P. Whellock. In Wren's "Parentalia" is the following note:—"The painting and gilding of the arches of the east end, over the communion-table, were intended only to serve the present occasion, till such time as materials could have been procured for a magnificent design of an altar, consisting of four pillars, wreathed, of the richest Greek marble, supporting a canopy, hemispherical, with proper decorations of architecture and sculpture, for which the respective drawings and a model were prepared." The figures in the windows are after Professor Schnorr; those occurring in the mural decorations are, for the most part, after the Baron de Triqueti. The baldachino is restored from a mutilated model left by Sir Christopher Wren.

THE EXHIBITION OF THE SOCIETY OF BRITISH ARTISTS.

The pleasant galleries in Suffolk-street are again busy-looking, with the well covered walls and bright-looking pictures of their Annual Exhibition: the older and well-known members muster in full force—J. B. Pyne, Syer, Cole, Pettitt, Tennant, Clint, Woolmer, and others, whose specialities of subjects, and mode of treatment, render the works of each readily distinguishable. Clint's sunsets are as brilliant as ever, Pyne's perspective as ærial, Cole's harvest scenes as truthful, Pettitt's as noble, and Woolmer's as fanciful as usual. Where there is so much to attract attention, it is not easy to particularise; but, besides the productions of the artists just enumerated, there are some charming contributions by G. Wolfe, Hayllar, Gosling, Warren, the late H. J. Boddington, Mrs. Curwen Gray, Miss Louisa Rayner, and others.

It is, however, more within our province to refer to the architectural subjects, which are numerous, especially in the water-colour room. Thus Mr. Wyke Bayliss exhibits four pictures of this class, all taken abroad, and including a good view of the "Choir and Transept of Antwerp Cathedral" (873), and a still better drawing (920) of the "Tabernacle in Louvain Cathedral." The "Interior of Lierre Cathedral" (790) strikes us as less happily managed, although the sale price is put down at a large figure. As a bit of correct, unpretending colouring, nothing can be better than Mr. H. Hawkins's "Interior of Eddelsborough Church, Bucks" (817); while equally faithful, and more picturesque, are Mr. S. S. Boden's "Old Cottage at Cluddingbold, Surrey" (932), and his "View of the Village of Chiddingfold" (957). "Ogmore Castle, Glamorgan" (853), by Mr. E. W. Robinson, is nicely handled; and so are "Arundel Castle" (882), by Mr. C. Pyne, and "All Saints Church, Hastings" (938), by Mr. Dakin. Mr. Dobbin, in his "City of Prague" (940), gives a very careful and interesting bird's-eye view, embracing several well-known buildings. This drawing is in every way superior to the larger one by the same artist (1035) representing the exterior of "Seville Cathedral," the effect of which is hard and liny. So also his "Archbishop's Palace at Liege" (948) has little of interest about it except the curious outline of the pillars which form the support to the cloister round the quadrangle. (969), a large drawing by Mr. J. C. Swallow, shows the "Palace of the Stuarts, York," an edifice built by James 1st, partly on the site of the Abbot's House and the Lord Protector's Palace, while the materials were chiefly supplied from the beautiful St. Mary's Abbey, close adjoining.

Mr. W. W. Deane has a fine interior view in oil (343) of "St. Mark's Venice," while Mr. W. Henry exhibits (316) the everlasting "Cavelli Palace and Church of Sainta Maria Della Salute." Miss Louisa Rayner sends, as usual, painstaking and effective studies from ancient buildings (1074) in some "Old Houses in Edinburgh;" and (411) is "Rosslyn Chapel," an interior view, interesting as having been the last view painted on the spot previous to its restoration.

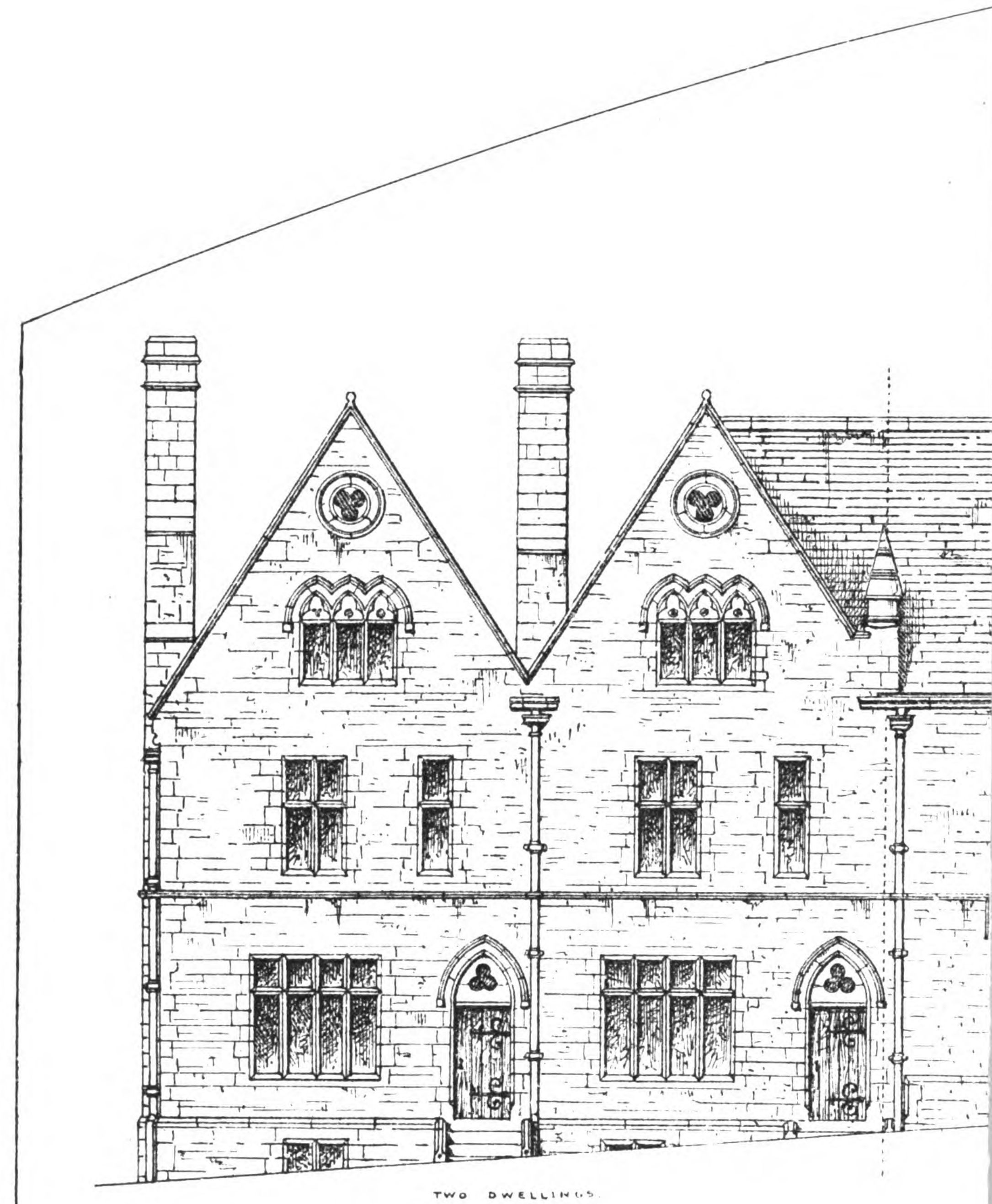
AKROYDON, NEAR HALIFAX, YORKSHIRE.

(With Engravings.)

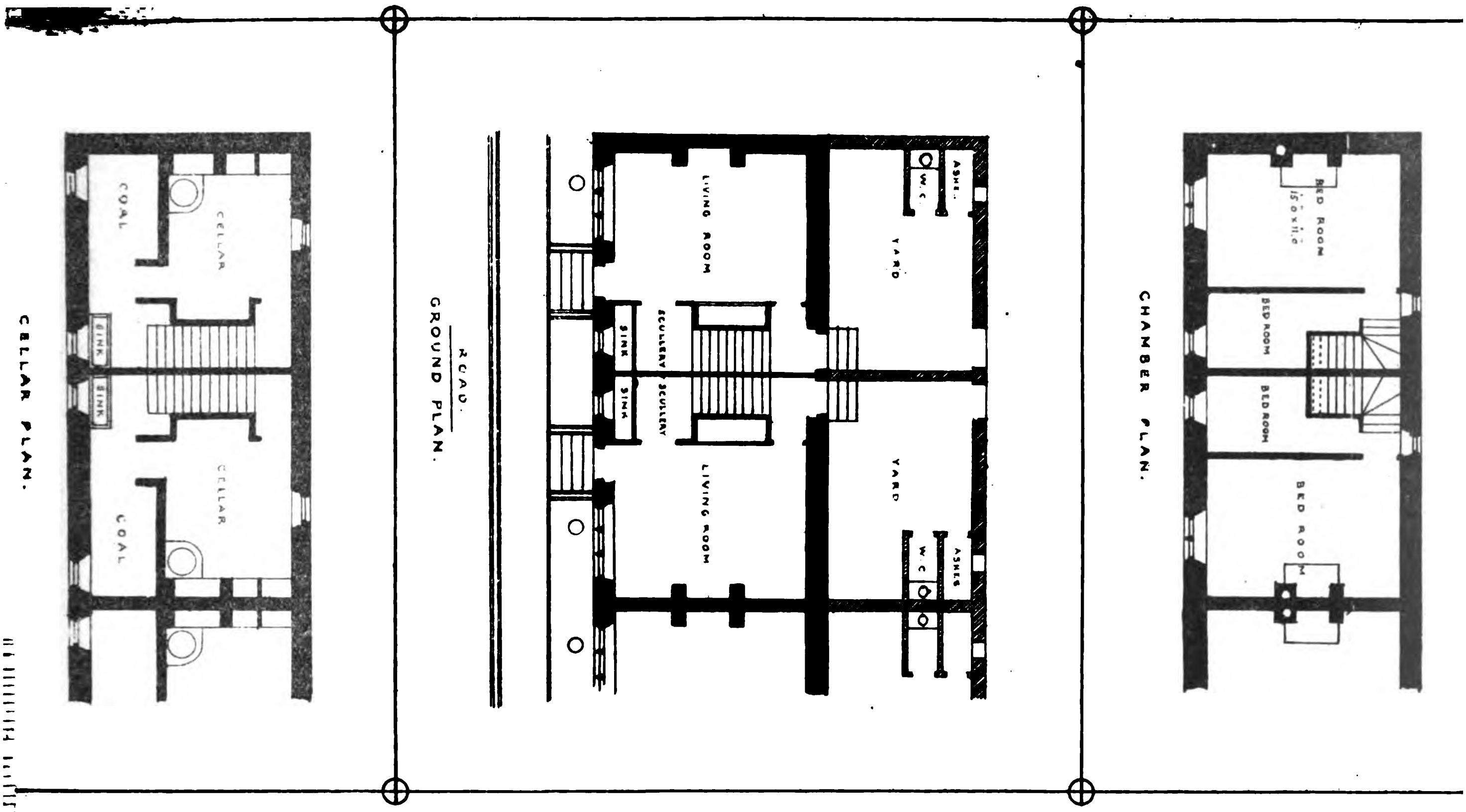
Akroydon is a village in the suburbs of Halifax, which derives its name from its founder, Mr. (now Colonel) Akroyd, M.P., at whose sole expense the neighbouring beautiful Church of All Souls', Haley-hill, was erected some years ago. The arrangement of the buildings at Akroydon has been based on a well-studied and convenient plan, embracing every essential to the health and comfort of its inhabitants; and the undertaking, which has proved in every way successful, is now in a forward state of completion. The general scheme of the plan may be described as occupying a rectangular area of about 800 feet deep, by a frontage to the main road of rather more than 600 feet. It consists of a double row of dwellings on three of the sides, and of three parallel rows on the side towards the north. The ground slopes rapidly from east to west, and the centre of the quadrangle will be railed in and turfed, and there will be a handsome fountain at the intersection of the cross-walks. All the buildings are being carried out in the most substantial manner, and with due regard to correct, though simple, external effect. The designs, in some respects, vary in the different blocks of buildings, but those which we have selected for illustration will give a good general idea of the whole. These plates form part of a series illustrating a thoroughly practical volume on "The Homes of the Working Classes," by Mr. J. Hole, which was reviewed at some length in the January and February numbers of this Journal for the current year, and to which we may refer for additional particulars. The accompanying illustrations have been kindly furnished to this Journal by Colonel Akroyd, in answer to a special request, inasmuch as we are anxious to bring to notice, for general application, the various improvements made from time to time in that important national consideration—a working man's dwelling. The problem which Mr. Akroyd set himself to solve cannot be better stated than in his own words:—

How a limited outlay of capital may materially assist in raising the general standard of workmens' houses in any locality to an extent far beyond the original capital employed.

This problem Mr. Akroyd solved by availing himself of the advantages offered by an excellent building society in Halifax;

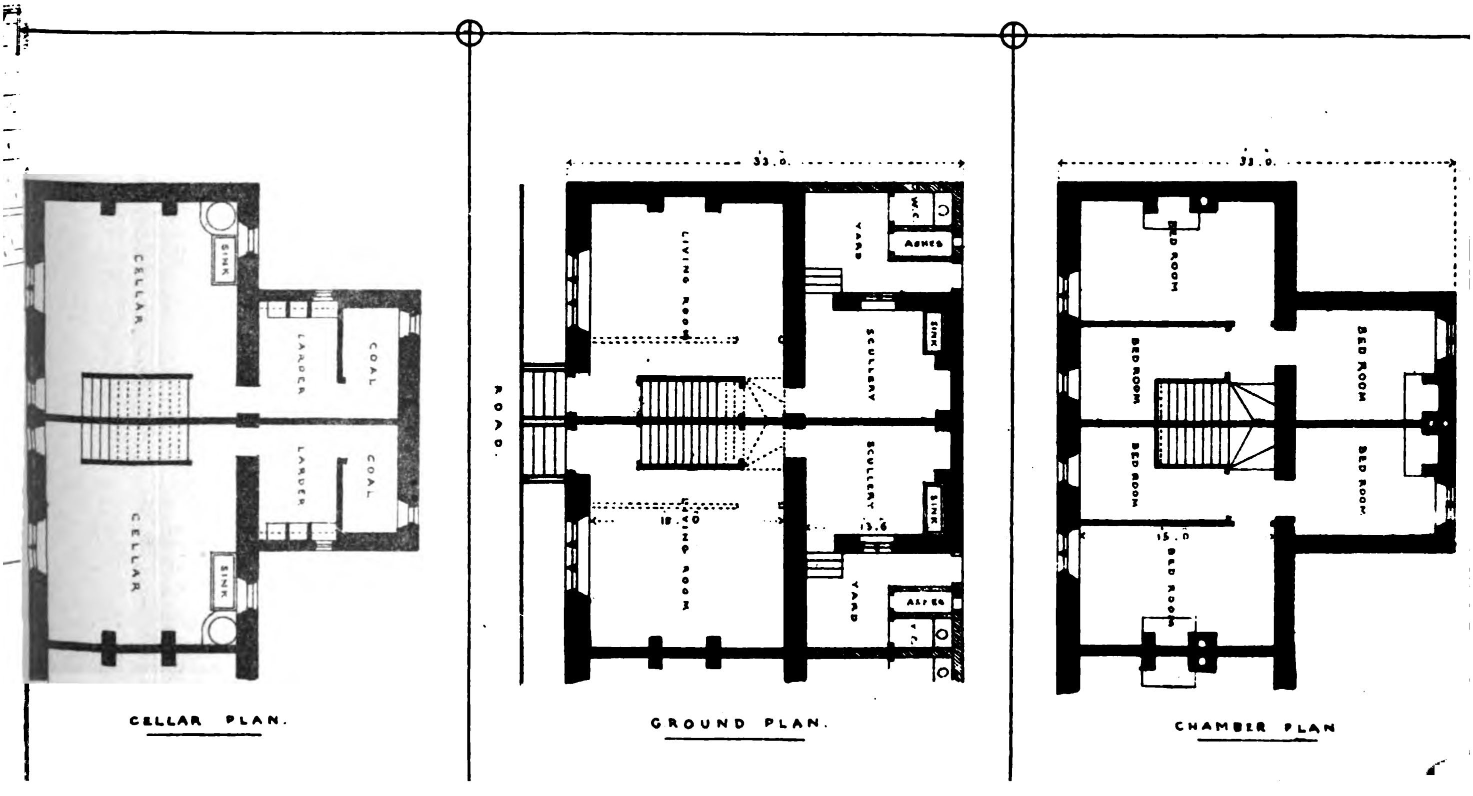


SOUTH ELEVATION.

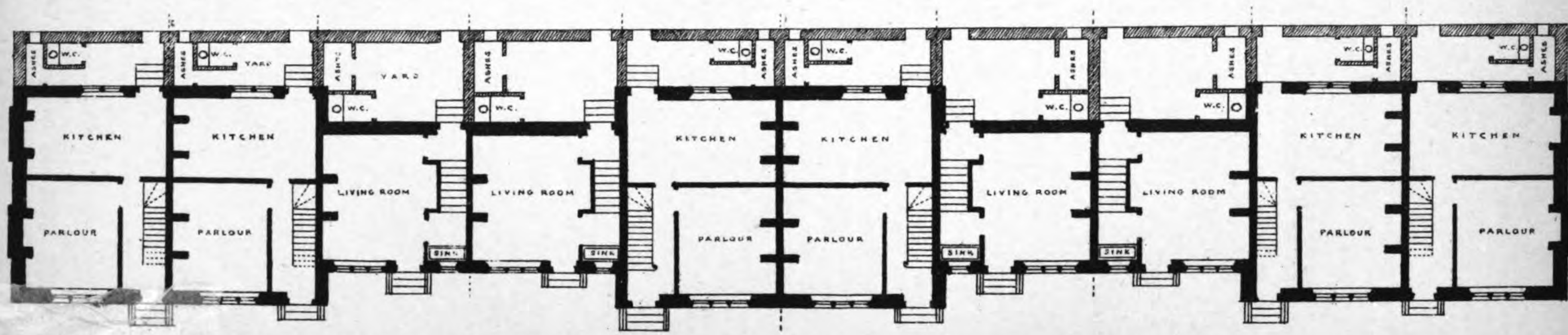


AKROYDON . BLOCKS II & III.

PLATE 24



SOUTH ELEVATION.



PLAN.

or, rather, he supplemented them by an arrangement calculated very materially to increase the benefits which such societies are capable of conferring. His plan was this:—

To purchase a suitable plot of land for a building site; to obtain designs from an able architect for building blocks of dwellings, eight or ten to each; and to find parties who were willing to take up each successive block, forming themselves into a Building Association for that purpose, in connection with the Halifax Permanent Benefit Building Society, which would advance three-fourths of the capital required.

Mr. Akroyd bought a suitable plot of land, obtained designs not only excellent in a sanitary point of view, but also architecturally beautiful. He undertook to provide plans, to defray all expenses connected with the contracts and supervision, and to guarantee the fulfilment of the contract within the estimate. These were liberal concessions; but a more important one still remains to be mentioned. Where the purchaser is of good character, but unable to advance the one-fourth of the purchase-money, the payment to the building society is spread over fifteen years, instead of twelve years; and Mr. Akroyd guarantees the first three years' subscription to the building society, after which his guarantee ceases, as the building society then possesses sufficient security against loss, in the mortgage of the property.

The first two blocks erected comprise eighteen houses, which vary materially in the cost. Upon the original plan there were provided one living-room, 15 feet by 13 feet; an adult bedroom, 15 feet by 11 feet; and a small bedroom, 11 feet by 6 feet 6 inches, with scullery or wash-kitchen under. All are single houses, solidly built of the stone of the country, and covered with blue slate, presenting a neat, pleasing exterior (see plates 22, 23, and 24). At the back of each house is a small yard, with ash-place and convenience, to which there is a separate back entrance. Water, for general purposes, is supplied in pipes to every house, and the proper drains have been carefully laid down, with sanitary tubes. Gas, from the borough, is also conveyed to each house.

The number of dwellings erected up to this date is 38, including a large and commodious store, the property of the Halifax Co-operative Society. The dwellings erected are in six blocks, and are of several classes in each block, varying in cost from £136 to £460. The £136 represent the No. 4 class, the £460 the No. 1. The intermediate cost is £154, £190, £220, £240, £320." Of the pecuniary success of the scheme Mr. Akroyd thus speaks:—

It has been already intimated that this class of model dwellings will not pay as a commercial speculation. The *proprietors* have no reason to complain if they can realise 6 per cent. upon their investment upon a house *so well* and *substantially* built that for many years the cost of repairs will be but trival. But I candidly admit that the *promoter* or *landowner will sustain a loss* on the first blocks, besides giving the land required for the streets. This is not suprising. At present the working classes are so little accustomed to a really good house, of a pleasing elevation, and fitted up with every convenience, that they are unwilling to pay the increased cost. I was prepared for this result; and therefore offered a premium to the proprietors of the first blocks, to secure their erection after my own design. I am sanguine that the houses will advertise themselves, and obtain such a rental as will enable me to protect myself from material loss in future blocks, and yet insure to the proprietor or member a good return for *his* outlay.

Mr. Akroyd suggests that under this system the munificent donation of £150,000 by Mr. Peabody to improve the dwellings of the poor of London, if thus supplemented by benefit building societies to the extent of three-fourths of the value, might have been made the means of building four times the amount of houses, assuming that a sufficient number of working men could be found to take up the dwellings.

PAINTED DECORATION.*

By Mr. S. Fisher.

Before commencing a description of the various methods and materials employed in painted decoration, I wish to refer to painting as a branch of the building trade, as this and decoration are so intimately connected that it is worthy of more consideration than it generally receives, especially since in the present day the greater feeling which prevails for art in every shape induces us to undertake work which we think worth preserving; whether posterity will be of the same opinion with regard to what we do is a matter of uncertainty; but, as Mr. Burges has said, one of the acts of the next generation will be to destroy all the painted windows executed in this, other departments of art-workmanship can hardly be expected to entirely escape. An opinion is becoming very general that most of the building trades have deteriorated in quality, and painting, as one of them, is not so well executed as it used to be. Anyone who is accustomed to observe these things feels that this is really the case, and I believe that one of the principal causes, if not the cause indirectly, of such falling off, is to be found in the modern system of contracts. In the old times builders were not the agglomeration of various trades in one person that they are now, but each craft carried on an independent business, and had for its head a man who understood his work practically, took a honest pride in it, feeling sure that its excellence would be recognised, and trusting to that for increase of business rather than to lowness of price, hence the infinitely better work in every department than we have often the opportunity of seeing at the present time. A master tradesman in any particular branch used to be a person of some little importance, and that within the memory of people not past middle age; but now, except in an occasional instance, he is either a builder himself, in self-defence, or must be content to become a builder's subordinate. The contractor can seldom be master of more than one trade; he can, however, surround himself, and mostly does, with competent foremen in other branches; but it is impossible that these men, who, but for the contracting system, might be masters themselves, can feel the same interest in the work they supervise as they would if personally responsible.

The system may have its advantages, but chiefly for the builder, I think, if they are carefully considered. It is an advantage to know the cost of a work before undertaking it—about this there can be but one opinion—but this is surely as easy to ascertain, by casting up three or four amounts in an architect's office, as it would be by the same process in a builder's. It is thought to be an advantage as regards cheapness, but that I hope to be able to show is a fallacy, for the builder gets fully as much profit out of the trades collectively as would compensate a master tradesman in each department; or when he contents himself with less, the difference is more than made up by the extra cost of his labour, which is necessarily more expensive than it would be to a practical man who was personally interested. When contracts are sub-let (a common practice) the profit is divided between the sub-contractor and the builder; the latter, though in this case a mere agent, taking the lion's share, as anyone who has been compelled by circumstances to undertake builder's work I am sure would testify. How is it then to be expected, when any credit to be obtained from the work is entirely ignored, and a large proportion of the legitimate profit finds its way into another person's pocket, that a man should care for doing more than the letter of his contract compels him to, just getting over his work, and that with as little cost as possible? The architect finds it very likely less trouble to deal with one man than half-a-dozen; and this saving of trouble has had some influence, doubtless, in creating the present almost universal system, joined to a belief in the necessity of having a middle-man or capitalist—which is the position occupied by the large builder—to take the reponsibility of important works, as if there would be any difficulty in finding men who practised only one branch of industy sufficiently stable to undertake works of any magnitude. Very likely there are other reasons which will suggest themselves to you as being in favour of the modern practice; but if nearly all good and conscientious work is to be sacrificed for them, a return to the old-fashioned system of dividing contracts into various trades would be a step in the right direction.

The methods of painting in common use are only distemper and oil-colours, and for ordinary purposes one or other of these mediums is the best that can be employed; but for works of an ornamental character there are others much, I think, to be preferred. Distemper painting is too easily injured and affected by external moisture for permanent work; internal damp, that arising from the structure of the wall, is fatal to every kind of painting without exception, and oil has so great a tendency to darken, in any but a very white light, that purity of colour is sure to be destroyed. In painting woodwork, oil cannot very well be dispensed with, but for wall and ceiling work there are three other methods available—Fresco, Water-glass, and Encaustic. With regard to the first, there has been a great deal of controversy, and opinions are still very much divided as to its suitability; certainly the examples we have of fine-art work in fresco, at the Westminster Palace and else-

* Paper read before the Architectural Association

where, are not calculated to impress us very favourably with this method, but under certain circumstances it is a very valuable one—for covering large surfaces with merely diaper patterns, there is a superiority of texture about fresco to any other medium. With a dry wall to start with, and proper precautions being taken with reference to the lime and sand to be employed, when carefully executed, I believe it will last as long as the plaster. I have used this method largely for some years, and have great confidence in it as an inexpensive and effective means of decorating in a simple way the walls of churches, or for halls, corridors, &c., in private houses. But as soon as anything more than mere diaper is wanted—and happily these occasions are becoming more frequent—the difficulties of fresco-painting commence; the small number of colours that may be really depended on to withstand the action of lime, cramps the artist in his design to begin with. The necessity of finishing every part of a day's work to the minutest detail before proceeding to the next, renders it impossible to make any alteration as the painting proceeds; and there are very few artists who would not consider it an advantage to be able to return and tone down, or alter certain portions of their work; but retouchings are impossible in fresco, except at a sacrifice of all transparency.

Possibly a great artist would make light of these difficulties, but he needs to be a really great one, and he wants a means of decoration that can be employed by one of more moderate calibre. The establishment of Schools of Art throughout the country, by placing the means of education in drawing and painting within easy reach of everyone, must ultimately result in furnishing us with artists able to execute decorative work of a higher class than we have been in a general way accustomed to; and many persons who would have looked upon the clever imitation of woods and marbles as the greatest result to which an ornamental painter could arrive, will, in consequence of these facilities, become capable of producing something more worthy in an artistic sense.

It must be understood that I am not endeavouring to underrate the skill of our best imitators of woods and marbles, for some of them execute work which is so beautiful as almost to justify us in preferring shams to truths, and altogether different to the vulgar work we see so much of; only it must be admitted, without entering upon the question as to whether imitations are allowable or not, that there are, or should be, objects in decoration which the best imitative painting will not supply.

It is rather curious to note that the rise and progress of graining and marbling have so nearly kept pace with that of false art in other ways, such as architecture in cement, and concealment of construction generally. This art, in its perfected state, is of very modern date. There used to be a process, called graining, which was extensively employed in house-painting in this country from the earliest times, which was perfectly guiltless of being an imitation of anything under the sun; and some such means may have been used by decorators during the best periods of art, merely as a suggestion. But it remained for our generation and country—for it is peculiarly an English art—to adopt it almost to the exclusion of every other. About seventy years ago, the idea appears to have struck the decorative painters that they might improve upon their work by making it more natural; and the first attempts at this were so highly appreciated, and exceedingly well paid for, that a race of artists sprung up who each improved upon his predecessor, until that which was originally a clumsy, conventional imitation, and pretended to be no more, became an exceedingly clever work; for, though it has become somewhat the fashion since the Renaissance of Gothic to despise graining, to execute such work well requires great patience and skill and a fine eye for colour—the same qualities which, directed by the Government Schools of Art into another channel, will develope into a class of artists able to compete with those of any country or period. Supposing that all the manipulative drawbacks of fresco could be easily surmounted, there still remains the unfortunate fact that it has not yet been made permanent. The earliest fresco-paintings in any public building in this country of which we have any account are those by Aglio, in the chapel at Moorfields; they consist of, or rather did, an enormous picture of the Crucifixion, occupying the entire space of wall at the east end of the church. This was painted in 1820, in fresco, and was a very few years afterwards, repainted in oil colours, in consequence of the fresco picture almost entirely disappearing. This oil-painting was obliged to be restored by the original artist in 1837; and, upon the chapel being repaired eight years ago, it was cleaned and varnished, and has now a glossy surface, which magnifies all the irregularities of the plastered wall, and completely destroys the effect of the picture in most lights. And the ceiling, which was painted at the same time as the first work, and appears to have been left in the original fresco until eight years back, when, being almost indistinguishable, it was cleaned and restored in distemper colours, and in as coarse a manner as could well be conceived. The painting on the east wall is an excellent example of how unsuitable a medium is oil for mural painting, the effect being evidently very different to that intended by the artist, or that it had when first painted. The beautiful figures at All Saints' Church, painted by the late Mr. Dyce, were, two years ago, obliged to be repaired. These are painted upon a thoroughly sound and dry wall—the temperature of the church must be tolerably equable—and we may fairly conclude that every precaution that could be thought of was taken to render them permanent; but the fact that a restoration was necessary so soon after they were painted, taken in connection with the state of the frescoes at Westminster, is a very convincing proof that the process is not a suitable one for us. There is a very fine picture in fresco painted by a German artist, whose name I have not been able to ascertain, over the chancel arch of the Church of the Redemptorist Fathers, at Clapham, which shows unmistakable signs of decay, and that has been painted only some ten or twelve years. Therefore, that the artists engaged at Westminster are justified in abandoning a method which has been proved unreliable is without doubt; but that, in employing water-glass, they have fixed upon one which is in every respect better is, I think, by no means so certain. This vehicle is as regards its permanence really yet an untried one; and that it has been found to stand in Germany is no proof that it will do so in our moist climate, and even there, about 20 years is the extreme time-test to which it has been subjected. The first experiments in the manufacture and application of this vehicle to painting were made public by Dr. Fuchs in the year 1825, but at that time did not appear to attract much attention; and in 1859, an elaborate and exhaustive description of his invention was translated by desire of the late Prince Consort, and published in the Journal of the Society of Arts, which was the first time public attention was called to the method in this country.

The process of stereochromic painting—as it was named by Dr. Fuchs—found to be the best, is to paint upon a plastered, or other absorbent surface, in colours mixed with water only—that is, without size or any adhesive medium, and, when the painting is entirely finished, to saturate the work by means of a syringe, perforated with a number of small holes, in order to get a very finely divided stream, with a solution of water glass, till absorption ceases; the more absorbent the surface painted on, the more perfect is the operation. It has been found impracticable to employ it in the manner of any other vehicle, by mixing it with the colours, on account of its stiffening the brush, and setting before the painting could be accomplished by the most rapid execution. The result is really a water-colour painting which will bear washing without injury, and resembling fresco, excepting in the luminous quality so peculiar to the latter; but whether it will remain with that desirable property we have yet no adequate means of judging with certainty. If some of the solution is placed in a shallow vessel, or spread upon glass, and allowed to dry, it will appear at first like a colourless varnish, and extremely hard; but after the lapse of a few days it seems exceedingly sensitive to atmospheric changes, becoming in damp weather perceptibly soft, and covered with an efflorescence; it is also after a short time semi-opaque, or milky in appearance. In a state of fluid, the constituents of water-glass have a feeble affinity for each other, and are so easily acted upon by acids, that the smallest quantity added to the solution will immediately precipitate the silica in the form of an opaque white substance, thereby destroying all the fixing qualities of the fluid; and whether the carbonic acid with which the atmosphere of all public buildings is so highly charged will not by slow degrees produce the same effect is a question that time only can decide. This soluble alkaline silicate—as it is chemically termed—is really the same composition as glass, with just so much alkali in excess as renders it soluble in water in the first instance. It undergoes no chemical change upon its application to the painting, therefore the same influences must always affect it, though perhaps in a less degree, and it is a matter of grave doubt whether it will be found ultimately more durable than fresco. The various inventions for the preservation of stone are all analogous to the water-glass of Fuchs, and whether the end sought for is obtained by any of them is yet a very undecided question. There is one use made of water-glass which I think can hardly have been contemplated by its inventor, namely, the adulteration of soap, for which purpose it is largely manufactured in this country.

The third method, and the one to which I more particularly wish to call your attention, is painting in encaustic; and possessing, as this does, all the advantages of other mediums, without any of their drawbacks, the unaccountable neglect with which it has been treated hitherto is very surprising. There has been plenty of so-called encaustic painting executed in this country within the last twenty years, which is simply working upon a ground prepared in oil in the usual way with colours mixed with some preparation of wax. The decoration of the various Courts at the Crystal Palace are chiefly executed in this way; also the pictures in the dome of St. Paul's Cathedral, repainted by Mr. Parris about ten years since. The value of this method of preserving the freshness of the colours is undoubtedly great, and upon surfaces that have been previously painted it is the only way to derive any benefit from the employment of wax as a medium. But encaustic painting proper is an art almost unknown in England, which is the more remarkable as, if ever there was a process which resisted the action of time, it is this one. Encaustic painting in some form dates from the most remote antiquity, and every authority I have been able to consult speaks of it with favour. Sir Gardner Wilkinson states that "encaustic painting, with wax and naphtha as vehicles, was practised among the Egyptians," but there seems some doubt about the actual processes of its employment; it is enough, however, to know that wax was one of the ingredients used, and most likely the preservation of the examples noticed has been due to this. The Greeks practised it from a very early period. Pliny says of it: "We employ wax as a vehicle of painting, not only from the beauty it gives to the pictures painted with it, but also because it is a preservative of the walls which it adorns;" and, in another place, that "Lysippus, the painter, executed a work of this kind at Egina, and that he put an inscription under it, stating that he had himself subjected the work to the action of fire." This proves that the ancient encaustic was really burnt in, as its name implies. Among the Romans, encaustic painting, or at any rate painting with wax in some form, was very general; and it continued to be practised during the early centuries of Christianity, almost to the exclusion of every other mode, but after that time it seems to have fallen into disuse. Wax is not mentioned by Cennini, writing in 1437, except as a material for modelling, whence we may conclude that in his day the art had been lost; and Theophilus makes no allusion to it whatever. Lanzi mentions that "many old pictures were analysed by the celebrated chemist Pietro Bianchi, and they appeared to be painted in oil; and it was found that the oldest pictures, which were usually the most brilliant, gave indications of wax, but that no wax was found in pictures painted after the year 1360."

In the appendix to the third report of the Commissioners on the Fine Arts, published in 1844, there is a description of "Methods of Painting adapted to Mural Decoration," by Sir Charles Eastlake, in which he says, speaking of encaustic:—"The precise process of this art among the ancients has been the subject of much controversy: but the actual remains of antique painting at Pompeii and Herculaneum, as well as numerous allusions in the writings of the ancients, prove that it was common among the Greeks and Romans. It was also occasionally employed during the middle ages." And again, as the result of his own observation, he says: "The advantage of wax as a vehicle is its durability. A wall painted white, partly with wax and partly with oil, exhibits the same tint for some days, but by degrees the oil colour darkens, and after some months the two portions are quite distinct; that which was painted in wax retaining all its brilliancy." He also quotes a description of the nature and advantages of wax as adapted for general painting by Dr. Roux, who observes: "Colours mixed with wax are entirely saturated by it. Wax and colours form together a more solid, less fusible substance than wax alone. The pigments remain closely united with the wax. No skin appears on the surface of the picture, even when the wax has been mixed in abundance with the colours. An under-painting executed with wax colours has much more brightness than one executed in oil. A second painting on such a preparation appears bright and clear, on which account a painting in which wax has been used as a vehicle is always brilliant. When an oil painting at twilight begins to become indistinct to the eye, a wax painting next to it is still clearly visible."

The modern revival of encaustic painting dates from about the year 1829, when Montabert, in his "Complete Treatise upon Painting," extols it above the art of oil painting. But previously to this, Count Caylus, in France, and Mr. Bachelier had commenced experiments to recover the lost art; and the Count exhibited a head of Minerva, painted in the ancient manner, in 1754, which was much admired. From this time efforts were made to revive encaustic painting at Venice, Verona, Milan, and Rome, in each of which cities several works were executed. But after a time the method seems to have been again abandoned, from what causes I have not been able to ascertain. It was again revived at Munich, by the modern German School, under the patronage of the late King Ludwig, and large works were executed there, also at Berlin, Heidelberg, Vienna, and other places where the influence of that school penetrated. At Paris, the Churches of La Madeleine, Nôtre Dame de Loretto, St. Vincent de Paul, and other public buildings, are decorated in this mode; but no one example has ever, to my knowledge, been executed in England. I consider, therefore, we are justified in thinking this to be a vehicle that has been singularly overlooked, more especially as I believe it to be the one process of all others best suited to our wants. It is capable of any breadth or simplicity of treatment, or the utmost amount of detail; it allows of the use of any colours that may be employed in oil, and even more; and, above all, if the ground is thoroughly dry (not an impossible condition), there is scarcely any limit to its permanence. The singularly preservative action of wax upon all colours, even on those which are fugitive when used in other mediums, keeps the artist's design in all its original freshness for any length of time, as it undergoes neither shrinking or expansion from any alteration of temperature, wax being perfectly indifferent to any atmospheric changes. And as the heat to which the wall is subjected in the process of preparation entirely prevents any contraction of the plaster afterwards, resulting in the cracks so destructive to fresco painting, nothing short of violence can injure it.

The process of encaustic painting is as follows:—The surface, whether of plaster or stone, to be painted on, is heated by means of a portable charcoal fire till one can scarcely bear the hand upon it. A greater heat will not have the effect of causing the solution to penetrate any further than a moderate one about one sixteenth of an inch is the utmost depth to which a common red tile will absorb it, when made nearly red-hot.

It is then to be thoroughly saturated with a mixture of about two parts of white wax and one of gum damar, dissolved in turpentine, which is the medium to be used throughout the work. The addition of gum to the wax is necessary, as, alone, the wax would be too soft to work upon pleasantly but; any increase in this quantity of gum has a tendency to crack when the colours are laid on in any body. The employment of gum copal, or elemi, as being harder gums than damar, is preferred by some. Mr. Gambier Parry's medium is of this kind; but as he omits altogether from his formula the agency of heat, either to combine the finished work with the under-coats, or for the preparation of the wax, and also lessens the quantity of wax, his is not an encaustic process. These harder resins are more difficult to deal with, they require a stronger solvent than turpentine, or that a little oil should be added to the composition, which it is most important—on account of its tendency to darken—to do without; when used, they are no more impervious to damp than damar; and that they should be less soluble in turpentine simply is a very doubtful advantage. When the wall is sufficiently cold, the ground-colour may be laid on in the usual way; but, if more than one coat is necessary, it is essential that the first is left sufficiently long to become hard before putting on the next. The only difficulty of manipulation attendant on encaustic painting is the tendency of the upper coats to penetrate those beneath, but a little dexterity in handling will obviate this. Upon this ground the subject is to be painted, with colours ground in the same preparation of wax and resin, and thinned to an agreeable consistency with turpentine. The work may be added to or altered with all the facility of oil colours; and, when the whole is completed, it is to be re-heated regularly and slowly by means of the brazier. It is sometimes the practice, before this final heating, to varnish the whole surface with the wax medium; but if the wall, before commencing, has been thoroughly saturated, and a sufficiency of it has been used with the colours in working, this will not be found necessary. The result of this burning in is, that the finished painting, the ground, and the preparation of the wall, are all melted and amalgamated together in one homogenous substance, united to the wall in the most perfect manner, and remaining brilliant and imperishable. I have had considerable experience in all kinds of mediums, and their investigation has always been a favourite study, and I feel convinced that no one of them is so suitable or so trustworthy as encaustic when properly executed.

Distemper is a perfect style for mural painting as regards brilliancy of colour, and flatness, or absence of gloss, but is liable to injury from moisture, whether arising from condensation or any other cause, and can never be properly cleaned. There is another cause, too, of its want of permanence which we are constantly meeting with in the remains of mediæval painting, and which consists of the decay of the size or gluten used to bind the colours, which in some places is so great as to leave them a mere dry powder on the walls, and in others having so slight an adhesion as to drop off in flakes at a touch. How much richer we should have been in these examples if the artists of the middle ages had been acquainted with the virtues of wax painting, which no superincumbent coats of whitewash could have injured. In the Lady Chapel at Winchester there are some wall paintings in better preservation than usual, which, from the cursory glance that is permitted by the attendant verger, I imagine to be a species of encaustic, but of this I am not sure; they are, however, certainly worthy of careful examination. Oil will bear any amount of washing, but from its tendency to change colour and become horny in texture, and from its glossy surface, is the most unsuitable vehicle of of any for architectural painting. Fresco is too difficult of manipulation, independently of its want of stability; and water-glass, which may be all that its advocates represent, has not yet been sufficiently tested. Encaustic alone possesses the best qualities of all the other methods; it is as bright and pure in colour as distemper, as readily cleaned and as easily worked in as oil, almost as luminous as fresco, and (if required) as perfectly flat; but it is also capable of receiving just as much, or as little, gloss as may be wished to give richness to the darker colours, by simply polishing with a cloth; and in certain positions this may prove a very great advantage. Whatever medium may be chosen by artists for painting with, the one indispensable requisite is a perfectly dry ground; without this is secured no painting of any kind will be permanent; and, where there exists the slightest doubt upon this point, the best way is to cover the wall before painting with canvas, fastened on with a cement composed of red lead and oil, which hardens to a perfectly impenetrable substance, so that, if the wall should at any time become damp, the painting can be easily removed without injury, and re-attached when the ground is considered safe. This plan has also the advantage of enabling the artist to work in his own studio, as the painting may be fixed in its place just as readily when finished as the unpainted canvas. Of course, encaustic paintings cannot be executed upon a ground of this kind, but we may still have the benefit of wax as it is commonly employed by painting on an oil basis.

I have confined my remarks almost entirely to the executive processes of decoration, without touching upon the art questions of colour or treatment, in the thought that it would be the more acceptable form in which to treat the subject.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

The Institution of Civil Engineers of Ireland held its last annual meeting in the Museum Buildings, Trinity College, Dublin, when Mr. Robert Mallet, F.R.S., delivered an able address, of which the following is an abstract:—

The President's Address.

Ours is the age of material progress, which reflecting men begin to see necessarily involves with it changes and progress in the world of mind and of spirit the most searching, fundamental, and unexpected. Social habits and polity; commerce, domestic and international; the modes of taxation, the diffusion of knowledge, the planting of the waste places of the earth; the conduct of war, its weapons, its modes of attack and defence; the artificial barriers set up between classes, the antipathies of caste; the ceremonies that await the sepulchring of the dead; and even beliefs and ancient creeds and forms of faith and worship—all are being kneaded beneath the unseen but resistless influences upon them of those palpable and material powers over time and space, and weight and matter, which have been evoked by the engineer within the last eighty years.

Many of the moral and physical changes being effected by the powers of steam locomotion by land and water alone, are of a character that no man could have foreseen; and, startling as they already are, foreshadow others still greater, and seem to point out to us clearer notions as to the nature of the forces which really govern the world and determine its progress than we had been taught previously.

It might possibly have been foreseen that the steam-ship and the railway would in time enable the luscious fruits of the tropics, within a few weeks of their having been gathered in the sun, to be eaten amidst frost and snow by the fur-clad Russian; that the pine-apple, the very symbol, but a generation ago, of the rich man's feast, should be sliced and sold from barrows in the streets of London and Paris at a price to suit even the *gamin;* but who could have predicted that the same power should change the etiquette of courts, and bend to its modes the habits of monarchs and the course of diplomacy? Who even yet fully realizes that over the whole continent of Asia, and more especially in our India, where preaching has indeed proved itself to be foolishness, the steam-ship and the railway are destined to be the real missionaries; and that under the levelling influence, without persuasion or compulsion, of this new power to move and travel, caste, and the theologies and creeds to which it belongs, social ceremonies and systems bound up with these, all of them the most ancient of which we have any certain history, and hitherto the least mutable, are melting away and moulding themselves into new and more true and living forms?

But I must forbear to enlarge upon the tempting theme of the mental and moral effects upon our race of material progress, as especially urged forward by the engineer, which, in its silent but powerful action, seems to underlie all other progress, and like the stone cut out without hands which the Chaldic Seer saw launched through the midst of heaven to fall upon the earth, the destined instrument to break in pieces the brass and the iron and the miry clay of the feet of that Colossus of ignorance, falsehood and violence, that still tyrannizes over and oppresses the sons of men.

It is but thirty years since railways commenced to be a mode of travelling, yet already more than eleven hundred millions of money have been expended in spreading upwards of seventy thousand miles of lines over our globe. Each year adds largely to the total. Within the last two years Parliament has either already sanctioned, or been applied to for sanction, for nearly 270 miles of new railway in and around our own metropolis of London. The capital necessary for those sanctioned is about twenty-one millions, and that for those now before Parliament, nineteen millions, or a total outlay of forty millions in and about London alone. Amongst these projects are embraced two new tunnels under the Thames, and five new bridges over that river.

If we look to our progress upon the water, we find that we are adding to our mercantile marine at the rate of more than a tonnage of 200,000 tons per annum, of which nearly one-half the ships are built of iron. This is exclusive of ships of war, of which, in armour-plated vessels, our own and the French navies contain so many noble examples of constructive skill—the cost of each of which may be reckoned by hundreds of thousands. Indispensable these are probably in the present state of the world, but we cannot avoid longing for the time in human progress to come when such enormous masses of the wealth produced by human labour may not be diverted from its proper uses, in the comfort and sustentation of man, to provide by brute force against the probability of brute violence or fraud.

The problem of invulnerability in ships of war to the direct stroke of a given maximum projectile, requires as its fundamental datum the dimensions and form, speed (for upon that depends the weight of engines and boilers), and equipment of the *largest* ship that is practicable and proper for the destined use. This, in our own case, finds its limit in the largest and longest ship of war that can berth at our marine arsenals and manœuvre in our narrow channel seas—this last greatly depending upon the smallness of circle within which "going about" can be performed. This circle rapidly enlarges with increase in length, the power of the rudder of given size to turn a given form of ship varying inversely as the fourth power of the length. These elements of the ship being settled, the question of defensive armour resolves itself in the first instance into this—How shall the total spare tonnage that the ship possesses above her power, fuel, and equipment, be so disposed over the required area of defended surface of hull, as to give, when reduced into a structure of iron and wood, or of any other material, the maximum resistance per unit of surface to the impact of shot at the greatest given velocity? It is well thus to state the problem with precision, as it is very far from being yet solved, and many who treat of it show a want of clearness as to its conditions and limits. The experiments made at vast expense, in this and other countries, have not advanced the great features of the question much beyond this, that no armour yet devised and capable of being borne by any ship of war afloat or designed, can withstand the stroke, a few times repeated about the same spot, of a projectile of 600lbs. weight, with a velocity of under 2,000 feet per second. The only remarkable advance in resistance conferred by mere disposition of material of a given total weight, has been due to Mr. Chalmers' arrangement, in which the wood backing is divided and supported by transverse *septa* of plate iron. So far, however, the victory is with the guns, and it may be added it is likely to continue so. The problem of the most powerful possible gun, like that of the armour, rests upon the data of the weight, form, and velocity of shot demanded; the latter element depending simply upon the weight of powder charge in relation to the weight of the shot. The form of the latter, and hence the calibre, which it determines, fix the limit at which any increase of weight with a given velocity, or of velocity with a given weight, the gun, even though made of steel and wrought iron, our most resistant materials, and disposed in the best manner, in ringed structure, becomes crippled after a few rounds.

With rifled guns it is pretty certain that this limit is reached at a calibre not much exceeding 13 inches, and with a projectile of 600lbs., propelled with a velocity of about 2,000 feet per second. Under these conditions every round produces some sensible deterioration of the gun; the metal of the interior tube, although of steel, becoming fissured first at the angles of the rifle grooving about the seat of the powder and section of maximum strain, and the whole of the metal soon affording evidence of partial disintegration by simultaneous compression and tension in orthogonal directions in a plain transverse to the axis.

Rifled cannon are, however, not indispensable to the destruction of armour-plating, and it may be stated as certain that the value of such guns afloat has been greatly overrated. Great range, accuracy, and extreme velocity, to effect *punching through* armour-plates, are the supposed advantage for marine use upon which those interested in the manufacture of rifled cannon have based their arguments for the preference to them over smooth bores throwing spherical projectiles. But accuracy and great range are all but useless in a cannon borne upon an oscillating deck, and of all conceivable ways in which a given amount of projectile power can be expended in penetrating armour-plating, *punching out* a round hole by an extreme velocity, having just the diameter of the shot and admitting of being easily plugged, is that which effects the smallest amount of permanent injury. A smashing blow delivered by a ponderous projectile at a moderate velocity, which shall either stave in a large area of the ship's side at once, or shall produce a large irregular star of radiating fractures and detached pieces of plate, with shaken and damaged internal framing, is that which must produce the most "unmedicable wound" in any ship's side, and the one that may be followed up by "shell fire" from rifled guns with the most fatal effect. Such a blow may be delivered best by very large spherical shot with a moderate velocity. In such case the strain upon the gun is greatly reduced, not alone by the diminished initial velocity, but by the reduced inertia of the spherical shot in relation to the unit of area of the calibre of the gun. Moving in this direction, it is pretty obvious that the victory can be kept with the gun, and that an absolutely invulnerable armoured ship is an impossibility within the tonnage to which practical conditions limit it.

It is not a little remarkable, however, that, notwithstanding the great sums that have been expended in firing at armour-plate targets at Shoeburyness and elsewhere, not a single satisfactory experiment has been made, with a view to fairly compare the destructive effects of rifle shot at great velocities with those of much heavier spherical shot at comparatively low ones.

Before leaving the subject of artillery, in which there is much of interest impossible to advert to here, I may mention that at present the well-known house of John Brown and Co., Limited, are now making tools and arrangements for rolling out the "uses" or forge blocks, for making field guns, or even those of larger size, so as to avoid the evils incident to forging by the hammer—thus carrying out into practice that which was suggested by myself in 1855, in my treatise on the "Materials for the Construction of Ordnance." One of the consequences of this will be greatly to reduce the cost of production.

In iron shipbuilding there are no radical changes to note, but a steady improvement in the proportioning of parts is observable. The necessity of iron decks, in order to complete the upper member of the ship viewed as a hollow beam, is becoming admitted. The recent loss of the *London* will accelerate their introduction, inasmuch as iron decks admit of the construction of engine hatchway coamings in much stronger and safer ways than with wood decks and coamings. That all such hatchways ought to be fitted with that excellent form of self-releasing iron shutters known as "the butterfly coaming shutter," and that ventilation, to supply the furnace draught in the boiler room when these are closed by stress of weather, ought to be provided by a concentric cylindrical casing surrounding the funnel with air space between, the loss of this ship proves; a lamentable form of demonstration that, however, was not needed by any of our best iron shipbuilders, whose desires are too often compelled to yield to the merely financial wishes of owners. It may be hoped that, after this catastrophe, Lloyd's rules may embrace those requisites as indispensable to a seaworthy steam-ship. Iron hollow masts and yards are being largely adopted, partly recommended on mistaken mechanical principles, but mainly from their cheapness and the increasing difficulty alleged in procuring large fir spars. Such hollow, and relatively very thin, tubes are enormously stiff, but in relation to their stiffness, very weak. As a result of their extreme stiffness, every variable or impulsive transverse strain, in place of being diffused and producing flexure over the entire length, and so easing the material, as in a wood mast, is transferred almost completely at once to the lowest point of the mast at the resisting fulcrum, and where the stress is necessarily greatest. If fracture occurs, it is, by the nature of the material, and of these conditions, at this point, and directly transverse. The iron mast thus presents scarcely any of the chances of temporary use or of refitment at sea possessed by the long splintering timber spar.

One of the effects of the extensive and extending employment of iron in shipbuilding upon the not very distant future, will be the rapid increase in the total amount of the mercantile navies of the world. In the days of exclusively wooden shipping, the average life of a sea-going ship could not be taken at more than ten or twelve years (free from all casualties), but with proper original construction, and due care in preservation, it is almost impossible to assign any limit to the life of an iron ship; and it will be far within the truth to say that each (casualties again apart) will last from four to five times as long as a ship of timber. The result must be the continual accumulation of mercantile shipping for many years, or perhaps decades, to come, and this cannot but be attended with great benefit to the world at large, in the diffusion of exotic commodities and the extension of trade and comforts.

I ought not to omit to notice the publication during the last year of the magnificent work of John Scott Russell, and of those of Mr. William Fairbairn and of Dr. Rankine, on shipbuilding, more especially of iron. The first of these works will ever mark an epoch in the literature of the subject.

The employment of twin screws for propulsion has, after slow and cautious trials, proved of great value, not only for the navigation of rivers and other shallow waters, and for affording the means of steam propulsion to the larger boats carried by ships of war, but, in the case of these ships themselves, enabling them to turn almost upon their own length, a precious element in enabling an enemy's fire to be partially avoided. I may be permitted to mention that in the two great mortar flats, designed by myself in 1854 for our own Government, and intended to carry the 36-inch mortars at Sebastopol and Cronstadt, twin screws were employed.

In the construction of marine engines, amidst many minor novelties of improvements as to detail, the most noteworthy progress consists in the constantly accruing perfection in the use of higher pressure with expansion, and of surface condensation, attended with the immense advantages that the feeding of the boilers with fresh water only affords. The employment of steel for shafts and cranks, and all severely strained parts of marine engines (urged by myself some years since in an account of some experiments proving the relative weakness of large wrought iron, forged "uses," read to the Institution in London, and then reluctantly received by marine engine makers) is now rapidly spreading. The greatly increased production of excellent steel, of various qualities and at a very reduced price (though still much too high) by the Bessemer process, facilitates this. The Bessemer converting process is now in extensive operation in several different parts of Europe, as well as in England, and is rapidly advancing towards its natural culmination, namely, that, except for special and exceptional purposes, wrought iron will become a thing of the past and be generally superseded by steel, a material weight for weight of much more than double the average resisting powers of wrought iron.

Much remains to be done by the physical experimentalist, however, before we can consider ourselves as having fully understood all the properties of this new material in constructive relations, and by the manufacturer to insure to his customer absolute metallic uniformity in the pieces he is called on to supply. Steel plates are already largely employed for ship-building, and more cautiously for bridge building, and for rails are being laid down to a very large extent. With steel rails and steel tyres the wear and tear of both is reduced to a mere fraction of that with those of wrought iron, and the co-efficient of traction sensibly reduced likewise.

The discovery of the oil springs in America, and the expiration of Young's patent for the production of somewhat similar oils by the distillation of coal at a low temperature, have given impetus to the endeavours of several experimentalists here, in America, and on the Continent, to adapt these oils as a liquid fuel for steam navigation. Many of the advantages alleged are real and well founded, and it can scarcely be doubted that ultimately the safe and perfect combustion in marine boilers of such fuel will be affected, and will be adopted on a large scale for certain special purposes at least. Up to the present time, however, no method tried for burning these oils in marine or other large boilers has met the conditions required to be fufilled.

The increased tonnage and length of iron ships, and their so far unpreventable tendency to foul at sea, and still more in harbour, and most of all in the warmer latitudes, have produced the necessity for graving docks on many foreign stations. For structures of this character, always costly and in tideless seas expensive to work, floating docks built of iron have been substituted with great advantage. Some fine examples of these have been produced by Messrs. Rennie, of London and Deptford, for the Spanish and other Governments.

As regards direct improvements or changes in construction of steam engines for land use, there is not much of importance to notice. The applications, however, of steam power become day by day more universal and varied, as well as powerful. Steam ploughing, as well as steam traction on common roads, may be said to have become practically established and in use, although the short-sighted prejudices of landowners and local authorities have done their best to retard these beneficent substitutions of elemental for animal power. In both these classes of machinery, more especially in the first, the march of improvement is still continuous; and as the history of the locomotive shows that its practical perfection has been attained by years of bit by bit advances, so may we expect that, after a few more years, steam argriculture and steam traction will have become parts of the ordinary mechanical regimen of the world, as much so as steam travelling on railways.

The spread of steam boiler associations in Great Britain, for their inspection and insurance against explosion, though partly due no doubt to the desire of some to open up new avenues to employment or patronage, indicates the growing sense on the part of the public of the necessity of some controlling element to check the recklessness and ignorance with which steam power in all its applications, as well as machinery in general, and, we may add, many works and trades involving danger to life or insalubrity to health, are worked or carried on in our country.

It may be much doubted whether such voluntary associations are at all competent to deal with the evils; and, although opposed to our common prejudices in favour of that very *hazy* notion called self-government, it would seem that the time has fully come when the Board of Trade might with great public advantage have its legal powers of effective surveillance and control greatly extended, and based upon the legislation of France and Prussia in regard to government interference with dangerous or insalubrious trades. It is absurd that, while the Board of Trade investigates the nature and causes of railway accidents, and elaborately points these out in annual reports, these causes remain unaltered, and that there exists no legal power of compelling the removal of any one, even the most certain, obvious, or easy of remedy. It is needless to dilate upon the history of such matters as communication between enginemen, guard, and passengers, nor to point out that things declared beforehand to be impossible to be altered without ruin to whole classes, &c., such as the issue of manufacturing smoke, have been found easy to rectify, and advantageous to all, after legislative pressure has been once applied to them. Perhaps the most curious example is that of the great copper-smelters at Swansea, who, after having for years persisted in affirming that "copper smoke," which made the country around a desert, could not be prevented, have at length been reluctantly convinced by a German that it can be avoided, and avoided with enormous pecuniary advantages to their own interests.

Speed upon railways resolves itself into a question of mere cost. While on many of our lines even the existing speed of passenger express trains is in advance of the real public demand, as measured by return and dividend, there are a few special cases in which even an increase on the best speed yet attained—such, for example, as that of the Limited Scotch Mail from London—seems about being applied for, by the constantly increasing extent of business travel, and the urgency for economising time. Thus, it has been proposed to form a distinct express passenger trunk line, upon the broadest known guage, to unite the great centres north and south of Great Britain, and to travel thereon at a speed which, including the effect of reduced number of stoppages, might nearly double our present rate of express trains. Probably, as a whole, this project may be even yet premature. In one respect, however, the proposition of reverting (not to, but) towards the broad gauge, is far from premature. The pressure both of a scarce manageable traffic and for high speeds, during several years, has been attended with this, amongst other effects, that the size, height, and weight of the rolling stock of the broad gauge of Brunel has been gradually more and more approximated to in the engines, carriages, waggons, &c., placed upon the narrow 4ft. 8½in. gauge. The result has been, especially in the engines, to raise the level of the centre of gravity to a dangerous height above this narrow base in many instances. Engines of express trains may now be seen with the centre of gravity when in running trim, more than seven feet above the 4ft. 8½in. rails. With a co-efficient of stability thus reduced, the slightest obstacle or cause of lateral oscillation may throw the engine off the rails.

In the locomotive engine many important improvements tending to reduce the cost of traction, to increase its power upon steep gradients, or to facilitate management and diminish repairs, have been made comparatively recently in Great Britain and abroad. Mr. Fell's engines, grasping laterally by friction a deep middle rail, which are but the carrying out of an old idea many times suggested, and perhaps originally traceable to the inventions of my predecessor in this chair, Mr. Vignolles, have been found competent to ascend with facility, certainty, and sufficient economy, gradients the most severe that are necessary to ascend the crest of the Alps. Adapted to this principle, a railway is being now laid over the crest of Mont Cenis, to unite Bardoneche and Modane, on the Italian and French sides of the mountain, through the bowels of which the gigantic tunnel of Mont Cenis is simultaneously being cut. This great tunnel, although advancing at a rapid and satisfactory rate per day, is not likely to be perforated through and the rails ready for traffic for probably five to seven years at least, and in this interval it is expected that the supra-montane railway will have returned a respectable profit, and may then yield to its levelling competitor beneath. Sharp inclines have been at all times, but increasingly of late years, more courageously employed by Continental engineers than by those of our own country, where, indeed, the natural fetaures of our islands do not present the same necessity for sharp gradients. The Giovi and Sömering inclines at an early period called forth, through the skill of Borsig and several others, locomotives of before unknown weight, adhesion, and power; but even these have gradually given place to engines of still greater evaporative power, and so placed upon their wheels as to utilize their entire weight in adhesion.

The latest of these is the engine designed by M. Thouvenot (for certain Swiss railways), which may be viewed as two locomotives applied end to end at the fire-boxes, which are thrown into one greatly enlarged, and fed at the sides. These engines will weigh 80 tons, and in size and weight far exceed those of Mr. Petiet on the Great Northern of France. Into the details of this engine we cannot go; it proposes several advantages, some of which are real, in addition to great evaporative power and great and uniform adhesion, but its effects on any ordinary rail will be damaging, especially on curves.

Coal burning in locomotives has become universal, and although the coal supplied in France is generally inferior in quality to our own, the perfection of the combustion, and freedom from smoke or smell, are in advance of our general practice. A still further advance has been very recently made on one or two of the French lines, in the adaptation of the fire-box arrangements specially for consuming very small coal (so small as to be almost coal dust) without material waste. The results obtained are satisfactory, and of high importance in many parts of Europe, especially in such regions as Bohemia and Hungary, where the coal is tertiary (lignite in fact, though presenting when dug out the aspect of good Newcastle coal), and yet slacks to pieces and falls into dust in a few days. Such coal-dust is compressed in hot cast-iron moulds, and reconsolidated into bricks, which are used as fuel in the steam vessels navigating the Theiss and Danube, &c.

Steel fire-boxes have been in several instances substituted for those of copper on the French railways, upon which, as well as upon our Indian railways, and upon some of our British lines, the Giffard injector has almost superseded the feed pump. The theory of this remarkable instrument has within the last year or two received striking advances at the hands of French and German engineers.

Explosions of locomotive boilers continue to occur every now and then with generally fatal effects. These are, to our disgrace, very much confined to England, and result almost entirely from the systematic neglect of periodical proof of the boilers by water pressure, a matter compulsory abroad, and against which the irrational dicta of locomotive superintendents in England ought no longer to be tolerated. These accidents have resulted in throwing some little additional light on some before obscure circumstances, whereby mechanically induced change of form in such boilers aggravates the loss of substance locally by corrosion.

The Mont Cenis tunnel, to which I have already alluded, presents the first example upon a great scale of the successful application of power to the perforation of rock. The origination of the machinery directly employed is unquestionably due to an English engineer, the late Mr. Bartlett, while the special machinery by which the natural torrents descending from the flanks of Mont Cenis are made available to compress air, as the motive power and means of ventilation, are due to MM. Sommeiller, Grandis, and Grattoni, the engineers now charged with this magnificent work. The success of these machines for jumping holes in rock, now some years proved, has since led to many others for like purposes, and to the admirable coal-cutting machinery, driven by compressed air, now at work both in the North of England and in South Wales. These machines, while relieving the coal-hewer of the most laborious part, if not the whole, of his dangerous and unwholesome task, effect an economy in the coal necessarily destroyed in getting, to the extent of at least five-sixths of the whole.

In connection with these fine instruments for quickening man's mastery over matter in its crudest and most resistant form, may be noticed the revival of the employment both for blasting and for fire-arms, &c., of gun-cotton, resulting from the improved methods of its manufacture, due to Colonel Lenk, of the Austrian service. The superiority as a *rending* agent in blasting of gun-cotton over gun-powder, and its advantages in some other respects, are now established facts, and its manufacture as an article of trade has once more become active. Some other new explosive agents with much less promise have been brought before engineers, amongst which are a new gunpowder, the oxidising agent in which is stated to be chiefly nitrate of barytes, and the formidable and hazardous nitro-glycerine or blasting oil, now on sale in England.

In noticing the methods of tunnel cutting by machinery, I may not omit to notice the remarkable work of Herr Rziha and his admirable substitutions of wrought-iron framing, &c., for the mass of timbering usually employed in tunnelling operations. Nor, as being works highly analogous, and occasionally full of difficulties requiring to be overcome, can I pass the beauty of the methods, and the success with which vertical shaft-sinking, whether for colliery or other purposes, has been achieved in Northern Prussia and in Belgium. Amongst these the successful methods of M. Guibal for sinking through running quicksand without air pressure, or pumping out the water, are worthy of all attention.

Tunnelling in water-bearing strata, as beneath the beds of rivers or estuaries, which received a shock from the disasters of the Thames tunnel that prevented any like undertaking for many years, has once more resumed the position from which it ought never to have been displaced by the wholly exceptional conditions in which the elder Brunel placed himself. The Thames tunnel was, in fact, bored not so much beneath as through the Thames, for it was in some places but four feet below the bed, the latter being of mud almost as liquid as cream. Why this disastrously high level was chosen we need not now go into. If, however, the level of a tunnel be so fixed beneath a large river as to leave an abundant thickness of covering material above it, the work in reality presents no conditions different, or more difficult to be coped with by well-known means, than those constantly met with in every land tunnel through a hill of water-bearing beds, the water supply of which may be practically inexhaustible, as for instance was the case at the Kilsby tunnel, on the London and Birmingham Railway.

And in accordance with this view I may mention, that a leader whose practical ability is justly valued in our profession, my friend Mr. Hawkshaw, has recorded his readiness to undertake a new tunnel under the Thames, and has expressed to myself personally his unhesitating willingness to undertake one beneath the Straits of Dover, and I should not be suprised if in the progress of events he may yet live to be called upon to do so.

Another and wholly different method of tunnelling beneath rivers or arms of the sea, has also been matured since Brunel's early day, in which the work is done in segments from above, and partly by coffer-damming, or the sinking of iron caissons. This admits of placing the level of the roof of the tunnel actually no lower than the bed of the river. This method has been proposed for crossing beneath the Mersey above Liverpool, and it is at this moment in active operation in London for passing the new tunnel that is to carry the pneumatic dispatch railway from the Waterloo station south of the Thames, to the northern side at Whitehall, under the direction of Mr. Rammell, C.E.

(To be continued.)

SUGGESTIONS TO YOUNG ARCHITECTS.

At the meeting of the Architectural Association held on the 18th May, a paper was read by Mr. B. Ferry, F.S.A., containing "Suggestions to Young Architects for facilitating their correspondence with Chartered or Diocesan Church Building Societies, and Hints on some Practical Points."

Mr. Ferry detailed the steps which should be taken to obtain aid from the various societies established to assist in the building of new churches or enlargement of existing fabrics, and explained the nature of the rules and conditions under which such aid was to be obtained. Glancing, then, to the works themselves, he deprecated the tendency exhibited in some directions to run up churches with the meretricious aid of the iron-founder. He was in favour of a sensible and severe form, adapted to the site and the aspect, and for exemplars he recommended the student of architecture to visit Normandy and see what had been done there in the way of parish churches. Solidity of construction ought to be kept in view as much as possible, for without it it was impossible to obtain that impressive effect which ought to be the first characteristic of a building dedicated to God. It was, he thought, a reproach to an age in which thousands upon thousands of pounds could be readily obtained for any utilitarian object, that raising money for the building of churches should be a matter of so much difficulty. It was, in fact, a national reproach that architects should so often be asked to prepare designs for "cheap churches." It was, however, due to the committee of the Church-Building Society to state that they were anxious in all instances to obtain fabrics of a church-like character; the first consideration being accommodation for the services of the church, and for the worshippers, leaving the tower and ornamental details to be completed out of funds to be provided hereafter. It was to their credit, also, that they were anxious to preserve old work as much as possible, and not to pull down or change any features of a building which marked the period of art to which it belonged. Many fine old parish churches had been pulled down in consequence of the ignorance of the professional adviser. A notable instance of such destruction had lately occurred in the county of Middlesex, where a fine old parish church, of great architectural beauty, which might have been restored with the best effect, and preserved for centuries to come, had been immolated to the ignorance of the persons who had the direction of the matter. Many hideous-looking churches and chapels had also been "put up" by local builders, no architect having been employed to give designs or superintend the construction. Some practical information of great value might be gathered upon these points by the study of the paper printed by the Royal Institute of British Architects in reference to them, and he recommended all young architects to take the advice there given. Referring next to the manner in which the walls and roofs of churches should be constructed, Mr. Ferry pointed out the necessity of choosing the most eligible site, so as to avoid land-springs in the foundations, and to get as much protection as possible from the south-west wind, which, when accompanied by continuous rain, would soak almost any wall exposed to their combined influences. In making foundations in clay soils, he recommended the free use of concrete rather than very deep foundations. He would advise, to insure solidity and provide against damp, to lay down a platform or bed of concrete, which experience had shown to be the best precaution. The circumstance that in so many old parish churches the south-west walls were found to be plastered, arose from the circumstance that a driving rain of many hours' duration would generally find its way through, no matter of what materials the walls might be constructed. In order to prevent this, he recommended an inner lining of brick or ashlar, with an interstice between, which would be found to keep the interior face of the wall dry in any weather. The roofing of churches was also a point deserving the utmost care. Panelled roofs were the best, not only for the comfort of the worshippers, but also for the conveyance of sound; but, in cases where it might be necessary to have open roofs, he recommended that attention should be paid to ventilation, and sufficient draught secured to prevent the accumulation of moisture upon the beams. This moisture often fell in drops upon the pews, and, independently of the inconvenience, did much damage to the woodwork of the church. Another subject which the author brought under notice as deserving the attention of the architect, was the manner of laying encaustic tiles now so generally used in ecclesiastical structures. Great care should be taken in preparing the surface before laying the tiles, so as to prevent the use of unslacked lime. Many instances had occurred in which the tiles were broken and the flooring destroyed by the expansion of particles of unslacked lime. With regard to bells, now that steel bells were coming so much into use, owing to their cheapness when compared with those constructed of ordinary bell-metal, he recommended that in no case should the supports of the bells be made to rest upon any portion of the tower in which they were hung, as the vibration was destructive of masonry. The caging of timber or machinery upon which the bells rested should be altogether independent of the tower. The neglect of this precaution often did immense injury to this portion of the building. Moreover, it was well known to those who had paid attention to the matter, that the tone of a peal of bells was far better when the machinery by which they were supported was altogether unconnected with the solid masonry of the building. With reference to the new system, Mr. Ferry commented upon the evils of unendowed or proprietary churches, which, he said, necessarily led to the total exclusion of the poor, because the income of the incumbent and the expenses incidental to maintaining the services of the church had to come out of whatever funds were obtained from the letting of the seats. Architects had, he thought, reason to deprecate the pew system, with all its abominations. Mr. Ferry concluded his paper with some practical hints on the building of parsonage-houses, explaining the equitable nature of the arrangements for assistance made by the Commissioners of Queen Anne's bounty. No sum greater than three years' value of a living or benefice was advanced; but the payment was extended over thirty years, and became a charge upon the property, which no change of occupier could affect. By this means the occupier for the time being was in no case bound to contribute a share to the burden beyond that for which he obtained full value.

INSTITUTION OF CIVIL ENGINEERS.

May 15, 1866.—The discussion upon Mr. Burnell's paper "*On the Water Supply of the City of Paris,*" occupied the whole evening.

After the meeting, Mr. H. Temple Humphreys, Assoc. Inst. C. E., exhibited and explained, with diagrams, an instrument called the Cycloscope, for setting out railway or other curves, without the aid of the transit theodolite, &c. Externally, it somewhat resembled a box sextant. It was composed of two essential parts only, viz.: two plane mirrors, one of which was silvered over the whole of its surface, and the other over one-half of its surface. By a law of physical optics, which was called either combined or successive reflexions, a series of images would be formed in the half mirror, which were rendered available to set out any curve of any given radius, by applying the eye to an eye-hole in the back of the whole mirror, and at the same time setting the two mirrors at an angle to one another equal to the required tangential angle. Then the several successive reflected images of a ranging rod, for instance, were seen to lie upon the circumference of a mathematically true circle. The curve was then readily set out in the field by simply placing other ranging rods in line with these several images. This could be done by looking through the unsilvered half of the half-mirror, and planting the rods opposite to and overlapping the successive reflexions. No error could arise in the manipulation, and the whole process of setting out a true curve was shortened and simplified. After setting the mirrors to the requisite tangential angle, no further adjustment or support was needed than could be afforded by the top of a ranging rod placed at the commencement of the curve, and shifted occasionally to any stake on the curve that the limits of distinct vision might require.

Cork Springs.—In a recent report upon new mechanical applications the secretary of the *Franklin Institute* called attention to the use of cork in place of india rubber, as a support for freight cars and like heavy vehicles. One would not be led by any means to predict the efficiency of cork in this connection, from ordinary impressions of its properties. The cork used for these springs is of the commonest description, harsh, hard, and full of fissures. It is cut into disks of about eight inches diameter, each pierced with a central hole. Previous, however, to cutting it, it is soaked in a mixture of molasses and water, which gives it some softness and renders it permanently moist. A number of these cork disks are placed in a cylindrical cast iron box, a flat iron lid or disk is placed over them, and by hydraulic pressure is forced down so as to reduce the thickness to one-half. A bolt is then run through box, corks, and cover at the centre, and a nut being screwed on this, holds all in place, when the press is relieved, and the box of compressed cork, disks, or cork-spring is ready for use. One of these springs, placed in a testing machine, under a weight of 20,000lbs., shows an elasticity suggestive of compressed air in a condensing pump, One would expect, from the appearance of the material, that under heavy pressure, it would be pulverized or split into shreds, especially if this pressure was assisted by violent shocks; but in fact no such action takes place. A pressure which destroys india rubber, causing it to split up and lose its elasticity, leaves the cork unimpaired, and, with the machinery in use, it has even been impossible, with any pressure attainable, to injure the cork, even when areas of but one inch were acted upon. In connection with this subject, the President, Mr. Wm. Sellers, remarked, at the conclusion of the Secretary's report, that he had for some five years, employed a forging machine in which a spring of the form and material above described was used and subjected to continual and violent shocks, and that its performance had been most thoroughly satisfactory, with no signs of deterioration.

The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top.

Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I indulge the hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private shipbuilders to introduce partial iron decks so formed into ships designed for commerce. I may add, that these proposals do not form the subject of any patent.

GRAVESTONES.*

By the Rev. E. L. Cutts, M.A.

Let us first take a rapid glance at the Mediæval gravestones, to which we naturally look for models, or at least for suggestions, for our own practice; and first of all we may notice that the Mediæval gravestones seem to be modifications of Classical ones. The old Roman sarcophagus continued to be used by Christians, and was gradually diminished in size and modified in form, till it took the shape of the tapering stone coffin with its coped lid. A sarcophagus of Classic shape, Romano-Gallic, with Christian symbols, from France, shows the transition from the Classic to the Mediæval form. The ordinary head-stone, with a rounded (not a cruciform) head, has its prototypes in Greek and Roman gravestones. On Etruscan sarcophagi we very commonly find reclining effigies of very elegant design, which perhaps suggested the Mediæval effigies, though the attitude and spirit of the figures is very different.

The rude upright unhewn stone, of earlier than Classical times, such as Jacob erected upon Rachel's grave, was first marked with a small cross; then the head was rudely worked into a cross shape; and so it came to be developed into a finished cross, like the Runic or Saxon crosses, and still later into the elegant Mediæval churchyard cross. When we put together the ancient examples which exist in the British Islands, we find a very large number of all the kinds which I have mentioned, and extending in date from Roman times downwards.

But there is another kind of monument more ancient, more appropriate, and more universal than all the rest, viz., the earthen mound. These were the monuments of heroes in the days of the Trojan war, and how much earlier we do not know. They are dotted like low natural hills over the Steppes of Tartary; they are found buried under the rank tropical vegetation of Central America, monuments of races of whom no other monument remains. In England all the races who have successively inhabited the land have left those monuments behind. The British barrows in Salisbury Plain come into one's mind; and the Roman tumuli, erected over sepulchral chambers, and the Saxon barrows, in which we find the remains of whole families, the men with their rusty spear-heads and swords lying by their bones, the women with their gold-enamelled ornaments mingled with their dust; and the low turf mounds, which the sexton heaps with his spade over the humble graves in our country churchyards, are the undoubted successors and representatives of the barrows of our Saxon forefathers. Until a recent period the people were buried in them uncoffined, as their forefathers were. After all, it is the most appropriate monument. It tells us that there one of our fellow-men has been "laid in ground," as the old ballad says, and has displaced just that length and breadth of kindred dust which you see raised above the general level of the earth; that heap of dust is his *vera effigies*, for dust he was; the green grass which will grow over it will be his symbolical epitaph—"As for man, his days are as grass."

In England these grave-mounds are always of the low rounded shape, with which we are all familiar. In Normandy I have seen grave-mounds shaped in imitation of a ridged coffin-stone, and sometimes with a strip of turf raised from end to end and side to side in imitation of the cross upon a coffin-stone. The old types of monument which have been chiefly imitated in our modern Gothic gravestones are the recumbent stone, which we commonly call a coffin-stone, the upright head-cross, and the sarcophagus. Let us glance at the chief peculiarities of these ancient gravestones. The coffin-stones are usually long, narrow and tapering from head to foot, and probably always formed the actual lid of the stone coffin in which the deceased was buried: the coffin was sunk till its upper margin was level with the earth, and then the lid formed his monument. Sometimes the lid is flat, sometimes it is coped, as if to throw off the rain. In nineteen cases out of twenty there is a cross carved upon the coffin-stone. When the stone is flat, the cross is sometimes only outlined with bold incised lines; sometimes it is sculptured in low relief. There is seldom an inscription, and then little more than a name; but there is often a symbol of the calling of the deceased sculptured beside the cross. The cross itself was the symbol of the Christian person: when two persons, or man and wife, were buried under one stone, we find two crosses; in one case a little cross is added, perhaps the symbol of a child. The symbol of calling was placed beside the cross: a sword for a knight, a chalice for a priest, a bow and arrow for a forester, and a pair of shears or scissors for a woman. There is one symbol frequently found attached to the middle of the shaft of the cross whose meaning has baffled all our ingenuity. It is something like a bracket on each side of the shaft }|{ ; sometimes the lines are headed like those of a riband; sometimes they are stiff, as if of stone or metal, and they differ a little in shape. There is one at Horningsea, Cambridgeshire, and others at Helpstone, Peterborough; they are very common. There is a similar ornament on a Roman gravestone engraved in Montfaucon.

The thing that most strikes us, perhaps, in looking over a collection of drawings of these coffin-stones, is the endless variety of ingenious, fanciful, beautiful cruciform designs upon them. Among them are some examples of a method of countersinking the design in a way which saves labour, protects the design from wear, and often adds considerably to its effect by enclosing it in a kind of frame.

After looking over a collection of drawings of old designs, it would seem to be the easiest thing possible to reproduce them, or to design modern ones in the same spirit; but if we look through a series of drawings of modern designs, we shall see that the attempt to reproduce an ancient design generally fails somehow to retain the simplicity and breadth and vigour of the old one; and the attempts to design new ones in the spirit of the old are, I venture very humbly to say, too often unsatisfactory.

These, perhaps, are some of the reasons of failure:—

The first, I think, is the shape. There is something picturesque in the long, narrow, tapering coffin-stone; but it derived that shape from the fact that it formed the lid of the stone coffin. When we lay it over one of our modern graves it is inappropriate, for it is not the shape of the grave over which it is placed, and it is not large enough—wide enough—to cover it. It is a coffin-lid without any coffin under it; it is a gravestone which is too scanty to serve its purpose of covering the grave.

But, 2ndly, to remedy this defect, and to make the monument larger and more imposing, the coffin-stone in modern practice is often mounted on a massive slab of stone by way of base. But this introduces another incongruity. The massive slab is the real gravestone, and it should be dealt with accordingly. I do not think it is a happy idea to take a stray coffin-lid (the tapering shape irresistibly suggests the idea of a coffin-lid) and lay it upon the gravestone by way of monument. In the margin of a manuscript in the British Museum is a figure of Death on the pale horse, who carries a taper coffin-stone by way of a shield; to lay one on our gravestone is to use it similarly as a symbol.

A third source of failure, I think, is in the character of the designs sculptured upon the coffin-stones. If we compare the design and execution of the old gravestones with contemporary architectural sculpture, we shall find that, in the great majority of cases, the gravestones are comparatively simple in design and rude in execution. The design is generally bold and vigorous, often ingenious and beautiful; but, after all, it is simple, and it is only deeply scratched or rudely carved on the stone. I can imagine that the caligrapher of the neighbouring monastery drew the design on a scrap of vellum, and the local mason hatched it out with his stone axe. The designer showed some taste in giving such a simple broad design as could be effectively executed by such rude hands, and the mason did his work well when he had cut it deeply, or hatched it in relief, with freedom and vigour. But when this kind of work is copied,

* From a paper read at the Architectural Museum.

with our modern elaborate precision, its vigour and spirit usually vanish, and leave nothing but a bald and tame result. When such a stone is mounted on a massive base, and protected perhaps by an elaborate iron screen, the poverty of the design is made more conspicuous by this sumptuous treatment.

I venture to suggest that the modern recumbent gravestone should be the rectangular on plan, *i.e.*, of the shape and of the size of the grave which it is to cover. The flat and the coped coffin-stones suggest two different styles of treatment. In the flat style, the size of the stone leaves ample room for an inscription round the margin, to be enclosed within marginal lines or mouldings. These will advantageously narrow the field of the stone, and upon this field may be placed a cruciform design. I think our modern taste requires for its satisfaction more elaboration of design and greater skill in execution than are found in the majority of these old coffin-stones; and now there is not the slightest difficulty in obtaining both. There are some of the old stones which possess these characters, executed probably where skilful design and workmanship were easily accessible. At Milton, Oxon, for example, there is a foliated cross in which the foliation is of the best style of Early English foliage. At Hexham, Northumberland, there is an incised slab in which the whole field of the stone is covered with a pattern of vine foliage. In Lincoln cloisters there is a thirteenth century stone which has a "tree of Jesse," very well designed and sculptured, covering the field. The method of countersinking the design, shown in some of the exhibited examples, is worthy of consideration; and both in incised and countersunk work it may be considered whether the incisions may not be filled in with colouring matter, if any colouring matter will resist the weather; or filled in with coloured stone, if, again, such inlaid work will stand the climate. This method of inlaying with coloured stone and marble, if it will stand our climate, opens up a wide scope for elaboration in a style which has taken a strong hold of the present taste; only, again, I confess I have misgivings whether, except on a very simple and careful use of it, it will stand our climate.

The coped stones suggest another mode of treatment. Let the stone still be rectangular in plan—not tapering; mould the edge deeply, leaving a plain fillet among the mouldings, broad enough to carry the inscription, and from the upper moulding carry up a plain prism, with a bold and simple roll at the angles, to form a kind of cross. The tomb of William Rufus, in Winchester Cathedral, is something after this kind. One in the Temple Church has sculptured ornaments carried along the edges of the prism with very good effect. Or the mouldings may be made a little deeper, and a narrow flat top left for the reception of a cruciform design. It is very usual in modern practice to add a head-cross and foot-stone to a crossed coffin-stone. This, I venture to think, is also a mistake. It is an unnecessary combination of two different monuments. Where there is a coffin-stone with cross and inscription, a head and footstone beside are unnecessary. If the ends are rather high, and look bare, cusp the gables, or incise a symbol upon them. Where there is a head-cross, and it is desired to lay a stone over the grave to protect it, it should, I think, not be a regular coffin-stone, but a plain and simple stone, without any cruciform device. There are some examples, both in England and on the Continent, of a variety of the coped stone which I can best describe as being on the plan of the roof of a cross church. The ridges, with a bold roll on them, form a plain cross. It is a very beautiful design, susceptible of architectural moulding—dog-tooth, ball-flower, &c., the like in the base, and of cusping in the gabled ends. Some of the modern adaptations of this type are among the most successful modern designs I have met with.

I come now to the class of head-stones. There are two great types. In one, the general form of the stone is that of a cross; in the other, the stone has a rounded head, and a cruciform device is either incised or carved in relief upon the face of it. Very few ancient examples of these head-stones remain: there are hundreds of coffin-stones; of head-stones only a dozen or two. Our modern designs for head-stones are, I think, less satisfactory than the modern coffin-stones. This does not arise from the scarcity of ancient examples, for many of the cruciform designs on the flat stones are equally applicable, with a little adaptation, to head-stones; and the gable crosses, of which we have many fine examples, would also afford authorities easily ›lied to the purposes of head-stones. It is the latter type which has chiefly been followed in modern designs, and the fault in them arises almost entirely from making the stone too large—too high, and too wide. The fault does not lie with the designer, but with his clients, who will insist upon having a stone large enough to contain a long inscription, or inscriptions, to several members of a family.

The most noticeable thing about the few old head-stones which we have is, that they are small in size and very simple in character. In the modern adaptation of them, a cruciform head of proper size is put on the top of a high, wide slab, and the effect does not satisfy the eye. Many attempts have been made to shape the slab so as to make it a proper base for the cross with more or less success. Some of the modern head-stones retain the proportions of the old ones, and look pretty well on paper; but when you see them executed you find that, though the old proportions are retained, they are magnified two or three fold, and that the result is the usual high, wide slab, with a cruciform head of much too large a size. In short, I have looked through a considerable number of modern designs, in which the designers have attempted to solve the problem, and I come to the conclusion that it is simply impossible to combine a high wide base with a cruciform head so as to produce a satisfactory result. We must, I think, try to persuade people to be satisfied with low and narrow head-stones. If such a stone seems too simple, and does not satisfy the desire to have something more sumptuous, perhaps we can arrange the matter by making the monument of marble and bestowing some carving upon it of a more artistic character than usual, *i.e.*, give them the value of the money they insist on spending on art instead of material. The greatest difficulty, perhaps, will be to persuade them to be satisfied with a very short inscription; and anything but a very short, unostentatious inscription will spoil the effect of the design. We might, perhaps, obtain leave to have a proper head-stone if we put a flat stone behind it, on which an epitaph might be inscribed; only this stone must be low and narrow, and unostentatious, or it will spoil the effect of the head-stone.

The other type of head-stone, in which the stone is cut into the form of a slender cross, does not seem to have been much followed in modern design; probably because it offers still less space than the other type for inscriptions; but I think it offers scope for a wide range of designs which would be artistically satisfactory. What we especially want in the monuments for our crowded cemeteries is great variety in their general form; and this class of crosses, ranging from a slender plain cross a foot high up to a tall cross of the ordinary "churchyard cross" kind, or even to a cross of the Eleanor Cross type, offers greater scope for variety in dimensions and outline than any other.

Most of the ancient crosses of the head-cross type which remain to us are of early date, and of Saxon character. I have seen some of them reproduced in modern designs, and I do not think the result is satisfactory. I do not believe there is any great beauty to our eyes in the intricate interlaced work in which the Northmen so much delighted, or that we appreciate the mystical meaning of the lacertine monsters which they used so commonly in ornamentation; and I doubt whether the peculiar outline which we find commonly associated with such ornamentation is that which our modern taste desires. Of course, some people take pleasure in the reproduction of these forms or they would not reproduce them, but I think it must be an antiquarian pleasure derived from the associations which they awaken rather than from the intrinsic beauty of the designs.

The great majority of the tall crosses to which I have pointed as affording a suggestion for monumental crosses are of this early type. Of the station and churchyard crosses of Gothic design few have escaped mutilation; a stepped base and broken shaft may be seen in hundreds of our villages, but the head—the crown of the design—is almost always broken away. It is quite a wonder to me that, while people have been reviving everything else Gothic that was beautiful, they have not revived the churchyard cross. It was not the early Reformers who broke them down, it was the Puritans. Some of them may have had superstitious images upon them, and may have deserved to be broken down; but it is easy to restore them with a cross head, or with a sculptured group which has nothing objectionable in it. I should be very glad to see all the old ones restored, or a new one erected in every churchyard. I do not know any small architectural work which is more beautiful, and its significance and appropriateness as the ornament of the churchyard or cemetery are manifest.

In saying that sepulchral ornaments of this kind might be erected, besides the one churchyard cross, it has to be considered how it would look to have several such crosses in the same churchyard. If they were not too numerous, and if they were sufficiently varied in general size and form, there would be no fear. There are two at Penrith of the same size and design, at the head and foot of a long space, enclosed by very ancient semicircular stones, called the Giant's Grave; they do not spoil one another. There are two at Sandbach, Cheshire, in the market-place, so close together that their bases touch one another; they are of different size and design, though of similar date and character, and they form a very picturesque group. In MS. illustrations we sometimes find three or four tall monumental crosses represented in the same churchyard. The churchyard cross would be distinguished from sepulchral monuments of the same type by being placed on a base of steps; and it might easily have a further pre-eminence given it by the style of its design or subject of its sculpture. It might have evangelistic symbols at the angles of its base, and a figure of the patron saint in a canopied niche on its shaft. The monumental crosses would, I suppose, not have the same spreading octagonal graduated base, but would rise from a base which covered the grave, and that base would afford ample space for an inscription.

Another very common form of modern monument is the high tomb: it does not seem to have been used as an outdoor monument in Mediæval times; but now-a-days it offers the supposed advantage of a more imposing and sumptuous monument than a mere coffin-stone or head-cross, and is therefore popular. Some of the modern designs are adopted from the old sarcophagus. The old sarcophagus, hewn out of one stone, was a very massive and imposing monument, and derived solemnity from the fact that it actually contained the body of the deceased. Some of the modern designs have the modified form of a Mediæval shrine. But a modern high tomb, which is built up of several storeys, is not imposing from its massiveness,—it is only a very tiny building; and it has none of the solemnity of a sarcophagus, which contained the dead, or of the interest of the shrine, which contained a saintly relic. The body lies in a grave beneath, and the interior of this sham sarcophagus or shrine is empty. In a working drawing for one which I saw the other day there was this direction written on the section of the interior:—"To be filled with rubbish;" brickbats, I suppose, and fragments of stone—a convenient way of getting rid of the mason's *débris*, and calculated, I think, to illustrate the inappropriateness of the kind of monument.

Sometimes the high tomb is a copy of the Mediæval altar tomb. In the prototype, I suppose, the body was contained within the tomb, and masses for the soul were offered upon its top, so that it is doubly inappropriate for modern use. These objections to the high tomb may, however, be easily removed by not enclosing the space beneath the top, whether the top be flat or coped, *i.e.*, by mounting the top on columns, or by piercing the enclosing sides in panels, so as to show that it is only a monumental slab mounted on an architectural base.

Since variety of type is a great desideratum, I will suggest one of these table tombs, with a square tester over it; there are some comparatively modern ones (seventeenth century) in Wales. Or, again, a table tomb, with a canopy over it; there are two in Aston churchyard, Cheshire, with effigies lying on the high tomb, which seem to have been sufficiently protected from the weather by the broad ogee canopy.

Perhaps the greatest difficulty the designer has to contend with in getting monuments that shall look effective is, that the monuments are so crowded together in many of our churches and cemeteries, that they make the place look like a stonemason's yard, and the designs ruin one another. This crowded appearance is exaggerated by the unnecessary size of all our monuments—coffin-stones on massive bases, head-stones three times as high and broad as they should be, and other types of monument on the same over-large scale. If the monuments were less we should get more greensward, which is what is wanted as a setting for the pieces of architecture.

We may often obtain a broader foil of green, and a more complete isolation from neighbouring monuments, by judicious planting of shrubs and trees. A better effect for our own monument, and for its neighbours also, may often be got by designing the monument with reference to the place it has to occupy. If there are many head-stones about the place, a flat gravestone will have more individuality, and *vice versa*; if the neighbourhood is only too crowded already with both coffin-stones and head-stones, a slender head-cross may be relieved against their broader forms, or a short massive cross, like that at St. Buryan, will assert itself by its solidity, or a tall churchyard cross will make itself conspicuous. The best effect of all would be obtained if one-tenth of the people would erect monuments, and all the rest would be content with plain turfed grave-mounds.

What do we want any other monument for? Partly as a lengthening out of the last sad offices of affection—a doing something more to show our love and regret; partly, I suppose, to ensure the grave from violation; partly to form a more permanent record of the place to which our visits of affection may from time to time be paid; partly it is to keep the memory of the lost one alive a little longer among men.

To preserve the grave from violation;—a very natural feeling, and yet, alas! how vain the attempt. Go into any village churchyard and look round you. All the generations of the inhabitants of that village, from its first Saxon settlers down through 1,300 years to the fathers of the present generation, have been buried in that churchyard. How could you preserve their graves from what you call "violation?" And, if you could, why should their graves be preserved from "violation?" They passed away from the fields which they once tilled, and a fresh crop of spring corn is at this moment green upon them, sown by other hands. They passed away from the houses which they built, and others' children are now cradled within the old walls. And so their dust was mingled with the earth of the churchyard, and successive generations have been laid over and over again in the same graves until their dust is indistinguishably commingled. You cannot preserve them from violation.

But you want to mark permanently the place where your own dead lie, and to keep their memory alive among men. Well, it might be cynical to say that your own memory ought to be *your own* sufficient remembrance of your dead, and that you will strive in vain to make the *world* remember them unless they have themselves done something to be remembered for. At any rate, a gravestone will not serve the purpose very long.

What has become of all the old gravestones? In pulling down old churches, to rebuild or repair them, we often find a churchyardful of them built up in the old walls, as at Bakewell, Doncaster, and Helpstone. And, depend upon it, *our* monuments will no more remain inviolate than those did, and may chance to be put to much viler uses. Why, if everybody's grave had been kept inviolate, and everybody's friends had put up a stone monument to perpetuate his memory, there soon would not have been fields left for men to grow their corn and pasture their cattle upon: the mountains would have been levelled for monuments, and the face of the whole earth would have been crowded with monumental lumber. Let us be satisfied to have our dust mingled, confused, lost, amidst the dust of our fellow men, there will be nothing wanting of us at the resurrection: let us be content to have our memories fade out of remembrance in the world, if only our names are written in the Book of Life.

INCRUSTATION IN MARINE BOILERS*

By P. Jensen.

The question of keeping marine boilers free from deposit or incrustations has for many years been one of the most prominent before the profession; in fact, ever since the first steamer entered sea-water, and it is still well worthy of our closest attention. It presents itself to us principally in three distinct forms, viz., safety against explosions, economy of fuel, and durability of the boiler itself. All know that sea-water causes incustration and corrosion when boiled in a close vessel like a steam boiler. It is not, however, intended to enter into the question of internal corrosion of marine boilers, though closely connected with the subject before us, for fear of extending the length of this paper; but, we may, in passing, note the fact that internal corrosion below the level of the water in a marine boiler does take place to some extent where the scale has been removed; but that otherwise this scale, so injurious when allowed to accumulate to any thickness, acts the part of a shield or protector to the plates of the boiler against the action of certain salts contained in sea-water, of which the muriate of magnesia is by far the most destructive, though, happily, the smallest in quantity. And here the author may be allowed to call the attention of the meeting

* Read before the Society of Engineers.

to an excellent paper "On the Wear and Tear of Boilers,"* read before the Society of Arts, in 1865, by Mr. F. A. Paget, who treats the subject of corrosion of boilers very fully. In the ordinary practice of sea-going steamers with common condensers the feed-water is drawn from the hotwell of the condenser and thence forced into the boiler at some point or points near the bottom, and at a temperature of about 110 deg. Fah. The evaporation of steam leaves all, or sensibly all, saline or other extraneous matters contained in the water behind in the boiler, and, unless some means were adopted against it, we should, of course, soon get the boiler choked with incrustation or deposit. The means proposed or adopted for this purpose are many and varied, as will be seen in the sequel; but this much is certain, that any considerable thickness of scale allowed to accumulate renders the plates impervious to heat to a great extent, as this scale is a bad conductor. The heat generated in the furnace, heating the plate next to it, cannot readily enough penetrate as far as the water, which, if in constant circulation, continually exposes fresh particles to the action of heat. The consequence is the overheating of the plates, and this to such an extent that holes may be burnt nearly through, leaving a sheet of iron the thickness of writing paper. That explosions do and must occur by thus weakening the plates or by rents thus formed is an established fact, and has for years formed the subject of many investigations and different theories. But even only partial explosions, caused by rents or collapse of internal parts of the boiler, have proved dangerous by scalding those that happened to be near at the time. The conducting power of wrought iron decreases with the temperature, so that at 400 deg. Fah. it has little more than half that at 32 deg. Fah.; how it stands with still higher temperatures we do not know as yet. If, from some reason or other, such as the coating of the plate with incrustation, which has sixteen times less conducting power than iron, the plate with its covering of crust should become heated to above 340 deg. Fah., then the water would exist on its surface in a spheroidal state, and thus only slowly, and by the forcible ejection of it by colder water, enable the heat contained in the plate to diffuse itself into the water; thus the plate would get hotter and hotter, and at last burn or oxidise where next to the fire. It is thus that plates are burned nearly through on account of incrustation. Important as is the question of the safety of the marine boiler against explosions, it cannot be denied that the economy of fuel, as regards marine boilers, has at all times—being a mere question of pounds, shillings and pence—commanded, it is believed, as much attention as the consideration of human lives. Witness the numerous patents, amounting to about one hundred and fifty, that have been taken out in this country for the prevention of incrustations and consequent loss in evaporative duty in marine boilers. Now this is not an occasion for speaking about the patent laws, or entering into the desirability of maintaining, altering, or abolishing the same; but as one argument in favour of maintaining them struck the author while preparing this paper, which has a direct bearing on this and most other engineering questions, it would be worth while to hear what the opponents of the patent laws have to say against it. The question is simply this, how and where should we find a complete record of the progress of engineering, inventive, and progressive talent but for the record of the Patent-Office? In spite of all the nonsense that is patented, no doubt in sober earnest, still we find a vast amount of information in the specifications of patents. Would those that speak against patent laws like to do without the patent specifications? To return to the subject—it has been said above that the scale has 16 times less conducting power than iron. In an inquiry on incrustation of marine boilers by a Frenchman, M. Cousté (Annales des Mines, 1854), the following is stated:—That with marine boilers, starting quite clean inside, a loss of 8 per cent. or 10 per cent. of the evaporative duty of the fuel takes place after the first few days' work (a fact every marine engineer is aware of). At Bordeaux he found 15 per cent., and at Havre, after some days' constant work, he observed 40 per cent. In general practice, he says, it has been estimated that 40 per cent. of the heat of the fuel is lost by internal incrustation or deposit. He gives the following analysis of the incrustation of French ocean steamers:—

Station.	Sulphate of Lime.	Carbonate of Magnesia.	Free Magnesia.	Iron and Aluminium.	Water.
Hamburgh [deposit from the surface of boiler, partly crystallised]	85·20	2·25	5·95	...	6·5
Mediterranean tubular boiler [amorphous]	84·94	2·34	7·66	·41	4·65
Mediterranean [amorphous deposit]	80·90	3·19	10·35	6·50	4·56

The water contained is believed to be mechanically present in the pores of the scale, and not chemically dissolved. Of course marine boilers are scaled as often as it can be done; but for long voyages it is often out of question. Starting with 20lb. pressure in the boiler, and clean fires, it is generally found that, on the second or third day, in spite of greater exertions of the stokers and harder firing, only 19lb., or less, can be kept constantly, and this loss in efficiency goes on at an increasing rate. In eight days' constant steaming it has been found (in one instance) that, starting with 22lb. pressure, the same was reduced to 15lb. at the end of the voyage, this, it is supposed, without at all forcing the firing. Take another instance, at random, the Persia log, from year 1858, September 30th to October 9th, inclusive:—Total number of nautical miles travelled, 2,886; total quantity of coals consumed, 1,402 tons. But whereas the consumption of coals per hour per indicated horse power was 3·95 on 30th September (it left New York on the 29th), it had increased to 4·314 on the 8th of October (*Artizan*, May, 1860). These few items illustrate sufficiently the well known fact that incrustation, even only as thick as paper, has a very great and perceptible influence, tending to counteract the economy of fuel.

As to durability, marine boilers, with all care, on an average only last five years; but this is chiefly owing to internal and external corrosion, rendered more intense by the salts contained in sea-water, which, besides, promote galvanic action in various ways. This must be understood to apply to boilers properly managed, that is to say, in such a way that only a very thin scale is allowed to be formed; for, as mentioned above, if thick scale is formed anywhere in places exposed to the heat of the furnace or the escaping gases, this circumstance contributes directly to the burning away or oxidising of the plates. This fact, that marine boilers wear out so quickly, must, as far as can be seen at present, remain unaltered so long as salt water is employed, and, in spite of repeated trials, and more or less success in surface condensing, still we are far from the general introduction of surface condensation; and, considering the vast number of marine engines in existence worked with common injection condensers and salt water in the boilers, the importance of the subject under consideration is left intact. It is now proposed to give a general explanation of the action of sea-water as it obtains in the marine boiler. The specific gravity of sea-water varies according to different localities; and calling that of pure distilled water 1,000, the average specific gravity of sea-water, according to Faraday, is 1,027. For sea-water of the specific gravity of 1027·2, such as he used in his experiments, one cubic foot weighs 64·1416 lb., or 1026·265 oz avoirdupois, and contains of

	oz.
Chloride of sodium, or common salt	25·763
Muriate of magnesia	3·343
Sulphate of magnesia	2·212
Sulphate of lime...	1·013
Total	31·269

besides small quantities of other salts, but too minute to be of any consequence.

Dr. Ure found the largest proportion of salt held in solution, in the open sea, to be 38 parts of 1,000, and the smallest 32; the Red Sea, however, contains 43 parts in 1,000; the Baltic contains 6·6; the Black Sea, 21; the Arctic Ocean, 28·5; the British Channel, 35·5; and the Mediterranean, 38.

The following table shows the boiling point and specific gravity of water of different densities at a barometric height of 30in. of Mercury:—

	Saltness	Boiling point.	Specific gravity.
Pure water	0	212 deg.	1·000
Common salt water	$\frac{1}{32}$	213·2	1·029
	$\frac{2}{32}$	214·4	1·058
	$\frac{3}{32}$	215·5	1·087
	$\frac{4}{32}$	216·7	1·116
	$\frac{5}{32}$	217·0	1·145
	$\frac{6}{32}$	219·1	1·174
	$\frac{7}{32}$	220·3	1·203
	$\frac{8}{32}$	221·5	1·232
	$\frac{9}{32}$	222·7	1·261
	$\frac{10}{32}$	223·3	1·290
	$\frac{11}{32}$	225·0	1·319
	$\frac{12}{32}$	226·1	1·348

The deposit of salt begins at a density of $\frac{4}{32}$, and at $\frac{12}{32}$ we have arrived at the point of saturation, or the point at which water is incapable of dissolving any more. According to M. Cousté, an imperial gallon of water is capable of holding in solution, at 60 deg. Fah., and at boiling point, viz., in the open air, the following weights, nearly:—

	At 60° Fah.	At boiling point.
Carbonate of lime	Merely traces	Merely traces.
Silica	70 grains	,,
Sulphate of lime	170 ,, ...	,,
Carbonate of magnesia	3·25 ounces	,,
Sulphate of potassium	10 ,, ...	40 ounces
Chloride of sodium	32 ,, ...	30 ,,
Chloride of magnesium	266 ,, ...	580 ,,
Nitrate of lime	500 ,, ...	580 ,,
Chloride of lime	540 ,, ...	unlimited.

The order of decomposition in the boiler as the water becomes concentrated is:—

1st, carbonate of lime; 2nd, sulphate of lime; 3rd, the salts of iron and oxides, and some of those of magnesia; 4th, silica or alumina usually with more or less of organic matter; and 5th, chloride of sodium or

* See *C. E. & A. Journal*, vol. 28, p. 182.

common salt. Now it is well known that sulphate of lime is the worst of all the salts in a marine boiler. We have seen that $\frac{12}{32}$, or 37 in 100, is the point of saturation for common salt, but in the case of sea-water which contains other salts besides, 36 parts in 100 saturate at 226 deg., and 30 in a hundred at 228 deg. Now, taking 20lb. pressure, which is the most prevailing now, this with a saturation of $\frac{3}{32}$ to a rise of 1·2 deg. per $\frac{1}{32}$ according to Professor Rankine, corresponds to a temperature of say 262·9 deg. Fah. How much salt can be held in solution at that temperature is not known to the author; but it is well known that the quantity decreases with increased temperature, and this is the reason of our not having yet arrived much beyond 20lb. pressure in marine boilers working with salt water. In marine boilers we have chiefly to do with sulphate of lime, the proportion of the same so largely preponderating in the incrustation on analysis. As to carbonate of lime, this enemy to boilers is fortunately not a constituent of salt water, except in the Mediterranean, which contains a trace of it (·001 in 100 parts).

Sulphate of lime forms deposits at all temperatures and all densities. Salt, on the contrary, forms deposits, as we have seen in the foregoing, not to any extent except when in the quantity of $\frac{3}{32}$ or $\frac{4}{32}$, the quantity of the same required for saturation decreasing with increased temperature, and the amount of deposit that will take place long before the point of saturation having been arrived at, increasing with increased temperature or pressure. Sulphate of lime will deposit at any temperature; but it so happens that increase of temperature also increases the amount of deposit of this salt, for, according to M. Cousté, the solubility of sulphate of lime at different temperatures is as follows. The table indicates the solubility for different temperatures, as well as degrees of concentration at which the saturation of sulphate of lime takes place:—

Degrees of areometer corresponding to the saturation.	Temperature.		Total pressure in atmospheres.	Solubility or proportion of sulphate of lime in 100 parts of water at saturation.
	Fah.	Cels.		
13½	217·4	103·00	1	·500
12	218·64	103·80	1	·477
11	221·27	105·15	1	·432
10	227·48	108·60	1¼	·395
9	231·3	111·00	1¼	·355
8	235·76	113·20	1¼	·310
7	240·44	115·80	1½	·277
6	245·3	118·50	1½	·226
5	250	121·20	1¾	·183
4	255·2	124·00	2	·140
3	261·68	127·60	2	·097
2	266	130·00	2½	·060
1	271·94	133·30	2½	·023

Now this table, and that of the amount of salt which can be held in solution at high pressure, say 20lb.—a table, the author believes not to be found anywhere—would give us, as near as possible the quantity of water that ought to be blown out of a boiler to prevent, 1st, accumulation of chloride of sodium, and, 2nd, the deposition of sulphate of lime in any quantity injurious to the boiler in any high degree. True, there is one way of getting over the difficulty, viz., working with a lower pressure, but this is out of the question for several reasons, and we must hence use experience and experiments as our guide. From the foregoing it will be clear that every pressure requires a different treatment and a different amount of water to be blown off. If we blow off more than is necessary to prevent accumulation of salt in the boiler, we have to pump a greater quantity of feed-water in, and consequently a great amount of sulphate of lime in solution, which will be deposited as a hard, tenacious scale. On the other hand, if we blow off too little, we will certainly get less sulphate of lime, but the accumulation of common salt will ultimately choke the passages in the boiler. This maxim, though true in theory, is modified in practice because of disturbing elements, viz., the more or less rapid circulation of the water. To strike the just balance it is, as before said, necessary to be guided by experience. It seems that ignorance has prevailed in high quarters till very late years because of want of data. Thus, we find that Mr. James Napier read a paper, in 1859, before the Institution of Engineers of Scotland, in which he recommended the use of a much larger regenerator (a sort of tubular feed-water heater, the heat of the brine blown off being made use of for that purpose), and blowing off to a greater extent than generally used. He tried the experiment himself, and gave the results in a paper, read February 17th, 1854, before the same institution. For the screw steamer Lancefield, trading regularly between Glasgow and the Hebrides, he made a regenerator of ten times the usual surface, and blew off to such an extent as to keep the density of the water in the boiler at very nearly the same point as the water in the sea. After four weeks' running, the boiler was examined, and instead of its being clean and free from scale, he found, to his surprise, it was coated with a much thicker scale than under usual circumstances, but soft, like newly made mortar, but it dried and hardened before he could get it all out, and it was then nearly as difficult to scrape as the ordinary hard scale. On one voyage, when he was present himself, he gave the boiler as much feed as the pump would do, and he observed then that the water in the gauge glass was muddy. He continued the experiment for six months, but with lesser quantities of feed, and blew off till the tubes of the regenerator gave way, and then he discontinued. He saw then M. Cousté's paper, and the table contained in the same, which shows that at two atmospheres pressure sea-water becomes saturated with sulphate of lime even at the ordinary density, and as he loaded to 40lb., and generally worked at 30lb., he saw at once the explanation of the phenomena. Although he blew off constantly from the surface by a conical tube, only some of the deposit of precipitate matter could be got rid of. This tallies exactly with the experience of some others. Some steamers in the American navy work with about or nearly 30lb. pressure and salt water, but it is believed not with our ordinary tubular boiler, but with long cylindrical boilers, having large round tubes and very ample water way. In the discussion following, Mr. Elder said he had worked marine boilers with 30lb. to 35lb. and salt water. One naturally expected to find most deposit in that section of the boiler which contained most salt and and lime, but in a boiler divided into eighteen parts (supposed to refer to his spiral flue high-pressure boiler), he found that though in the last section there was two-and-a-half times more salt in the water than in that of the first section, yet the deposit of lime was about equal in all parts. He concluded that the amount of deposit of lime depended on the temperature of the water, and not on the quantity of lime in it. The Americans, he said, ran with 40lb. pressure, and did not appear to suffer from deposit, but they cleaned the boiler whenever they came into port. He found the deposit to be greatest where there was no current. He had observed boilers running with 45lb. for three or four months, and there was not much more deposit than when working with 25lb. He believed that there was a greater tendency for the lime to separate and deposit, but it did not necessarily settle down on the heating surface of the boiler.

The *Mechanics' Magazine*, in an article on Incrustation in Marine Boilers, February 24th, 1860, mentions Mr. James R. Napier's paper, and assumes, for want of better data, 28 parts of sulphate of lime to 1,000 of solution as the limit of saturation in boilers working at a pressure not exceeding 20lb., and finds that, with this assumption, half the water must be discharged to keep the boiler clean, and this is affirmed by the practice of the British and North American Mail Company and others. Mr. Thomas Rowan found that when he had evaporated

$\frac{2}{10}$ of the water a trace of sulphate of lime deposited
$\frac{4}{10}$ " " "
$\frac{5}{10}$ " sulphate of lime deposited in large quantities;
$\frac{6}{10}$ " " " decided
$\frac{8}{1}$ " " very large quantities, also magnesia,

and salt began to form. It is probable, therefore, that half or more of the water would have to be blown off in order to prevent formation of crust. This means that the density of the water should be kept at $\frac{2}{32}$, for as sea water contains $\frac{1}{32}$ in its pure state, it is evident that half the water must be blown off to keep it at double its natural density. It may here be remarked that a density of $\frac{2}{32}$ is very generally kept in marine boilers, using about 20lb. pressure of steam, and if this be constantly and carefully attended to, no considerable or deleterious thickness of scale accumulates, at least in places where the circulation is good.

We come now to a brief survey of the various means proposed or adopted for preventing incrustation. They consist in

1. Surface condensers.
2. By heating the feed-water to such a temperature before entering the boiler, so as to oblige the sulphate of lime and other salts to accumulate in the heater only.
3. By introducing various substances into the feed-water before entering the boiler, the feed-water at the same time being subjected to heat so as to throw down the salts without allowing the same to enter the boiler.
4. By introducing various substances into the boiler so as to neutralise the effect of the salts, and
5. By blowing off in the usual or various other ways.

1. Surface condensers: This seems at once to do away with the nuisance; the economy anticipated has not, however, been quite realised in practice; it has been found necessary to inject a little salt water along with the distilled water from the condenser, and the duration of the boiler has been found in many cases to be even shorter than with salt water, on the reasons for which it is not thought necessary to enter into here.

2. Heating the feed-water before entering the boiler to such a degree that the salts are supposed to be thrown down into the heater instead of the boiler. This looks very feasible, but after all it amounts to shifting an evil from one place to another; let the heater be choked with salt and incrustation, and the engineer in charge has his hands as full as ever. To be admissible on board ship it must be compact, and at the same time accessible for thorough scaling, two conditions not very easily reconciled. The most practical shape is that of a casing with a number of dishes or shelves piled on the top of each other, which can be taken out and replaced by clean ones in a short space of time. This plan has been patented by Mr. Spencer, No. 896, and in 1864, No. 86, by M. E. Martin, a French civil engineer. It is possible that this idea, by no

means novel, possesses practical value, and at some future time may prove successful.

3. The plan of medicating the feed-water in a heater before it is admitted to the boiler, feasible and correct in principle as it appears, resolves itself, however, into a commercial question, and is contingent upon the price and bulk, and other qualities of the substances proposed to be used for neutralising the salts contained in the feed-water. Many substances have been proposed for this purpose, some evidently not of a harmless character as regards the iron plates of the heater, some evidently so expensive as to be out of question, and only one or two of a really feasible character. This latter class will be treated under the next head.

(To be continued.)

IMPROVEMENTS IN PARIS.

There is no diminution in the work of demolition and reconstruction which has now for several years proceeded with such unprecedented rapidity, and which seem destined in the end to obliterate nearly all the old landmarks of the city of Paris. The alterations which are being made in the neighbourhood of the Champ de Mars are, with a view to the coming Great Exhibition, being pursued with more than ordinary vigour; the excavation of the heights of the Trocadero for the new Place of the King of Rome, so named from the fact that it was on that spot that Napoleon proposed to erect a palace for his son, the young "King of Rome," are being carried on by night as well as by day. Thousands of cubic yards are being carried by rail across the Seine to the Champs de Mars every day. It is at night that the sappers fire the mines which are gradually reducing the heights of the Trocadero to masses of rubbish. The earthworks are completed in parts, and the ground is being levelled for the grand esplanade of the Place du Roi de Rome. This esplanade will be upwards of 1,600 feet in length by about 800 in width, and there will be eight wide boulevards or avenues, in addition to the bridge of Jena, leading from it to various parts of Paris and Passy.

An interesting discovery was made the other day in the old island of the Cité, in the demolitions now going forward on the site of the new building for the hospital of the Hôtel Dieu. An enormous oak beam, more than fifty inches square, was found in one of the oldest houses; it was but little worm-eaten or decayed, and on one of its faces was found the following inscription, in rude but perfectly legible characters:—"I was placed here in the year 1450, and I was 600 years old when I was taken out of the forest of Rovray." If this description is authentic, and the age of the tree were not overestimated, the tree from which this gigantic piece of oak was cut must have been almost contemporary with Charlemagne, and the wood must now be more than a 1,000 years old. One of the most remarkable instances of reconstruction now under hand is that of the corner of the Palace of the Tuileries nearest the river, called the Pavilion of Flora, and the long gallery which connects it with the Louvre. The pavilion, finished as regards the main work, is now in the hands of the sculptors and decorators, and begins to present a very imposing aspect. The upper part of the pavilion has two very important decorations; on the western face an ornamental fronton, surmounted by a colossal group of three figures, representing War, and, on the southern face, another group of the same dimensions, illustrative of Peace and Agriculture; the former of these beautiful frontons is by M. Cavelier, and the latter by M. Carpeaux, two of the most eminent sculptors in France. The wing, which will include, in that part nearest to the pavilion, a new *salle d'etat*, or hall, for the meetings of the Emperor and the members of the two chambers; in the other portion, the extreme end of the great gallery of the Louvre, which has been demolished, and, below, a series of fine arcades giving access to the Place de Carrousel, is not so far advanced as the pavilion. It is, in fact, a very extensive work, and consists of nine parts, each crowned with its pediment, and the style is in accord with the beautiful gallery of which it is a continuation. It is, moreover, the most elaborately decorated work which has been undertaken in Paris for many years; the whole of the upper portions of the building are covered with sculpture and ornaments. The lower part of the river front is Doric, with fluted pilasters ornamented with vine and ivy leaves, the capitals bearing lions' heads, crosses of the Legion of Honour, and bees. The pediments are alternately curved and pointed, and the frontons are decorated with the following sculptural works:—Agriculture, by M. Carrier-Belleuse; Navigation, by Madame Bertaux; Astronomy, by M. Ferrat; Commerce, by M. Choiselat; Amphitrite, by M. Cabet; Concord, by M. Walter; and Sculpture, by M. Perray. The roof is pierced by two rows of highly decorated dormer windows and otherwise ornamented. The inner side of the wing is of the Ionic order, after the model of the central portion of the palace, by Philibert Delorme. The frieze is decorated with subjects representing commerce, war, music, and the chase. The first floor is Corinthian, the capitals of the pilasters bearing rams' heads; between the windows are niches for statues, and over them a series of medallions of Roman emperors and poets. The attic story is similar to that of Philibert Delorme. The ornamentation of this portion is exceedingly rich; near each window is a seated figure, corresponding with the subject of the fronton above, executed in bas-relief, and surrounded by laurels, and above these are groups of animals by the sculptors Delabrière, Cani and Fremiet—two lynxes chained, and a Minerva; two dogs and a globe sprinkled with bees, and crowned with an imperial diadem; two hounds and a woman's head, with branches of oak and laurel; two otter hounds attached to a stag's head; two panthers chained to a vase filled with grapes. The first fronton representing Diana the huntress, is by M. Merley, and beneath it are two figures of huntsmen, with implements of the chase. The second fronton is devoted to glory, and is from the chisel of M. Gumery; beneath is a man with a trident, and a Roman warrior, holding a javelin and a small shield with a lion's head. The subject of the third fronton is the rape of Europa, by M. Demesmay, with figures of a German warrior and a Roman soldier beneath. The fourth fronton is decorated with a group entitled History, by M. Franceschi, with figures of a soldier and a sculptor below. The fifth represents a Dryad, by M. Delaplanche, and beneath are Neptune and a youth, representing a river. On the sixth fronton will be a figure of Venus, by M. Vitani, with Tritons blowing trumpets. The seventh represents Power, by M. Thomas, with figures of Hercules and Samson. On the eighth M. Perrault is to execute a Victory, with warriors below. The ninth and last fronton, which projects beyond the rest, are to be Cupid, by M. Soitoux, with figures of a woodman and an artist. On the entering angle, between the eighth and ninth frontons, will be two figures, Apollo holding a lyre and a laurel crown, and Paris with crook and apple of discord. The whole of the pediments are connected by a balustrade, on which are vases decorated with masks of fauns, and crowned with flames. The roof on this side has a double range of windows, ornamented with rams' heads and garlands of flowers, the whole being executed in that rich lead repoussé work, which has lately been revived with such admirable effect. In this mechanical age too much encouragement cannot be given to works of this class, which form the strongest link between the artist and the *ouvrier*. The Louvre, the the Tuileries, the Hotel de Ville, and other buildings, present much deserving of study in this kind of work. Before the summer is over the whole of the newly-constructed portion of the two palaces will be completed, at least as regards the interior, and the grand river front will then present a consistent whole, the beautiful work of the sixteenth century being no longer brought into comparison with the heavy inartistic building of the eighteenth century.

LOCKS AND KEYS.

At a recent meeting of the Institution of Mechanical Engineers, a description of a new construction of lock and key was communicated by Mr. J. B. Fenby, of Birmingham. The writer pointed out that in all previous locks there had been two important defects in principle, which are fatal to their security—the first being that, although access to the works of the lock is greatly impeded by many ingenious contrivances, they still admit of the works being got at through the keyhole, and thus allow of a series of attempts being made to pick the lock; while the second defect is the possibility afforded for repeating the trial of a false key, and thus perfecting it by successive alterations after trial. In the new lock described in the paper, which is the invention of the writer, the principle is adopted of dividing the key into two parts, the bit or portion by which the levers of the lock are raised being separate from the stem or handle of the key. For unlocking the lock the bit is inserted through a second keyhole into a radial slot contained in a solid rotating cylinder, the cylinder being then turned round by the stem of the key acting in the centre keyhole; the bit while being carried round is also pushed outwards along the radial slot by means of a cam, and is thus made to protrude from the circumference of the cylinder sufficiently to act upon the levers of the lock, and thereby set the bolt at liberty to be withdrawn. The bit is then pushed out of the radial slot, and drops into a receptacle inside the door: and the further revolution of the cylinder withdraws the bolt, and unlocks the door. The consequence of this mode of construction is that, as soon as the bit has been inserted in the lock and the cylinder turned round for unlocking, the radial slot in the cylinder is carried away from the keyhole, which is completely closed by the solid cylinder, whereby all access to the interior of the lock through this opening is effectually prevented, nor can anything be passed into the lock in this way except a detached bit of metal not larger than the bit by which the lock is opened. The centre keyhole, into which the stem of the key is inserted for turning the cylinder, is simply a blind socket with parallel sides, and without any communication with the interior of the lock. The only possibility of opening the lock by fraudulent means lies, therefore, in the use of a counterfeit bit introduced into the lock in place of the true bit; but this counterfeit is absolutely lost to the operator and retained inside the safe at the very first trial, so that he is not only limited to a single attempt, but from the attempt itself no clue whatever is obtained as to the nature of the defect in the counterfeit. In consequence of the levers not being accessible for feeling through the keyhole, and therefore not requiring to be all shaped to the same average curve at the portion acted upon by the key, each lever can be shaped to its own proper curve, and the play in the action of the levers is thus reduced to a minimum; hence a much slighter amount of error in the counterfeit than is admissible in the case of previous locks will prevent its opening this lock. The importance of these advantages in the principle of the new lock is illustrated by the celebrated bullion robbery on the South-Eastern Railway some years ago, which attracted special attention from the remarkable skill with which it was accomplished and the large value of the property stolen; but even in this case success was not attained until as many as seven trials had been made with the same false key, the latter being altered after each trial according to the indications obtained from the trial, until it was at last sufficiently perfected to be capable of opening the lock of the bullion safe. In that instance also the successive trials were made without leaving any indication behind that the lock had been fraudulently attempted, although it was fitted with detector contrivances for this special purpose; but in the present lock the false bit, being retained inside the safe, is found when next the safe is opened, and furnishes proof of the fraudulent attempt having been made, as well as showing how near the counterfeit key has approached to the original. The locks are made with six levers, and the corresponding steps in the bit are cut with the greatest accuracy by a machine specially contrived by the writer for that purpose, with a permutating arrangement, having an extent of permutation admitting of each lock differing from every other lock made. For locking the lock, the stem only of the key is required, as the bolt is shot simply by turning the cylinder; and as the keyhole for the stem is made with a notch cut out on one side only, while the cylinder is not permitted to make a complete revolution, the key stem cannot be taken out of the lock whilst it remains unlocked. This lock has an important advantage in simplicity as well as solidity of construction, as there are no more than sixteen separate pieces altogether in the complete lock; moreover, as both keyholes are simply blind holes with parallel sides, having no communication with the interior of the lock, they do not admit of injury to the lock by the explosion of gunpowder. Specimens were exhibited of the new lock, the action of which was shown both with the true key and with counterfeit keys; and it was shown by trial that the counterfeit failed to open the lock notwithstanding that, by means of the permutating cutting machine, it had made a much nearer approach to a perfect copy than was practicable in the best handwork from a wax impression. The key-cutting machine, for cutting the bits, was also exhibited, having been lent for the purpose by Messrs. Whitfield, of Birmingham, the makers of the locks.

INDIAN RAILWAYS IN 1865.

Sufficient time has now elapsed since the Government first gave its aid to the establishment of railways throughout our Indian Empire, to furnish data as to the expense of the lines when completed, and the probable profit and loss of the undertakings. From a multitude of sources, from the Government report of Mr. Juland Danvers, from figures published in India, from the writings of Mr. W. P. Andrew, chairman of the Scinde Railway Company, from the survey of the Euphrates Valley, by Major-General Chesney, and from other authorities, a mass of statistics is here given of the present position of railways in India, and the probability of the future union of that system with the lines of Europe.

At Midsummer, 1865, the number of miles of railway opened for traffic in India was 3,186¼, and the length remaining to be finished, 1,730¼, making a total of 4,916½ miles, consequently about two-thirds of the lines sanctioned by Government are finished. Of the ten Indian railways and their branches, the following number of miles are open for traffic:—East Indian, 1,126; Great Indian Peninsula, 595¼; Madras, 571; Bombay, Baroda, and Central India, 306; Scinde, 114; Punjab, 252; Punjab, Delhi, none; Eastern Bengal, 114; Great Southern, 79; Calcutta and South-Eastern, 29; total, 3,186¼.

The miles of the sanctioned lines yet to be finished and opened are:—East Indian, 370½; Great Indian Peninsula, 670¾: Madras, 281; Bombay, Baroda, and Central India, 6; Scinde, none; Punjab, none; Punjab, Delhi, 320; Eastern Bengal, none; Great Southern, 82; Calcutta and South-Eastern, none; total, 1,730¼.

Here it will be seen that Bombay and Culcutta are not yet united, 670¾ miles of the Great Indian Peninsula Railway having to be finished before the English mails find a quicker route than going all round India. This link is not likely to be completed before 1870. There is another gap between Bombay and Madras, that being the route by which the inhabitants of Bombay wish the mails for Australia and China to be carried. To the extreme west is seen the portion of the coast of Beloochistan, recently explored by Lieut.-Colonel Pelly, a portion of the unknown district through which it is hoped a railway will run to Europe, *viâ* the Euphrates Valley, and Turkey in Asia.

With very little exception, the whole of the lines in India, finished and unfinished, are single, and the trains travel at a very slow rate of speed. On the East Indian there are 67 miles double, and on the Great Indian Peninsula 57, making a total of 124 miles. Besides this, the doubling of 42 miles more, on the latter railway has recently been sanctioned; all the rest, finished and unfinished, are single lines. In 1863, the number of miles open for traffic was 2,519, and on these open lines 194 accidents occurred in that year, 112 of them being fatal. This is a very high rate, the number of passengers in the twelve months being 10,706,030, but only eighteen of the number were killed by causes beyond their control. Of these eighteen, eight were passengers, and ten servants of the railway. Three of the eight were killed by a train being thrown off the rails by a stray buffalo, two lost their lives by a train getting off the line through negligence, and the others were purely accidental. In Mr. Juland Danvers's report, one of the deaths is described as caused by "the bite of a tiger," which, without explanation, appears a strange railway accident; and another fatal case was that of a passenger who jumped out of a train while it was on fire.

The following is a summary of the rolling stock employed on all the Indian railways, up to the end of the year 1864:—

Railways.	Locomotives.	Carriages.	Trucks and Waggons.
East Indian	311	518	4,197
Great Indian Peninsular	118	270	3,226
Madras	76	165	1,507
Bombay, Baroda, and Central India	65	236	3,121
Scinde	31	66	647
Punjab	8	36	140
Eastern Bengal	26	102	970
Great Southern	11	33	171
Calcutta and South Eastern	6	42	157
Total	646	1,468	13,796

The capital expended for rolling stock since the first Indian line was commenced, up to the 1st of May, 1865, was £54,942,029, the expenditure during the past year only being £3,806,044, of which about £2,418,345 was spent in India, and £1,387,699 in England. To meet this expenditure, 36,533 shareholders subscribed up to the 31st of December, 1864, £58,000,000. Of these shareholders 29,303 were registered in England, and 777 in India, 393 only of the whole being natives. Hence it is evident that residents in England consider Indian railways a good and safe investment for capital. The number of debenture-holders at the end of 1864 was 6,453. The rate at which capital has been expended upon Indian railways during the past fifteen years is shown by the following figures:—In 1850, £175,156; 1851, £351,323; 1852, £427,560; 1853, £670,649; 1854, £1,729,588; 1855, £3,371,005; 1856, £3,517,907; 1857, £3,417,268; 1858, £5,491,125; 1859, £7,162,872; 1860, £7,583,770; 1861, £6,558,614; 1862, £5,810,852; 1863, £4,771,775; and 1864, 3,806,044. The total loss to Government during the year 1864, after allowing for the profit gained by the lines at work, was £130,000. "But," says the Government Director of Indian railways, "each year this loss will diminish, and when the revenue receipts become larger than the capital expenditure in India, which will soon be the case, the balance of gain, which has hitherto always been on the side of the railway companies, will be on the side of the Government." It is not difficult to suppose such will be the case, seeing that as yet great gaps in the most important through routes stop large streams of traffic.

Here is one great fact. Indian railways have been free from parliamentary contests, consequently the cost per mile of Indian railways (if completed according to estimate) will be as follows, notwithstanding the expense of transporting men and materials from India:—East Indian, £20,849; Bombay, Baroda, and Central India, £19,230; Delhi, £18,750; Scinde, £17,543; Eastern Bengal, £15,789; East Indian (Jubbulpore), £15,555; Great Indian Peninsula, £12,646; Madras (N.W. line), £12,500; Punjab, £11,857; Madras (S.W. line), £11,178; and Great Southern, £9,316. The average cost per mile of English railways, including purchase of land, is £33,350. Although, then, the average cost of English railways is comparatively low, there has yet been plenty of extravagance on the part of some of them, as shown by the following table, which is given in the *Times*, of India, a local authority interested in the facts:—

Railways.	Percentage of working expenses to gross receipts.	Percentage on average cost of miles open really yielded by present gross receipts.	Percentage which present gross receipts would yield if working expenses were fifty per cent. only.	Percentage which the railways when completed would pay if their gross earnings were £48 per week.
East Indian	55·2	2·4	2·7	6
Great Indian Peninsula .	70·9	2·2	3·8	10
Bombay and Baroda ...	50·	1·9	1·6	6·5
Madras	58·3	2·1	2·2	10·4
Eastern Bengal	53·8	2·3	2·5	8
Scinde	93.2	·33	2·4	7
Punjab	72.2	·9	1·6	10·4
Great Southern ...	49·8	1·8	1·8	13·3

The excessive ratio of working expenses of the Great Indian Peninsula Railway in the above table is owing principally to the compensation paid during 1864 for cotton destroyed by fire or detained at the Thull Ghaut. There are such discrepancies, however, in the other figures, that special investigation as to this matter of working expenses seems necessary. The East Indian, especially, has an expensive establishment, much more than residents deem necessary for the efficient working of the line, which has a series of very magnificent stations. Officials in India should be highly paid, and we are not advocates for shabby stations; still this, and perhaps other companies, seem to have gone beyond the fair medium.

The fares on the Indian railways vary as follows:—First class, from 1¼d. per mile on the Scinde Railway to 1⅜d. on the Bombay and Baroda. Second class, from ⅝d. on the Madras Railway to 1d. on the Great Indian Peninsula, and several others. Third class, from ½d. to ¾d., half the lines charging the one amount and half the other. There is a fourth class at ⅜d. per mile on the East Indian, Eastern Bengal, and Calcutta and South-Eastern Railways.

The following shows the amount of guaranteed interest paid by Government during 1864, as well as the total amount paid since the first railway in India was commenced:—

Railways.	Interest paid up to December 31, 1863. £	s.	d.	Interest paid during 1864. £	s.	d.	Total to December 31, 1864. £	s.	d.
East Indian	5,200,109	1	2	1,057,448	19	7	6,257,558	0	9
Great Indian Peninsula ...	2,295,770	10	0	556,491	5	7	2,852,261	15	7
Madras	1,480,197	6	1	345,284	18	9	1,825,482	7	10
Scinde	388,336	7	9	92,462	11	4	430,798	19	1
Punjab	229,448	5	5	94,033	16	3	323,482	1	8
Delhi	37,986	2	11	52,274	14	3	90,260	17	2
Indus Steam Flotilla ...	68,080	6	9	16,644	8	5	84,724	15	2
Bombay, Baroda & Centrl. India	583,283	15	11	228,761	19	6	812,000	15	5
Eastern Bengal	207,774	7	1	70,000	0	0	277,774	7	1
Calcutta and South Eastern .	55,806	19	5	19,811	13	11	75,618	13	4
Great Southern	91,047	0	7	29,529	7	0	130,576	7	7
Total	10,592,795	3	1	2,567,743	14	7	13,160,538	17	8

Of the above total paid by the Government during 1864, £2,533,381 19s. 3d. was paid in England, and £34,361 15s. 4d. in India. Of the total amount paid from the first up to the end of 1864 by the Government, in the shape of guaranteed interest, £3,300,000 has been paid back by the earnings of the railway companies. When the traffic on the railways yields a profit of more than 5 per cent., the Government payment of interest, of course, will cease, and half the surplus over 5 per cent. will go to the railway companies, the other half to the Government. Of the shareholders receiving the guaranteed interest, more than half hold less than £1,000 stock, and, as already stated, nearly all reside in England. These shareholders appear to have as much confidence in the Indian railways as in the funds, and there is never any lack of applicants for more shares when any are issued.

The above, in a compact form, gives all the principal points of interest respecting the railways of our Indian empire, up to and in some instances later than December 31st, 1864.

Of the railway servants employed, only about one in twenty is not a native, and the natives only receive one-third or one-fourth the salary of Europeans, the latter being required to occupy the position of responsibility and places where skill and nerve is wanted. The natives make very good clerks and station-masters, but are useless as engine-drivers and pointsmen.

As regards the health of the European officials during the past year, twenty-two died and seventeen retired through ill-health. Of the deaths, eleven took place on the East Indian line, five on the Great Indian Peninsula, two on the Madras, one on the Bombay and Baroda, two on the Punjab, and one on the Calcutta and South-Eastern. The average number for the four previous years was thirty-five per annum, so the mortality last year had decreased. The mortality among those who go out to India averages rather less than one per cent. per annum, but many are prevented from leaving England by the examining physician refusing to pass them. Mr. William Brinton, M.D., F.R.S., is the gentleman who examines most of the candidates for the Indian railway service, and he says that he has been obliged to reject one out of every five during the past year. This proportion must be regarded as a large one, especially on consideration that a large number of the candidates had previously undergone a medical examination before appointment on the English railways. Many so employed in England show symptoms of premature decay to such an extent that no good London insurance office would accept them as first-class lives. Workers in metal, and those continually engaged in piece-work, exhibit these lessons or tendencies most, and it unfits them to resist the change of climate or to withstand hard work beneath the burning sun of India. Dr. Brinton states in proof of this assertion that the average age of the persons examined is thirty, and the average age of those rejected is from thirty-three years to thirty-five years. Railway officials in India are liable to a heavier rate of mortality than recruits despatched there for military purposes, unless the latter be on active service. The surveying and construction of railroads expose the engineers and others to trying ordeals, and to the heat of the noontide sun, and to the malaria of the marshes and jungles. At the foot of some of the Indian mountain ranges, more especially the Himalayas, a belt of marshy forest ground is often found, where even the native cannot live; yet, wherever the railway goes, there must the officials go also. Dr. Brinton states that the enforced idleness of the overland journey, and the very sudden change of climate by that route, is more trying and dangerous to European constitutions than the old route round the Cape of Good Hope. He recommends the latter whenever it is possible to choose it. Those officials passed by him are, as a body, remarkable for their vigour and health before leaving England.

The difficulties overcome by the engineers within the last year or two, to bring about the grand results that have occupied our attention, have been noticed from time to time in this journal. The Bhore and Thull Ghaut inclines, on the Great Indian Peninsula Railway, have broken through the great mountain range into the cotton districts of Central India. The Bhore Ghaut incline rises more than 1,000 feet in a little over six miles, in the midst of the grandest mountain scenery, and the Thull Ghaut has an incline of 1,000 feet in ten miles, the steepest gradient being 1 in 37 for 4 miles 30 chains, and the sharpest curve 17 chains radius for a length of 33 chains. There are thirteen tunnels of an aggregate length of 2,652 yards, and viaducts to the extent of 741 yards, one of 250 yards being 200 feet high. The cost of this incline was £50,000 per mile. The cyclone, which did so much damage at Calcutta about a year ago, spent some of its fury on the railway termini there, the East Indian sustaining damage to the amount of £9,515, the Eastern Bengal £12,600, and the Calcutta and South-Eastern £1,730; total £23,245. Such were the effects of the great hurricane, which is supposed to have originated at the Andaman Islands, a nest of storms, and a place where two troop-ships, according to Dr. Mouat, were once blown clean out of the sea into the jungle. In the storm now under notice, not only were stations and sheds swept away, but an engine and part of a train on the Eastern Bengal Railway blown over. On the western side of India the monsoon, in the middle of the year, is stated by Mr. Juland Danvers to have caused much damage by its floods. On the 27th of June the embankments of a culvert were washed away on the Great Indian Peninsula Railway, and on the following day a viaduct of 12 spans of 30ft. iron girders was destroyed. A night train passing shortly afterwards ran into the gap, and fourteen native passengers were unfortunately killed on the spot. Six spans of the great bridge over the Nerbudda river were swept away by the floods, and the traffic of the Bombay and Baroda Railway had all to be carried across the water here in boats for several months, the arduous and dangerous task of superintending the transit from side to side falling upon Mr. Frederick Potter, late of the South Wales Railway.

The quantity of materials sent out in 1854 for the construction, maintenance, and working of railways in India, amounted to 102,318 tons, in 233 ships. The value of the goods shipped was £1,018,164, and the amount paid for freight and insurance, £164,528.

The rate for first-class passengers on the East India Railway is 2½d. per mile, for second-class 1½d., and for third-class ⅜d. The first-class fare from Calcutta to Delhi is 95 rupees, the second 48 rupees, and the third less than 16 rupees. If we contrast the time—three months—that it took not fifteen years ago to make the same journey, and compare the £9 10s. with the enormous sum paid formerly, it may be acknowledged that railways are working wonders in India.—*The Calcutta Engineer.*

HIGH ART IN LOW COUNTRIES*.

By the Dean of Ely.

There is one preliminary question which stares us in the face. What do we mean by Art? And though this is a simple question, I am not sure that it is easier to answer on that account: in fact, it is not unfrequently just the simple preliminary questions which are least likely to meet with satisfactory answers. Ask many persons who use the terms to define what they mean by a *Whig* or a *Tory*, or a *right-angled triangle*, or a *respectable man*, or a *genteel female*, and you will probably find it difficult to get a clear answer; and you may be reminded of the wisdom of a certain leader of the House of Commons, who, having endeavoured in vain to obtain a definition of the duties of an Archdeacon, and being compelled to make a speech which involved the knowledge of those duties, began by saying that the duties were so well known that he would not take up the time of the House in explaining what they were. What then, I say, do we mean by *Art?*

In the first place, with regard to the word: it is, of course, the same as the Latin word *Ars, artis,* and as the French *Art.* This fact is not very interesting; but there is, I think, some interest connected with the etymology of the word if we trace it a little further. The dictionaries tell us that the Latin word *Ars* is the same word as the Greek *Aréte;* and this Greek word, which signifies any kind of *ability* or *skill*, but originally denoted more especially *warlike* ability or skill, *courage, valour*, is probably connected with *Arés*, the Greek god of war, the Mars of Latin mythology—a connection which I notice, because certainly *art*, as we understand the word now, *art* as the word is used in such a phrase as "The Wisbech Industrial and Art Exhibition," would have chosen any god or goddess in Olympus as its patron in preference to *Arés* or Mars, the fierce god of war; and if a name which originally described the power of an Achilles or an Ajax can now be used with most emphatic propriety to describe the power of those who beautify the houses of God and adorn our homes, then we may perhaps see in the change of meaning something of that change which is described by the prophet when he speaks of men "beating their swords into ploughshares and their spears into pruning-hooks," and "learning war no more." Again, the dictionaries tell us that *arrete* is probably connected with *arrén*, a *male*, as the Latin *virtus* is connected with *vir*, a *man; virtus* signifying originally *valour, courage*, those qualities which were considered to be the chief glory of *men;* but virtue is now no longer any special property of *men*. I should think it quite a sufficient claim for men that they should be put on an equal footing with their fair sisters; more than their half of the virtue which exists in the world I am certain they have not got. And so, also, if *art* originally implied anything of masculine skill, manly valour, warlike craft unsuitable for women, we may congratulate ourselves that it is so no longer, and that art, in the sense in which we are dealing with it to-day, belongs to men and women alike.

Let us, then, leave the word and come to the thing. Art may be regarded in the first instance as meaning skill in general; but we treat it as meaning skill of a particular kind. And I think that we may properly define what we mean by saying that *art is that kind of skill which is employed in clothing the useful with the beautiful.* Let us consider this definition.

Many things are useful without being beautiful. There is no beauty worth speaking of in a gasworks-chimney, or in a newspaper, or in a railway-carriage; yet all these things, and thousands more which might be mentioned, are singularly useful. It is not every useful article, perhaps, which admits of a covering of beauty; in some things the intensity of usefulness seems to make beauty unnecessary, or perhaps to make the attempt to add to it ridiculous; their usefulness, in fact, is beauty, and with that they must be contented. Nevertheless, it is surprising how very few (comparatively speaking) are the cases in which superadded beauty is impossible, and, therefore, art unnecessary. In fact, the instinct of art would seem to be almost coeval with the instinct of supplying the prime necessities of human life. Amongst the earliest remains of human handiwork which recent discoveries have brought to light are rude carvings upon pieces of bone, which no doubt were regarded by the connoisseurs of the time as marvels of imitative skill. Men were compelled by their necessities first to make tools, but they soon began to ornament those tools; and I suppose there is not a savage nation on the face of the earth in which utility is everything and art nothing. On the other hand, art appears to belong to man's simplest nature; and it is only in a very advanced state of society that men think it a mark of superior sense and judgment to glorify utility at the expense of beauty.

Nor is it to be wondered at that man's nature should be thus constituted, seeing that God made man, and that the principle of clothing the useful with the beautiful, which I have spoken of as the foundation of art, is just the principle upon which (speaking generally) we may say that God's works are constructed. Look at the human figure, the human face, the human hand, the leg, the foot. Every portion is useful; but not only so—every part is beautiful; and the beauty and the utility are married together. We may speak of the eye as an optical instrument; but when we speak of the bright eyes of our fair sisters we think of something very different from optical instruments. And the mouth is a very utilitarian organ, and has very commonplace work to do; but there is hardly anything more beautiful and more expressive than the human mouth, and we are not thinking of mere utility when we speak of ruby lips. So of other parts of the face and of the body. Organs which appear to be hopelessly utilitarian, like the stomach and the heart, are packed away in closets; and the human frame as presented to the eye—especially if not spoilt by barbarous costume—is a perfect specimen of the useful clothed with the beautiful: in other words, it is a perfect type of that which, in human works, we describe as *art*.

The useful and the beautiful, then, are combined in a work of art; and let me observe that the degree in which each of these two constituents will predominate varies very much in different cases. In some the use is almost everything, and the beauty superadded is trifling; as, for instance, when two kinds of bricks are used in building a house, so as just to break the dull uniformity of the walls; in others the utility has almost vanished to make room for mere beauty, as in the case of pictures. But, as a general rule, art does not seek mere beauty, but follows the example of nature, in which use and beauty go together, and utility is often an absolute condition of beauty; yet even in nature we sometimes find the beautiful almost as supreme as in the case of a picture; thus we have the gorgeous colours of the morning or evening sky, and on a smaller scale we have the butterfly and the humming-bird.

Hitherto I have been speaking of art as though it addressed itself entirely to the eye; and, in fact, the kind of art to which this Exhibition chiefly directs our attention is that which belongs to the sense of sight. But it ought to be observed, if only for the sake of justice, that the eye has not a monopoly of the pleasures of art. Art acts upon the mind, like almost all other things, through the senses; but there are only two of the senses which appear to be capable of being associated with art properly so called. The sense of *taste*, for example, might claim as its peculiar field the *art* of cookery; but we must not in an application of the term admit cookery to the dignity of *art;* and the sense of *smell* might claim that *art* which is hereditary in the family of *Jean Maria Farina*, of Cologne—but neither must the composition of perfumes be admitted to the dignity of *art*. *Feeling*, though a very useful, is so very humble and commonplace a sense, that it will probably hardly put in a claim. No, the two senses which are dignified beyond the rest as being the vehicles to the mind of the beautiful, and consequently the organs of art, are *hearing* and *seeing*. Hearing may well compete with seeing in the dignity of its art-function; music may challenge painting and sculpture, and claim equality of dignity: frequently the two join in partnership, as, for instance, in the

* An Address delivered at the opening of the Wisbech Industrial and Fine Art Exhibition.

choral worship of a beautiful cathedral; indeed, one may say that the *entente cordiale* between these two senses is complete, so that sometimes they interchange names with each other: thus, when I see a letter from a friend, I say that I am glad to hear from him; and when a person explains to me, by word of mouth, some difficulty, I say, "Ah, now I see what you mean."

It is no discourtesy, therefore, to those branches of art which have the ear for their organ, that we do not consider them to-day. We are dealing with art chiefly or almost exclusively as it belongs to the eye, and in so dealing with it I think we may adopt the definition which I have given already—that it is the clothing of the useful with the beautiful. The question, therefore, which it would seem to me should be prominent in the minds of those artists whose efforts we chiefly desire to stimulate by Industrial and Art Exhibition is this—How shall I make my work beautiful? How shall I produce that which is in good taste? And this question, like many others, is very briefly asked, but cannot be very briefly answered. Something, however, may be said which may be of use, and, with your permission, I will devote a few sentences to the subject.

I would observe that there are three great elements of beauty which ought to claim the attention of all art-workmen, and which comprise almost the whole of their artistic stock-in-trade. The three great elements to which I refer are—Form, Proportion, and Colour.

The importance of *form* is illustrated by the fact that with the Latins *forma* was actually equivalent to *beauty;* and so thoroughly does form imply beauty, that, if the form be good, it is almost impossible to destroy the beauty. Take an instance. No position is more trying than that occupied by St. Paul's Cathedral in the midst of London smoke. There it stands from year to year with the accumulations of the atmospheric filth of perhaps the filthiest atmosphere in the world; and if the dome depended upon the colour of its material for its beauty, alas! for the dome; but its beauty is its form, and as its outline catches your eye, lighted up by such daylight as the city of London enjoys, you cannot help saying that it is one of the finest buildings in the world.

The education of the eye to the delicate perception of form, and the education of the hand to the production of form, are, I conceive, amongst the prime requisites of art-education; and it is a kind of education which is the more important because the tendencies of modern times are in some respects unfavourable: there is such a tendency to manufacture things on a large scale, to use the rule and compass rather than the eye, to meet the demand of the times by the production of articles cheap and nasty, that there is danger of men being frightened away from sound principles of honest art by the dread of being starved in the process of carrying out the principles. Let me illustrate the importance of form by reference to something which I remember hearing from Professor Willis. Professor Willis invented an ingenious instrument, which he called a *Cymograph*, an instrument for obtaining correct drawings of the mouldings of Gothic architecture. It is not very easy to do this, as anyone will perceive who remembers how deeply under-cut and hollowed out many of these mouldings are; however, Professor Willis invented the cymograph, and he did so because he had long been struck by the contrast of effect between ancient work and modern work which professed to be merely an imitation of the old. Now, when the two came to be fairly laid side by side upon paper, by help of the cymograph, what was the difference between them? Just this, that in the case of the ancient work the lines of the mouldings were drawn by the artist with a free hand; whereas, in the modern, every curve was a circle struck with a compass. The ancient architect, in fact, went by the rule of *brains*, and the modern by the rule of *thumb;* and I well remember the perplexity caused by this distinction to a very clever and competent man, who for a time superintended the recent restoration of the Ely lantern. Mr. Scott had asked him to make working drawings of the old stonework outside the lantern, and the good man attempted to do so according to modern rules of art; but to his dismay he could find no centres from which to strike his circles, and every modern rule of stonework was ruthlessly set at defiance. If you had asked the great architect of the lantern, "With what do you draw the designs of your stonework?" he might have answered, like the artist in Dr. John Brown's Essay, who being asked, "With what do you mix your colours?" replied, "Wi' brains, sir."

So much for form; proportion is equally important. Indeed, it may be said that proportion is an element of form, that form depends very much upon proportion. Still, proportion deserves separate consideration, and I should be very glad to give it such consideration as my poor ability might enable me, if it were not that I felt the necessity of studying proportion also in my address, and hastening to conclude this portion of it, and proceeding to that which is more particularly implied by its title.

For the same reason I must pass, with a rapidity which much grieves me, over the subject of *colour*. I must remark, however, that in this department there is a great deal to be done, and great encouragement to Englishmen to endeavour to do it. There is a great deal to be done, because, until lately, colour was in many departments of art almost forgotten, especially in architecture. We seemed some years ago to regard as an axiom that we should have no colour except those of wood and of stone. Now we are beginning to wake to our mistake; and the danger is lest, in the zeal of our returning consciousness, we should rush with brush in hand and commit some tremendous blunders. It is for fear of committing such a blunder that the lantern of Ely Cathedral is now left in its unfinished condition. It was thought better to look at the woodwork in its cold, crude, patched condition, and to consider how it should be treated, rather than paint the whole in a hurry, and repent of the result at leisure. But there is, as I have said, great encouragement to Englishmen to work at the colour department of art. Englishmen have not, I think, as a nation, good eyes for form and proportion. Certainly we do not in general draw so accurately as our French and German neighbours; but we do hold a high position as colourists; and in any international exhibition of pictures, perhaps nothing will strike you more than the excellence of the colouring of works of the English school. Let me dismiss this part of the subject by saying that colour seems to me to be in a very special and peculiar way a gift of God. Form and proportion, you may say, are God's gifts, inasmuch as God gives us the power of appreciating the beauty which arises from them, and sets us examples of such beauty in His works; but the beauty of form and proportion is, after all, connected with geometrical necessity, and, therefore, can only in part be connected with divine benevolence. Not so colour. Colour, and therefore all the beauty and pleasure arising from it, is the result of a distinct creative act, which (as far as we can perceive) need not have been performed.

"God said, 'let there be light,' and there was light;" but when God created light, He created colour too. The beams of light were not simple, inseparable undulations, capable of discharging the useful office of conveying messages to the eye: but the white wave was made capable of splashing into numberless colours; and the great discovery which Newton made, not much more than a century ago, was in reality the discovery of a primeval act of God's providence, of which men had perceived, for thousands of years, the pleasant and refreshing consequences, though they were in ignorance of the method of God's operation.

I have now spent as much time as I can afford upon the general question of art, and I pass on to the more direct discussion of the subject which I have chosen particularly for this address, and which I have shadowed forth in the epigrammatic title *High Art in Low Countries.*

I do not know whether the notion is generally prevalent, but I confess that to me it seems very natural, that districts such as this in which Wisbech is situated should be unfavourable to the flourishing of art and the birth and growth of art genius. Far be it from me to say anything disrespectful concerning the Isle of Ely, but its best friends will not deny that it is flat, that it is deficient in picturesque features, and that there is not much in it to stir the imagination, or drive men to write poetry in celebration of its natural beauties. The wild land of mountains, waterfalls, woods, and rivers, seems to be, as Sir Walter Scott phrases it, the "true nurse of the poetic child;" in the midst of ditches and sluices the poetic child is likely to be smothered in infancy; and hence I think there is a tendency to imagine that the child of art is likely to fare as badly in our fen country or in Marshland as the child of poetry. But in truth any such imagination would be unfounded, and would be contrary to experience. That this is so I intend to prove for your comfort more at length presently, but before I do so I would first make two remarks.

In the first place, it seems to me that the very absence of natural beauty in a flat country is likely to force the minds of the inhabitants in the direction of art. The possession of everything upon which the eye can delight to rest all ready-made (as it were) by the hand of nature, may have the effect of checking the appetite for art, whereas the famine of natural beauty may compel a search for artificial food. Certain it is that the earliest works of art are to be found in the prosaic valley of the Nile, and in the flat country of Mesopotamia, and I think that everyone must feel that the existence of beautiful churches, such as we find throughout Lincolnshire and the Marshland district of Norfolk, is a boon which in a more interesting country we should not appreciate nearly so highly.

But, in the second place, I think it should be borne in mind that a flat country is not without its advantages even in respect of beautiful objects upon which the eye can rest with pleasure, and by which the artist's eye can be educated. The effects of sunrise and sunset, and generally all beauties depending upon the atmosphere, are seen nowhere better than in a district such as this; everyone must have been struck occasionally with the grand cloud-pictures which may be seen in a country having a wide horizon—eccentric forms, Alpine snowy ranges, weasels and whales, and every variety of hue: no lesson in colours can be better, and with such favourable lights it does not require much to make a picture: a twist in a river with a windmill, or a cottage, an old barge, a peasant, and a dog, will probably furnish the subject of a charming work of art.

Perhaps I may add, in speaking of flat countries, that they have in past times had an advantage over others in this respect, that they have got rich more quickly. Districts lying level with the sea, and intersected by natural highways in the form of rivers, with a rich soil ready for tillage, have generally been the earliest homes of commercial wealth, and wealth is necessary for the encouragement of art; "money" is said to "make the mare to go," and it makes the artist's brains and fingers to go too: artists of all kinds object to hunger, and unless there be men who are rich enough to be patrons of art, art is likely to wane.

To be sure you may sometimes find a man art-mad, like the famous French potter Palissy, who broke up his chairs, tables, bedsteads, everything, to keep up the fire in his furnace till his experimental pieces of pottery were sufficiently baked, and who got into scrapes with his wife in consequence which would have appalled a less stout-hearted man; and even Palissy, by-the-way, would not have been able to achieve what he did had he not met with influential patrons in the royal family of France. Money does not necessarily beget art; it may breed mere vulgarity and extravagance, still there must be wealth to enable people to patronise art, and there must be education to teach people to appreciate it, and those countries which rise early to opulence are likely to be found amongst the early nurses of art.

And these considerations lead me to speak upon the remarkable growth of art in times gone by in those countries which we claim, *par excellence*, as the Low Countries—the *Pays Bas*—or *Netherlands*. If anyone wishes to know how high art can soar in low countries, he should observe what art has done in Belgium and Holland. We people of the fens have, as I shall show you presently, some very special grounds of consolation concerning art here in this Isle of Ely; but if we are not contented with what we can find here at home, we may easily run over the sea and find, in a country very like our own, consolation enough to comfort the most weak-hearted. Will you kindly accompany me to Belgium and Holland for a very short trip, and as the G. E. R. Company has made everything so snug and comfortable by way of Harwich and Antwerp, will you consent to adopt that route?

As we steam up the Scheldt everything looks inartistic enough: mud-banks, the country as flat and uninteresting as our own; but as soon as we land at Antwerp, or rather for some time before landing, we find a pledge of high art in the beautiful spire of the great church of Nôtre Dame. This is a wonderful piece of construction, and is enough by itself to make Antwerp worth a visit; very lofty, 360ft. high, but much more remarkable for its structure than its height; it is light as lacework, being in fact scarcely a stone building in the proper sense of the word, but rather composed of pieces of stone clamped together with metal. The Emperor Charles V. is reputed to have said that it ought to be kept in a case. In my own humble opinion it is the most beautiful spire in the world; and I may add here, by way of parenthesis, that an additional stimulant to art is to be found in flat countries in the incitement which seems to be given to the erection of lofty buildings; when men have no mountains near them to dwarf their puny efforts, it is worth while to try how much of beauty can be gained for a building by the element of height.

The spire of Nôtre Dame at Antwerp is, however, merely the most conspicuous specimen of the art treasures of the old town. Even in the way of church art it merely stands at the head of a long list. I must pass over this list to remind you that at Antwerp you meet with the masterpieces of Rubens, and with specimens of others of the most remarkable of Flemish painters. There is, perhaps, hardly any gallery in Europe of the size which contains more treasures and less rubbish than that at Antwerp; and, after all, it does not contain what is regarded by many as Rubens's masterpiece, the "Descent from the Cross," which hangs in the great church.

The mention of Rubens, the king of the Flemish painters, and one of the greatest painters of the world, makes it necessary for me to make a few remarks upon the Flemish school and its connection with the history of art. I am speaking to you of "*High Art in Low Countries*," and nothing is more remarkable than the contributions to the art of painting which have been made by both Belgium and Holland. Belgium did, in fact, invent the great art of oil painting for itself. It is true that the Flemish artists were not the first to use oil in the tempering of colours—Giotto and the early Italian masters were considerably in advance; but there seems to be no doubt that the brothers Herbert and John Van Eyck not only invented independently for themselves the method of oil painting before the end of the fourteenth century, but that the excellence of their method was such as to gain European celebrity, and to induce an Italian artist to journey into the Low Countries for the purpose of learning it. Moreover, the excellence of the method and the genius of the inventors speak for themselves in existing works. It will be sufficient to mention only which is perhaps their masterpiece. I refer to the picture, or rather series of pictures, known as the "Adoration of the Lamb;" part of the work is in the Church of St. Bevan, at Ghent; part is in the Museum at Berlin. I have seen both, and certainly it is impossible to overstate the admiration which an examination of the work inspires; some of those to whom I am speaking have probably seen this great picture; for others it must suffice to remark that here we have a work in oil by the very inventors of the art, looking now, after nearly five centuries, as bright as when it came from the easel, and that of the crowd of saints represented as admiring the Lamb, containing several hundreds of faces, each finished with the beauty and perfection of a most elaborate miniature.

Who shall say that Low Countries are not good cradles for High Art? But the two Van Eycks were the beginning, and by no means the end, of the Flemish school. Of those who immediately followed them, there are just two whom I will mention. The first, Hans Hemling, or Memling, for he seems to bear both names, and of whose brush there is a wonderful specimen in the Hospital of St. John, at Bruges; it consists of a large chest or reliquary, adorned with a representation of the legend of St. Ursula and her 11,000 virgins, who were martyred at Cologne, and whose supposed bones you may still see there. The finish and preservation of this work are wonderful; and they tell you at the hospital that offers have been made to the governors of a silver chest of the same size for that which they possess in painted wood. The offer would be a poor one even on the poor ground of money value; for undoubtedly the visitors of Hans Hemling's work very soon contribute more silver than would be required to make the chest; and herein I may observe is to be seen an example of the royal prerogative of art, which can turn a few shillings' worth of wood and paint into a work absolutely more precious than silver or even than gold.

The other early Flemish painter whom I wish to mention is Quintin Matsys, and I do so not so much for the excellence of his paintings, though that is very great, as because he was by trade a blacksmith. Yes, blacksmith and painter!—nothing can check the career of genius—and a very skilful blacksmith he was, as anyone may satisfy himself by examining a wrought-iron canopy which protects a pump close to the great church at Antwerp. The story is that Quintin Matsys was in love with a young lady whose father objected to give his daughter to a blacksmith; so, for the sake of his lady-love, Quintin Matsys gave up iron and took to paint.

These men whom I have mentioned belong to the infancy of the art, and their works have the stiffness and formality inseparable from the circumstances under which they were produced. Rubens, with his master, Otto Venius, and his pupil, Vandyck, represent the Flemish school in its full manhood and perfection. A marvellous manhood it was! I feel myself incompetent to criticise it, and I know thoroughly well the small value which belongs to my opinion, but I confess that the genius of Rubens impresses me as much as that of almost any painter whose works I have seen; you must not judge him by anything which we have of his in England; so far as I know there are but two places in which you can see him in his glory, namely, Antwerp, and Munich; and when you do see him in his glory, the freedom of his drawing and the magic of his colouring make you doubt which of the two is the more admirable. Woe to the unhappy painter whose works hang near to those of Rubens.

If we went no further on our tour I think we might say—Well done, Low Countries! But the Low Countries have done much more. There is no country in which art has been applied to the architecture of towns more earnestly and more successfully than Belgium. We English people are wonderfully thick-headed with regard to street architecture; we have not half-a-dozen towns which are tolerable, and of our modern towns the intolerableness is generally unspeakable; only think of London and the large sums that are spent there on new streets and public improvements, and the small results obtained hitherto. However, it is not my business to abuse London, nor have I time to do so; my business just now is to call your attention to the picturesque character of the Flemish towns, and, above all, the town-halls which the people built in those towns when they were the centres of manufacturing industry, and when the inhabitants had plenty of money—for there was a time when the people had plenty of money, namely, when Ghent was the Manchester of trade, and when the English Government was obliged to go to the capitalists of Antwerp to borrow cash. It is satisfactory to see that our wealthy towns are now making efforts in the same direction; Liverpool some years ago built St. George's Hall, for courts of justice and other public purposes; and Manchester has just produced a really remarkable building for the accommodation of her lawyers, being probably the most successful modern application to civil purposes of the architecture of the Middle Ages. The great misfortune, I may remark by the way, of England, and especially of England's great towns, in this department of art, is her smoky atmosphere. When Flanders built her Hotel de Ville she had plenty of money and a clear atmosphere: we have the money, but we lack the atmosphere; and what chance is there of first-rate ideas entering the brain of an architect when they are all to end in smoke?

There is one other branch of art which must strike everyone in travelling through Belgium, and that is the wood-carving. I the rather mention this because we have imported a large quantity of wood-carvings from Louvain for Ely Cathedral; and anyone who has seen Ely Cathedral (as I trust almost all of you have) will remember how much the effect of the stalls in the choir has been improved by the introduction of carved panels, exhibiting subjects from the Old and New Testaments. The principal opening for carving in a Flemish church seems to have been the pulpit; and some of the works of art in this department of sacred art are certainly wonderful. A pulpit, for instance, shall represent the Garden of Eden, and then you will have the preacher surrounded with beautiful animals, peacocks, birds of paradise, squirrels, &c., with Adam and Eve, perhaps, as large as life. It may be doubted whether some of these pulpits do not represent carving gone mad; but certainly the details are very beautiful, and it would be difficult to go to sleep during a sermon preached from such an exciting platform.

So much, then, for Flemish art. In the superficial sketch which I have given, I have wished to impress upon you this conviction, that Belgium was one of the early nurses of art in Europe, and that it is impossible for anyone to pass through the country, even in these railway days, without perceiving that this is true; and the result, so far as we in the present day are concerned, is this, that here is a country, as uninteresting by nature as the Isle of Ely, or any other country of the kind, rendered positively delightful by the application of human skill to the highest departments of art; and, before I leave the Low Countries, I must ask you to observe that the same thing is true, though with variations, of the other great division of the Netherlands, namely, Holland. Did you ever go to Holland? If not, I am sorry for you. A visit to Holland of a few days supplies a man with recollections for the whole of his life. Of all the funny places I have ever seen, Holland is the funniest. It is the only country in which I have felt disposed to rub my eyes and pinch myself, to ascertain whether I was not in a dream. However, my business is not to speak of Holland's eccentricity, but of Holland's art; and undoubtedly its school of painting will bear comparison with any in the world. The most remarkable man in this branch of art was Rembrandt; and his case is the more worth noticing because there was apparently nothing in the circumstances of his birth to make him an artist. He rose from the ranks, so to speak; it was genius which would come out. He was the son of a miller; and this, by-the-way, in Holland, is not a very exceptional thing, for it is a land of mills. Between Saardam and Woermerveer, in North Holland, there are about four miles of mills, all planted by the side of a road as regularly as apple-trees by the side of a garden walk, so that one would say that there was a good chance for any Dutchman of having been born in a mill. However, Rembrandt was so born; and it has been suggested (I think very cleverly) that his peculiar style of painting, his method of lighting up his picture from one intense centre of illumination, may have been unconciously suggested by the interior of his father's mill, where he played as a child. Certainly it occurred to me when I was in a Dutch oil-mill, watching the process by which two worthy Dutch millers were extracting oil from linseed, and when I noticed the dark interior, with the bright light streaming in through the open door, that there was a ready-made "Rembrandt."

However this may be, Rembrandt was a prince of painters and a glory of the Low Countries. Perhaps the most remarkable triumph of his art—and I refer to it because it is a wonderful triumph of art in general—is his picture, which you may see at the Hague, of a certain Professor Tulk lecturing on anatomy. Only conceive the trial of a painter's powers who is commissioned to commemorate a famous anatomist by a picture subscribed for by his admiring pupils, and who undertakes to paint, not merely a head and shoulders, which in the course of two hundred years may stand for anybody, but the actual man demonstrating upon the dead human subject with his pupils around him! You may say the picture must be disgusting; but this is just what the picture is not: such is the power of art used by genius that even so strange and unpromising a subject as the interior of a school of anatomy can be made a picture upon which the eye delights to rest.

At the Hague you may also see Paul Potter's bull—such a bull! no rinderpest about *him*: fine, wholesome young fellow, who seems only to regret that the conventionalities of picture life prevent him from walking straight out of the canvas, and treating you to a good loud bellow. To me, I confess, this world-famous bull is not so striking as another picture by Paul Potter representing a bear hunt: this is the most living animal picture I ever saw.

Then there is a marvellous picture at Amsterdam by Van der Helst, sometimes described as the miracle of the Dutch school. It represents the City Guard of Amsterdam celebrating the Treaty of Munster: the picture has no great interest now, except as a remakable group of portraits; here are about five-and-twenty persons, life-size, grouped together on one canvas, and each a portrait such as would make the fortune of an artist in London, while the action of each man is easy and natural, and the finish of the whole quite perfect.

These great pictures which I have mentioned are merely prominent specimens of a school. Painting has grown in the soil of Holland just as truly as her tulips and hyacinths: the school has not soared to the poetic height of the Spanish and Italian, nor even of the German and Flemish; but it has done great things, and in imitative representative art, I need hardly say, it will challenge comparison with the whole world. My purpose, however, is not to institute an exact comparison between the Dutch and other schools of painting, but only to point out to you how thoroughly high art has flourished in, and has morally elevated, a country which, physically, is hopelessly low; and how it is true of Holland, as of Belgium, that a country naturally uninteresting has been endowed with charms of the highest order by the gifts of genius and the happy victories of art.

We must not linger, however, any longer in foreign countries. Time warns me that I must hasten to bring this address to a conclusion; but I must not do so without giving a moral, or what I should call in a sermon, a practical application. Let us come home, then, to our own country, and let me remind you that, although we cannot boast here an old school of painting, we may fairly say that in one department of art, and that a high one, namely architecture, we had, in olden days, a school in the Isle of Ely, of which the Isle may be proud. Ely Cathedral represents, as everyone will allow, Mediæval architecture in the perfection of its beauty; but it may not have occurred to everyone who has admired the beauties of Ely Cathedral to think, or rather some may not have had the opportunity of knowing, that the principal Mediæval glories of Ely, perhaps the whole, were home-grown.

I do not know the names of the architects of all the great works, but the architect of the most remarkable portion, the central octagon and lantern, was undoubtedly a monk of the convent, Alan de Walsingham. I suppose from his name that he was not born in the Isle, but came from Walsingham, in Norfolk, a place in those days much more famous than now. He would probably have come from his native village as a boy to Ely, and would never have gone much beyond the bounds of the convent, except to see those farms of which he had the care as sacrist. But he was a man of genius, and circumstances favoured the development of his genius, though in a singular way. First he showed his love of art by making himself a goldsmith, and then he indulged the same love by turning architect. Many opportunities he found for the exercise of this art; in fact, the good old monk seems to have been constantly building one thing or another; he designed the Lady Chapel, he built that exquisite little gem which we call Prior Crawden's Chapel, and several other buildings of less note; but the grand opportunity for exhibiting his full powers occurred when the old central Norman tower fell in 1320. "It is an ill wind that blows nobody any good:" and though the fall of the tower nearly frightened the monks out of their wits and emptied their pockets, it was (as we say) the "making" of Alan de Walsingham. Never was there a better opening, and Alan perceived it: he did not send to London for Mr. Scott, as we, his degenerate successors, do, when we need any alterations or improvements, but he set to work himself: he determined that he would have no more heavy towers, threatening to come down and keeping up a reign of terror, but he would recast the whole structure of the cathedral; and so he introduced that beautiful octagon which has been ever since one of the chief features of the building, and which may be reckoned amongst the prime results of Mediæval architectural skill.

Here, then, we have close at home another specimen of high art in low countries: art, let me observe, none the worse for being consecrated to the service and worship of God: indeed, it is true as a matter of history, and perhaps we might have expected it to be so, that the religious feeling has been more successful than any other in promoting the progress of art. Bezaleel, the son of Uri, and Aholiab, the son of Ahisamach, of whom we read that God "filled" them "with wisdom of heart, to work all manner of work, of the engraver, and of the cunning workman, and of the embroider in blue and in purple, in scarlet and in fine linen, and of the weaver, even of them that do any work, and of those that devise cunning work." Bezaleel and Aholiab were, I say, but the earliest specimens of a race of men who, under the old covenant and under the new, in the days of Moses and Solomon, and King Edward III., and Queen Victoria, have consecrated their artistic genius to the service of God. Here, no doubt, if a man have the power to realise it, is a spring of action which excites the bravest efforts and leads to the most transcendent results. You see the most complete illustration both of the power and of the success of the principle in the case of that most admirable painter the monk of Fiesole, whom it has become the custom to style *Fra. Angelico:* of him we read that he would never paint for gain, but that if petition were made to him for a picture for any sacred purpose, he would ask permission of his superior, and then give himself to the work.

We have no artist monks in Ely in these days, but the ceiling of the nave of the cathedral may be taken as evidence, not only that there is still high art in the low countries, but that the spirit which guided the brush of Fra. Angelico in Italy, more than 400 years ago, is alive in England at the present time. It is really a cheering fact with regard to art in our own country, that a work like that of the ceiling of Ely Cathedral should have been begun and completed by amateur hands. Most of you are probably aware that the painting was conceived and half-executed by the late Mr. Styleman-le-Strange, and that when death cut short his labours, sadly and suddenly, the work was taken up and completed by Mr. Gambier Parry. I have no time to describe this beautiful work, nor is it necessary; any-one who can come to Wisbech to hear this address can easily go to Ely to see this painting; and I am sure that those who do see it—I may add, those who see the many other works of sacred art which are to be found in Ely Cathedral—will conclude that somehow or other, although we have no Alan de Walsingham amongst us, high art does still find its way into the low countries of our Isle.

Long may this continue to be so!—and may this industrial and art exhibition help to foster the love of art, and the knowledge of art, and the study of art amongst us. Depend upon it, art is truly a gift of God; as Bacon, in the language of his latest and best editor, "declared with all the weight of his authority and of his eloquence, that the true end of knowledge is the glory of God, and the relief of man's estate," so also we may say that art has been given for the same great purposes, that it is intended to promote human happiness, and that it is used for its highest purpose when it is made to tend to God's glory.

All men are not artists, nor capable of appreciating art in its highest forms, but all men are benefited, more or less, by the progress of art; just as all men are not poets, and yet poetry softens the manners and polishes the mind, and makes this world more habitable even for the most prosaic. You cannot tie up the benefits of art to a few—it is a gift to humanity, and extends in its influence and its blessings as widely as the human race extends; it may be abused to evil purposes, to mere luxury and effeminacy, just as other good gifts of God may be abused; but there is no reason why it should be. It is not to be compared, in point of value, with those other gifts which affect the absolute necessities of the body or the still more absolute necessities of the soul; but, putting aside these sovereign gifts of God, there is none for which we should give greater and more continual thanks than for art, in all its multiform ramifications. We may see in it one of the most conspicuous proofs of God's goodness, because we find in it the evidence that He has given us this world, not only as a place to live in, but as a place in which the eye and the ear, and the whole mind may ever find abundance of beauty, and unfailing springs of delight.

GEOLOGY AS APPLIED TO ARCHITECTURE.*

By John Cumming, F.G.S.

The object of this paper is to indicate those points of contact between the geologist and the architect which must be useful to the latter and may not be uninteresting to the former. Some whom I address, no doubt, belong to what has been well-named the "Bricks and mortar school;" there may be others who are the slaves of mere æstheticism. The latter would be content simply to design, and if their conceptions culminated in nothing more than castles in the air they would consider their part complete. The former would ignore the art and sink the architect in the builder. To design in beauty, and not to to rest content till he builds in truth, is the position asserted for the true architect. To enable us to build in truth a knowledge of materials, founded upon a broader basis than that acquired in the drawing-office or on the building may readily be obtained. I cannot think that a knowledge of sciences, which provide the materials of which all edifices must be constructed, or which aid in their preparation, can in any way degrade or be beneath the notice of the true art student; on the contrary, with the knowledge, however small, of geology, mineralogy, or mechanical science, the architect may, and often does, save large unnecessary outlay, and by so doing is in a position to expend money thus economised on such æsthetic details as may be congenial to his taste or in accordance with his preconceived principles. To entertain discussion upon the relative merits of the pigments artists use is not beneath the notice of modern painters, and surely to understand something about the materials of which buildings are to be constructed cannot be beneath the attention of the modern architect, and geology will undoubtedly assist him in the investigation of stone, slate, marble, clay, cement, lime, sand, and gravel, for purposes of construction.

The science of geology has features which connect it with art in many ways. The late Mr. Richardson remarks:—"The

* Read before the Architectural Association, 1st June, 1866.

painter derives important aid from a science which teaches him the physical structure of a country and the principles which determine its scenery and aspect." Many works of great merit offend the eye by departure from the truth of nature, which a knowledge of geology would serve to correct. For example, how grave should we deem the error of the artist who, when depicting an event which occurred in the southern district of our island, should sketch the scene with the rugged outline which characterises the primary formations of the north; or if, in representing an occurrence which happened in the northern district, he should delineate the angular outline of its Plutonic rocks with the undulating lines which characterise the sedimentary rocks of the south.

Some of the most celebrated modern paintings exhibit faults of this description, for in some of them rocks are drawn and views pourtrayed in localities where, owing to the physical geography of the district, they could never have existed. Geology is to the landscape painter what anatomy is to the student of animal forms, and as such will repay his investigation. The sculptor is no less indebted to geology in the choice of material: and in other respects some of the finest productions of the chisel, owing to the choice of an unworthy material, are chipped and decomposed. The Greek marble of Pentilicus was much disfigured from its impurity and the admixture of metallic oxides; but the Italian quarries of Massa and Carrara are free from impurities—they consist of oolite stone crystallised. Many ancient works of art are spoiled from the impurities contained in the stone. A celebrated *chef-d'œuvre* of modern date, viz., the Ariadne of Danneker, is greatly injured from this cause. It may be added that the late Sir Francis Chantrey was so well aware of the value of a knowledge of this kind that he made himself a proficient in mineralogy and geology. If, then, the painter and sculptor can obtain such useful help from geology, may not the architect? It is my present object to try to point out how he may do so. Architecture has aided the science of geology in a remarkable though undesigned manner, and I claim a return from geology. The elevation and depression of parts of the earth's surface is an operation of constant occurrence, but in the early days of geological science could not be demonstrated to those who disbelieved in the new science. Architecture has, unconsciously, enabled us to verify this phænomenon. The Temple of Jupiter Serapis, at Puzzuoli, yields extraordinary evidence of its repeated submergence and emergence from the sea. "The ruins," says Dr. Mantell, "are situated on the shores of Baiæ, and consist of the remains of a large building of a quadrangular form (probably used as a bath), seventy feet wide, the roof of which was supported by twenty-four granite columns and twenty-two of marble, each a monolith. Many of the pillars are broken and strewed about the pavement, but three of them still remain standing, and on these are inscriptions not traced by the Greeks or Romans, but by some of the simplest forms of animal existence, which have left enduring records of the physical changes that have taken place on these shores since man erected the temple in honour of his gods. The tallest column is forty-two feet in height; its surface is smooth and uninjured to an elevation of about twelve feet from the pedestal, where a band of perforations, made by a species of marine boring muscle, commences and extends to the distance of nine feet, above which all traces of their ravages disappear. The perforations, many of which still contain shells, are of a pear-like shape, and are so numerous and deep as to prove unquestionably that the pillars were immersed in sea-water at the very time when the base and lower portions were protected by rubbish and tuffa, and that the upper parts projected above the waters, and consequently were placed beyond the reach of the lithodomi. The platform of the temple is now about one foot below high water mark; and the sea, which is only forty yards distant, penetrates the intervening soil. The upper part of the perforations is therefore at least twenty-three feet above the level of the sea, and yet it is evident that the columns were once plunged in salt water for a considerable period. It is equally clear that they have since been elevated to a height of twenty-three feet, still maintaining their erect position, incontrovertibly proving that the relative level of land and sea on that part of the coast has changed more than once since the Christian era, each movement of subsidence and elevation having exceeded twenty feet. The pillars are again subsiding so gradually that they still maintain their perpendicular."

I have thought it interesting to give this short account of an instance of architecture, proclaiming in unmistakeable terms the facts of science, in order that I may urge the possibilities of the science of geology one day assisting the art of architecture.

Leonardo da Vinci, best known as a painter, was an architect, and, it appears, a geologist also; that is to say, he was an acute observer of geological phænomena. He was one of the first to put a right construction on the fossils which had been found in his day, and made it his business to become acquainted with the structure of the earth. Many a man has found the inconvenience of a lack of scientific knowledge when in contact with the modern builder. How often is the young architect obliged to bow to the builder's superior knowledge of materials, the places from whence these materials are procured, and of many other practical topics? This may in some degree account for the increasing tendency, in this very utilitarian age, to employ builders only, without the intervention of the architect. The builder-architect frequently possesses a large amount of practical information not shared in, by at all events, the young architect. It will be admitted that the less the designer and the executor are united the better. The architect should not be obliged to bow to any man on practical questions which relate to his profession. Art and science are twins, each possessing a distinct path, but having converging lines and points of junction where they kiss each other and unite to speed a common weal. The aspirations of the artist have many a time been checked from the absence of power to carry them out. Science, with a helping hand, has often stepped in, removed mechanical obstacles, and opened the road to higher art achievements. Grecian science suggested the arch, Phœnician science taught the use of building-stone and its preparation. It is necessary to admit the connection between applied art and science. Where so much that is beautiful in nature is made the basis of architectural ornamentation, a just appreciation of the objects selected as the basis of the design is essential. This is eminently the case where flowers or foliage are introdued, and, however, we may conventionalise, it must never be at the expense of truth. To avoid error, a knowledge of botany, however slight, is useful. To the artist it is essential. To be a good sculptor you must be an anatomist, and if anatomy be essential in the design of animal forms, equally so must botany be essential in the design of vegetable forms. In fine, it will be seen that whatever science teaches of the structure of creation and the laws which govern natural phænomena should be hailed as an aid to place architecture in its legitimate position in the van of modern professions. Geology has been lately styled a popular science, but why I have failed to discover. It is true that many talk what is deemed geology, but their talk is as far from it as the Poles are asunder. Numerous works have appeared of late containing speculations as to the antecedents of the human race: whether Adam was the first man, or if he was but the first example of a fully developed human being. These, and many other questions, have been very cleverly discussed by men of acknowledged power; but these considerations do not belong to the science at all. On many occasions I have heard men argue upon some of these hypotheses from the perusal of the works upon these topics, but to call such men geologists is a misnomer. The public to some extent believes that to be a geologist is to be one who wishes to undermine all preconceived views of creation and historic religion. The error is with the public. To be a geologist means to be well informed upon the nature of the materials of which the earth is composed, and to recognise by its contained fossils and mineralogical characters to what position in the series a given stratum is to be assigned; to ascertain facts, and, when determined to be true facts, to record them. The speculations too often regarded as deductions from such facts are, in most cases sciolisms, not scientific inferences. The student-architect may employ some little of his time profitably in the study of geology. I do not ask him to give up his holiday sketching, his class of design, his life studies, &c., but may he not, with his sketching, keep his eyes open for geological features, and thus give an additional interest to his holiday reminiscences? In continental churches, monuments, and other buildings, may he not find out of what stone they are built from, what formation obtained, the distance from whence conveyed, the age when used, their state of preservation, probable reason of their employment, and such other notes as may be suggested on the spot? Would not memoranda like these be of use to the profession and yet be not devoid of interest to the geological world? To comprehend why the study of geology may be useful to the architect it is necessary to point out a few of the fundamental principles of the science. The present object is to awaken an interest that may induce some to look further into the subject and lead others to accept the work of the geologist as a useful help in the exercise of their profession.

The earth on which we live has for its upper crust a layer of materials, according to some four, to others six, or more miles in thickness. This is made up of different minerals deposited by the ocean, the river, the iceberg, and other causes, and altered in some cases, by chemical, in others by mechanical, influences, and in many other ways. Where continents and islands now dot the surface of the earth oceans and river once rolled, and at various times in the history of the world sea and land have changed places. These operations have been the work of ages, and each successive alteration has left its indelible mark on the sands of time. Till about a century ago the crust of the earth was considered a muddled mixture of various rocks and soils with an incandescent centre; but since, by the patient study of Smith, called the father of the science, Lyell, Murchison, De la Beche, and a host of other observers, both foreigners and English, the strata have been classified, and their relative chronological order ascertained with an accuracy the most complete. The fossils, once thought to be the spontaneous generation of the earth, or the unsuccessful efforts of the Creator, are found, in the language of Dr. Mantell, to be the medals of creation, so much so that scarcely an organic remain is exhumed but it can be at once referred to its legitimate place in nature's illustrated volume.

In a natural history of England, published about seventy years ago, says Mr. Richardson, it is gravely observed, "that at Bethersden, in Kent, a kind of stone is found full of shells, which is a proof that shells and the animals we find in them living, have no necessary connexion." Another amusing instance of ignorance on these subjects occurs in a history of the county of Surrey, in which it is stated that, in a search for coal near Guildford, the borers broke, and this was believed to be the work of subterranean spirits, who wrenched off the augers of the miners lest their secret haunts should be invaded. But the science has emerged from the incubus of superstition and is reduced to the foundation of facts. It has been demonstrated that each formation or stratification has a definite relative place in the series of rocks, as truly as a page has in a book, so that if a geologist sees a rock and ascertains by its mineralogical structure and its contained fossils its place in the series, he can prophesy with astonishing accuracy what sub or superstrata should be found. Fortunes have been spent in the search for coal in places in which it could never have been found. Fortunes, therefore, might have been saved if their owners had been in possession of a few facts of geological science. Chalk for manures, stone for building, and many other substances, are often carried long distances, when they may sometimes be found beneath one's feet. All the strata with which the globe is covered were, of course, deposited horizontally. The wearing action of the seas and rivers, the weathering of the surface by pluvial and atmospheric causes, and other disintegrating forces, have prepared the way for the transport of materials previously consolidated, and the seas and rivers have been the transporting agents. It will be asked, if all strata were thus laid horizontally, how it is that we are enabled to examine so many of them, seeing that the greatest depth which the miner has reached does not extend to a mile? During and since the deposition of the various beds of rock the earth has suffered from constant volcanic disturbances, the mountains have been cast down and the valleys have been exalted, strata have been tilted on their edges, and, like a pack of cards, overturned. Here we ride over the upturned edges of several formations, there we travel along the saddleback of only one upheaved stratum. The landscapes we admire, the hills of Scotland, the mountains of Switzerland, the slopes of the South, are the results of such operations. Large as the convulsions may have been, and gigantic as their effects are, chaos has not been produced. If no upheavals had taken place, no depression occurred, all the mineral wealth of this and every other country had been hidden from view. Not only would the beauty of the earth have been lost, but we should have been without the materials with which art's greatest triumphs have been achieved. Iron and coal would have been hidden in the bowels of the earth, and England's greatest treasures undisclosed.

Now the different beds of rock and other formations have, for the sake of study, been divided and named according to their position in the series. The old names were primary, secondary, and tertiary; now we have abolished the primary, and several other alterations have been introduced, but it will answer our purpose to adopt just now the threefold division. I will name the more important British rocks in their order of deposition, giving special attention to those which are employed in the arts by the architect. The basis of all the sedimentary rocks is considered to be granite, and over it all the subsequent depositions have been laid. The term granite to the geologist means more than it does to the general student. It is the name given to a series of rocks which differ widely in appearance from that substance which is commonly known by the name of granite. True granite is composed of quartz, feldspar, and mica, but the proportions of these minerals differ considerably in the various granites of this kingdom. In some specimens quartz is predominent, in others mica, and in many feldspar. The admixture of hornblende, hypersthene, actinolite, stealite, talc, and other minerals gives a variety of names to compounds, we need not here mention. The flagstones and parapets of London and Southwark bridges give good illustrations of a feldspatic granite, the crystals being large and well-defined. Micaceous granite is known by its glistening white or brown scales, and quartzose granite by the prevalence of that mineral. Included in the granitic system are porphyry, serpentine, trap, &c. Fossils have not as yet been discovered in these rocks, but, as fire or intense heat have considerably modified them, it is possible that the evidences of the existence of animal or vegetable life have been obliterated thereby. The recent discovery of a microscopic organism called the Eozoon, in the Laurentine rocks of Canada, seems to tend to the belief that in time the existence of fossils even in the granitic rocks will be determined. Granite is the hardest and, perhaps, the most enduring of all stones; its advantages have been recognised in all times. It is distributed over the whole world. Egypt, Assyria, India, China present monuments which attest its excellence. In this country, Cornwall and Devon yield the greater proportion of granite used in England. The quarries are very large and accessible, and the stone is easily worked. The Channel Islands yield a granite hard and good, but expensively tough in preparation. Similar granite is obtained from Leicestershire. The choicest stone, however, comes from Aberdeenshire. The well-known Peterhead, with varieties of pink and grey, so much in vogue just now, comes from Aberdeenshire. In that district, however, the quarries are not so easily worked, and the cost of transit renders the employment of their stone, except for ornamental purposes, limited. Professor Ansted says that good ordinary granite has a mean specific gravity of 2·66, that the cubic foot weighs 166¼ lbs., and the cubic yard about two tons. Granite is of all ages, and not, as was formerly believed, a simply primitive rock. It has been found in the Pyrenees, obtruded through the chalk. Syenite granite, in which hornblende takes the place of mica (according to Mr. Richardson), has been observed overhanging the chalk in Weinbohla, Saxony, and in Antrim, Ireland. Indeed, granite veins have often intruded themselves through granite rock of older date. These facts are given because we shall have to allude to the subject of granite as a building material, and to show that it is not all gold that glitters, and not all enduring granite that looks like it and bears its name. It is enough to mention, amongst the igneous rocks which are called volcanic in their origin, the names of greenstone, basalt, porphyry, lava, and tuffa. Greenstone is practically a variety of syenite, the composition of which I have given. It frequently passes into syenite, as is beautifully illustrated in the head of Ramases, in the British Museum, where the body is greenstone and the head syenite. Porphyry, derived from the Greek word (πορφύρα) signifying purple, has been used by the architect for ages as an ornamental stone and an enduring one. It is found of various colours and textures. Lavas are of different characters and bear various names, all, however, having the same basis, but having passed through different processes in their ejection or in cooling. Tuffa is simply lava frothed up by the air, as dough is made open by carbonic acid. Tuffa stone, a calcareous variety of which is found in Pembrokeshire, is used as a building stone. Its durability, lightness, and freeness in working recommended it to the masons of ancient times for filling up vaulted roofs, and there is no doubt that in the restoration of churches, where time has weakened the foundation of arches, groined roofs, &c., it might, on account of its lightness, take the place of heavier materials, especially in situations where the pressure upon it was not excessive. It has all the appearance of, and is, to all intents and purposes, stone. Of the metamorphosed or altered rocks which are next in sequence I shall state nothing, except that from them a beautiful crystalline limestone has been procured of the appearance of loaf sugar, and much prized for its purity by the sculptor.

The Cambrian and Silurian rocks are the next important division. These rocks form the elevated range from north to south for nearly the whole of the western side of England, from Cornwall to Cumberland, reaching the height of 3,000 feet, and producing all the grand scenery of the lakes of North Wales. The Cambrian rocks consist of slate rocks and conglomerates. The slates obtained from the Cambrian system are well-known from their exceeding smoothness, hardness, and fine grain qualities, which, for building purposes, give them their pre-eminence over slate from other and more recent formations. Slate consists of successive layers of mud indurated by pressure, and probably by chemical action, hence the ease with which it can be separated into sheets or slates of any thickness. The yield of slate can be increased to meet any demand. The use of slate, ornamentally, has not received the attention it merits. Mr. Mathews stated in his excellent paper on "Materials most appropriate for London exteriors," * that "slate is a material that might be more generally used in a decorative manner." Sawn, it might be used in panels, cornices, mouldings; the colour is good and will harmonise well with stone and brick. Enamelled slate offers a wide field for design.

The Silurian system affords us Llandudno flagstones and limestones, some exceedingly fossiliferous and beautiful—pages from Nature's book illustrated by the originals. I cannot in these remarks venture upon what is called the Palæontological part of the subject, *i.e.*, the description of the remains of ancient life, however interesting, but I would remark that, in the employment of stones for ornamental purposes, there is seldom sufficient notice taken of the limestones which contain so many beautiful examples of Nature's handiwork imbedded in them. It is true that now and then we see a mantel or chimney-jamb of Derbyshire marble with beautiful examples of orinordians or corals; but might not decorative art utilize to a greater extent the beautiful forms nature has afforded in these relics of the past? The Devonian, or old red sandstone, so called from the red colour, derived from peroxide of iron, consists of sandstone, grits, and marls, and limestones, amongst the latter some beautiful coralline marbles. The sandstones are of all degrees of compactness, and when of a slaty character are much used for heavy roofing. The next in importance is the carboniferous, or coal-bearing series of rocks. From these formations England obtains her greatest wealth—coal and iron—which have proved to her of more value than the gold of Australia or California, or the diamond mines of Golconda. Sandstones, shales, ironstone, millstone, grit, mountain limestone, and seams or basins of coal, make up the system. The beds of mountain limestone are estimated at about 1,000 feet of thickness; in these are found in great abundance ores of lead, zinc, copper, barytes, and some very fine marble, conglomerated, formed of the detrites of older rocks of the magnesian limestone, and the dolomitic conglomerates of Yorkshire and Durham. The latter are the beds from which the stone used in the erection of the Houses of Parliament was obtained, of which more by-and-bye. I may just remark, however, that as a building stone the magnesian limestone possesses the softness and facilities of working of the oolite with the hardness and durability of the more crystalline rocks. When highly crystallised it is termed dolomitic. The new red sandstone, which belongs to this group of rocks, consists of sandstones and marls coloured by peroxide of iron. The stone is too loose and friable to be employed for building, and the only feature of importance is the enormous yield of rock salt and briny springs in this stratum. At Droitwich the salt rocks are the more remarkable in that it is believed that they were worked by the ancient Britons, and for 2,000 years have not ceased to yield a supply. We next come to the lias, composed of clays, limestone, &c., filled with fossils of many kinds, and rich in the remains of the formidable saurians of a pre-Adamite period, the restoration of which by Mr. Hawkins, at the Crystal Palace, has excited the wonder and admiration of everybody. The limestones have not proved durable for building, or indeed for any purpose; as a road material, though very hard and apparently durable, they are worthless; they soon pulverise, and the result is mud. The oolite rocks, so termed from the egg-like structure of some of the beds, are very important; the uppermost bed, as the Portland rock, being unsurpassed as a building stone. Bath stone is the great oolite of the geologist, and is next in importance to the Portland stone in this group. The oolite beds are numerous, consisting of limestones, shales, clays, sandstones, and contain very many valuable products—Fuller's earth for example. The lias and oolite formations extend themselves throughout the length of the country, from Portland in the south, to Whitby in the north. Next in order are the wealden formations, consisting of clay, sand, and limestones, formed by freshwater at mouths of large rivers. The Isle of Wight and the south-east of England are the great depositaries of these strata. The sandstones, having no cementing material, are useless for building purposes, and the only beds it is necessary to name here are the Purbeck and Sussex marbles. The former has been in use as an ornamental marble from time immemorial, chiefly in ecclesiastical edifices. There is scarcely an ancient cathedral or church of importance in this country, erected during the middle ages, in which this beautiful marble has not been employed. Sussex marble is similar to the Purbeck in composition; that is, it is composed of a freshwater univalve, not unlike a periwinkle, called a paludina, cemented together with lime and sand. In the Sussex stone the shells are larger than in the Purbeck. When polished either stone is very ornamental, and the Romans appear to have used it largely in their edifices. In 1723, whilst the foundations of the council house at Chichester were being dug, a slab of Sussex marble was discovered, on which was an inscription to the following effect. I quote it here because of its antiquarian interest:—"The college or company of artificers, and they who preside over sacred rites, or hold offices there, by the authority of King Coridubnus, the legate of Tiberius Claudius Augustus in Britain, dedicate this temple to Neptune and Minerva, for the welfare of the imperial family, Pudeus, the son of Pudentinus, having given the site." Some of the coarser kinds of Sussex marble are excellent for coping and paving stones, and are very durable. The chalk formation has much interest for the geologist and but little for the architect, but there are several points of interest that may be noticed. Chalk itself is nearly pure carbonate of lime mixed with numberless microscopic shells, the remains of larger specimens, and with more perfect fossils. The difference between chalk and marble is simply that in the former the carbonate of lime exists in a minutely divided state, and in the latter it is crystallised. This has been demonstrated by Sir James Hall's experiments. By pulverising chalk, hermetically sealing it, so as to prevent the gases from escaping, and then exposing it to heat, the chalk was converted into a crystalline marble. Many efforts have been made to imitate nature in this way. Thus, not long since, it was proposed to execute works of art, sculpture, and tracery for architectural purposes in chalk, and when finished to indurate it by chemical processes, so as to render it enduring as marble. A certain amount of success followed, but the sharp lines of the sculptor's chisel were wanting, the beauty of marble was not obtained, and in many ways the anticipations of the inventor of the process were not realised. Carrara marble is a pure crystalline condition of lime, and most of the choicest examples are as truly chalk; but we cannot, though we have all the requisite materials, produce from chalk Carrara or Parian marbles. Alabaster, which is a stalagmitic carbonate of lime, has been employed of late in architectural works. As an instance may be mentioned the new church of St. Paul, by Mr. J. Newton, where the spandrils of the ribs are of alabaster. The best example of its use in ancient times is shown at the church of St. Marco, Venice. Alabaster is only suited for internal work, and that only in dry places. By exposure to moisture it very readily decomposes. One of the most curious applications of chalk has just been made in the introduction of graphotype, which threatens to abolish all engraving of an inferior class, and for the illustration of books it appears eminently fitted. By drawing on the surface of a block of chalk with a prepared ink, which indurates where it touches, and with a brush removing the intervening spaces of chalk which have not been

* See *C. E. & A. Journal*, for January last, page 5.

touched by the ink, an engraved block in relief, so to speak, is at once produced, giving with absolute faithfulness the artist's own touches. A stereotype from it may now be taken and printed as from an ordinary plate. The tertiary deposits above the chalk consist of sandclay, friable limestone, crags, &c., and, lastly, we arrive at the recent accumulation on the surface. Thus briefly we have gone over the series of rocks which constitute the crust of the earth, and in some measure have seen the application made of these rocks by man in the arts. To more than mention the chief deposits would be impossible within the limits of this paper. The question of the relative merits of building stones, the causes of their decay, and the means of their preservation, have occupied the attention of architects and men of science for some time past. It is no mean inquiry, for, next to the designing of beautiful edifices, the durability of the materials of which they are to be constructed occupies a prominent place. Our forefathers, whether by chance or skill in selection, in a great many cases appear to have adopted stone of a more lasting character than that employed in later times; and it is no small praise to them to acknowledge that, while buildings in this the centre of science and modern civilisation have shown symptoms of decay after a short existence of thirty years, their best works, some of them executed at a time when science and civilisation were under an eclipse, have stood the storms and winds and rains of centuries, and remain but little injured still. The reason why is the problem that can be solved in a great measure by the young architect of the present day in the way already pointed out; and I repeat, that to ascertain with accuracy the quality, the geologic age or formation, and from whence derived, of the stone employed in the most enduring architectural works, is the first step, and to state the amount of decay, and the position in each building in which that decay has most shown itself, will be the best way to point out the rocks to be avoided and to suggest those that are desirable. Professor Ansted classifies building stones under the heads of granites, limestones, and sandstones, and the subdivisions are those that can be worked only by the pick or by wedges, and those that can be worked by the mallet and chisel, the latter being called freestones. Let us look at these minerals in their application to building purposes.

1st. Granites. There are not more difficult materials to work with than granites; indeed, for centuries the architect rather shunned the strong material. Science, however, has come to the rescue, and by mechanical help great results are now obtained from the most refractory rock. While labour (that of slaves) cost nothing, granite, in early history, was selected for the images of gods, the tombs of kings, for their statues and temples, and for monuments of great events. Indeed, it was always employed in the erection of monuments that were intended to last for ages. In their choice of granite for these purposes the Egyptians were not mistaken. To this day the monuments of Egypt, nay, the hieroglyphs on their bases, are almost as fresh as if just from the sculptor's chisel. The cost of working, however, is still great, but as this cost decreases, as in time it must, we shall see more of it used in architectural work; not in the servile manner in which it is now the fashion to employ the red granite of the north, but in numberless instances where the wind and rain beat, and where it is so admirably adapted to withstand these influences. In this way it might prove a permanent and enduring assistance to buildings composed in other parts of more perishable materials. Granite can now be obtained of so many different shades of colour that any building stone can be found to harmonise with it easily. The sculptor has tried to employ granite in his art, but its mottled appearance and often faulty composition are sadly against it for his purpose. It is needless to quote churches and buildings in this country in which granite has been employed in past ages. Nearly all of them show no symptoms of decay, but in some instances disintegration or decomposition has taken place, and this from the selection of unworthy examples of stone, for it appears that there are some granites no more proof against the weather than the poorest limestones. Hard and compact as granite appears, it is, nevertheless, sufficiently open and porous to admit a considerable amount of moisture. By absorption it will take up nearly 1½ per cent. of water, and where disintegration takes place it is owing mainly to this circumstance. In all stones that admit water, and all do, frost employs its terrific force and separates particle after particle till the surface is destroyed. Water conveys the chemicals which exist in the air to the interior, and by its solvent power, due in a great measure to the carbonic acid it contains, decomposes all stones. To judge of the great power exercised by carbonic acid as a solvent, it may be mentioned that all the silica that exists in the vegetable world (and no plant can grow without it) is derived from the stones and flints of the earth, and absorbed by the microscopic capillary cells in the roots, but the solid silica could not pass through these cells and water, we know, will not dissolve flint. How then is it to be accomplished? The rain that falls collects the carbonic acid of the air, and acquires the same from the soil through which it passes, and in combination therewith it dissolves the flinty rock and stone, and thus conveys the necessary support to the roots of all vegetation. In the selection of granite for enduring purposes those in which the constituent minerals are most evenly proportioned are the best. Like small paving stones, each particle seems to help the other, and the smaller the grain the more completely is this the case. Large crystals of feldspar are always objectionable on account of their readiness to decompose. For ornamental purposes almost any granites are available, many affording very rich combinations of colour, and if the surface be polished the weather has less hold upon it and it lasts longer. If granite be totally submerged in water and never exposed it will last unimpaired for ever, thus showing that water alone, without the agency of the air and decrease of temperature to the freezing point, will not materially affect it. The feldspar of granite is the most likely to decay. The well-know kaolin, or China clay, is nothing more than decomposed feldspar, a material which exists largely in Cornwall and Devonshire, from which two counties 60,000 tons were exported in the year 1855.

(*To be concluded in our next.*)

Review.

Fires, Fire Engines, and Fire Brigades. By Charles F. T. Young, C.E., Mem. Soc. Engineers, Author of "The Economy of Steam Power on Common Roads," &c. &c. London: Lockwood and Co.

SECOND NOTICE.*

In introducing the subject of steam fire engines Mr. Young says, "The manufacture of steam fire engines in England, as a regular branch of industry, is of very recent origin; and although to England belongs the honour of having made the first steam fire engine so far back as 1829—when it was constructed by Messrs. Braithwaite and Ericsson, in London, by whom four more were made at a later period, all being eminently successful—yet, so strong were prejudice and other influences, that from 1832 to 1852, no more were made in this country, nor was public attention directed to the matter." That this should have been the case in a country professedly so practical, and disposed, in all instances, to treat things simply upon their merits, would be absolutely incredible, were not the fact patent to all who have taken the trouble to inquire into the subject. Unfortunately the late Mr. Braidwood, although undoubtedly a thoroughly clever and practical man in the handling of the then ordinary appliances for fire extinction, was prejudiced in his views regarding the introduction of novelties, such as the substitution of steam for manual power, and we cannot but think acted towards the real pioneers of improvement, Messrs. Braithwaite and Ericsson, with some injustice.

We quote the following plain but suggestive remarks from Mr. Young's work: "The late Mr. Braidwood was, from the beginning of his career in London until within a short period of his untimely end, a most strenuous and determined opponent of steam fire engines, 'because they were expensive,' and there 'was not sufficient water to supply them.'† Therefore, although 'admitting their great efficiency,' they 'were out of the question until a larger supply of water could be obtained; and then, his impression was, that when they came to have an adequate supply for steam fire engines, a higher pressure could be given, so that they could work from the main without requiring the steam fire engines!'" However, after all this, when the con-

* See ante, p. 182.

† See Mr. Braidwood's Paper on "Fires and Fire-proof Structures" in the *C. E. and A. Journal*, vol. xix. pp. 197 and 228.

struction of steam fire engines was revived in England by Messrs. Shand, Mason, and Co.—who made their first steamer towards the close of 1858, and constructed one in 1860, which was hired by the London Fire Engine Establishment—we find that this engine seems to have been viewed with peculiar favour; for Mr. Braidwood wrote of it: "That at large fires, beyond the reach of the steam floating engine, the land steam fire engine has been of great service. It is not only the *large quantity of water which it throws* (!) but the height and distance to which it is thrown which makes it so valuable. At the same time it can be worked as gently as an ordinary engine."

"It is curious to find that the objection so persistently urged against the use of steam fire engines from 1829 to 1856, viz., that they *threw too much water*, should in 1860—2 be esteemed one of their chief advantages; and that, too, by their most strenuous opponent! It is difficult to assign a reason for this, since fires were as heavy in those days as at the present, and certainly as likely to require 'a large body of water' then as now. After this we find Messrs. Shand, Mason, and Co., the 'sole steam fire engine makers' to the London Fire Engine Establishment; at least, such is the case *practically*, as no other maker has been favoured with an order to construct them a trial engine; and when one was offered on loan by another firm, it was declined. From this we should infer that the 'Establishment' did not desire to find out or employ the *best* engine, but to keep up and maintain a close monopoly in steam fire engines with their favoured makers, regardless of the results of practical working or improvement; and by this course cannot be said or considered to do or have done anything towards settling which is the best steam fire engine."

It would no doubt be a matter of some difficulty to fully explain the causes of Mr. Braidwood's marked change of opinion here adverted to, and his subsequent persistent patronage of one firm only. Very possibly, however, there were in this case, as we well know there have been in numerous governmental departments, influences at work which led him to judge with different eyes to the public at large. Be this as it may, it is very certain that, whatever its merits or demerits, Messrs. Braithwaite and Ericsson's engine was set aside on grounds which were subsequently put forth as advantages in respect of an engine by other makers; and we cannot but sincerely regret that when a change occurred in Mr. Braidwood's opinions, he did not at once allow those gentlemen a sufficient opportunity of competing for the business to which, in so far as we can judge, they were justly entitled. Their first engine (Fig. 4) is thus adverted to:—

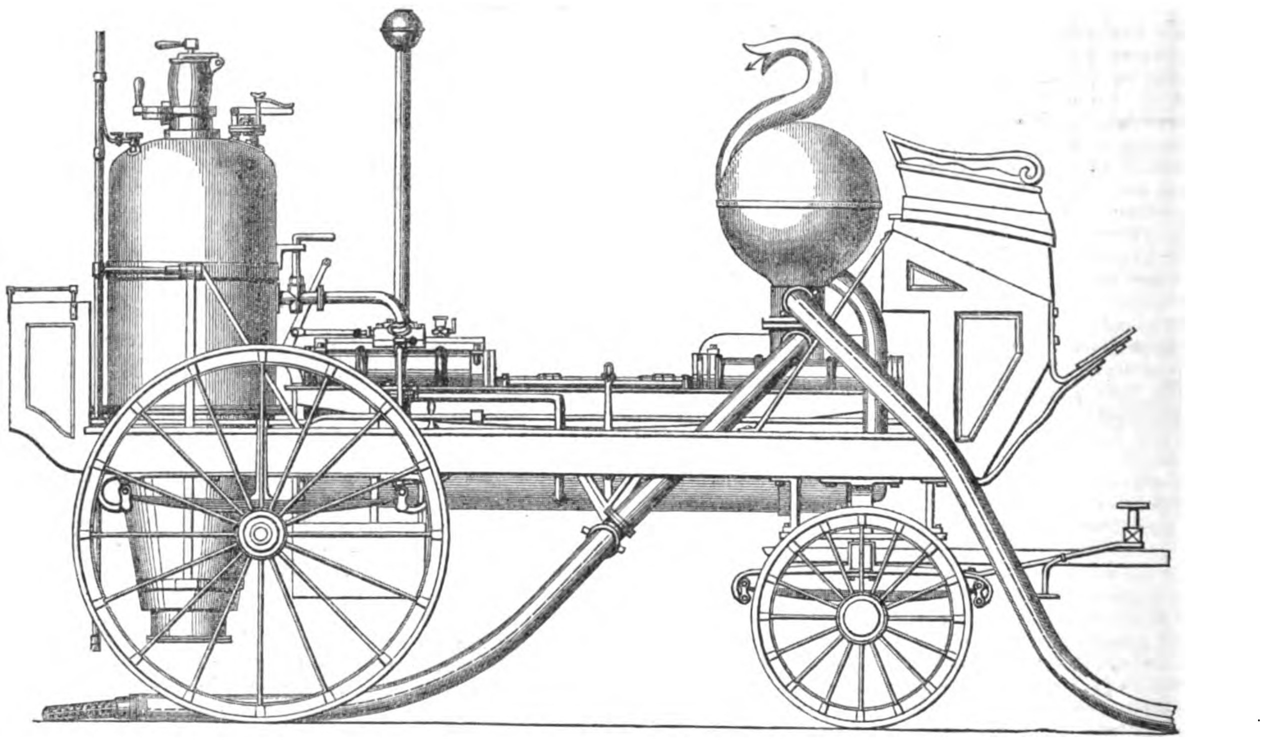


FIG. 4.—THE FIRST STEAM FIRE ENGINE, BRAITHWAITE AND ERICSSON, 1829.

The application of steam power to work a force pump, arranging the engine, boiler, pumps, etc., on wheels, so as to be easily portable, and thus enable it to be readily employed as a fire engine, was first carried out in the year 1829, by Mr. John Braithwaite, C.E., of London. In this year he constructed, at his works in the New Road, in conjunction with Mr. Ericsson, an engine of 10-horse power, with two horizontal cylinders and pumps; each steam piston, and that of the pump, being both attached to one rod. The waste steam from the cylinders was conveyed through the tank containing the feed water by means of two coiled pipes, thus giving the feed water a good temperature previous to its being pumped into the boiler. Fig. 4 is an engraving of the engine made from the drawings, under the superintendence of Mr. Braithwaite himself, as were all the engravings of his engines. Its weight complete was 45 cwt., and it threw from 30 to 40 tons of water per hour to a height of 90 feet, having thrown well over a pole that height. During its five hours' working at the fire at the Argyll Rooms, it threw well over the dome, and consumed 3 bushels of coke. This engine worked with the greatest success at the fire at the Argyll Rooms, at Charles Street, Soho; at the burning of the English Opera House, and Messrs. Barclay's Brewery, besides many others of less magnitude; at all of which it rendered signal service in preventing the fire from extending. For these gratuitous services, and the great outlay encountered by Mr. Braithwaite, he received but little patronage and support from the general public; and from the insurance companies, who must have benefited to the extent of some thousands of pounds by his exertions, he received the magnificent testimonial, presented to his men, of One Sovereign!

Immediately after the fire at Messrs. Barclay's brewery, the engine was lent for several weeks to be employed in pumping and starting the beer from the different vats in the establishment; a duty it well performed, having to be kept at work day and night for one whole month, which it did without the slightest hitch throughout that period.

During the fire at the Argyll Rooms, the cold was so severe that the manual engines quickly became frozen and useless; but the steamer worked incessantly for five hours without a hitch, throwing its stream clean over the dome of the building.

Mr. Young says, "In 1858 Messrs. Shand and Mason constructed their first land steam fire engine, on the patent of Mr. Shand, which was sent to Russia. The engraving (Fig. 5) is from the patent drawing, which shews the general appearance of the engine."

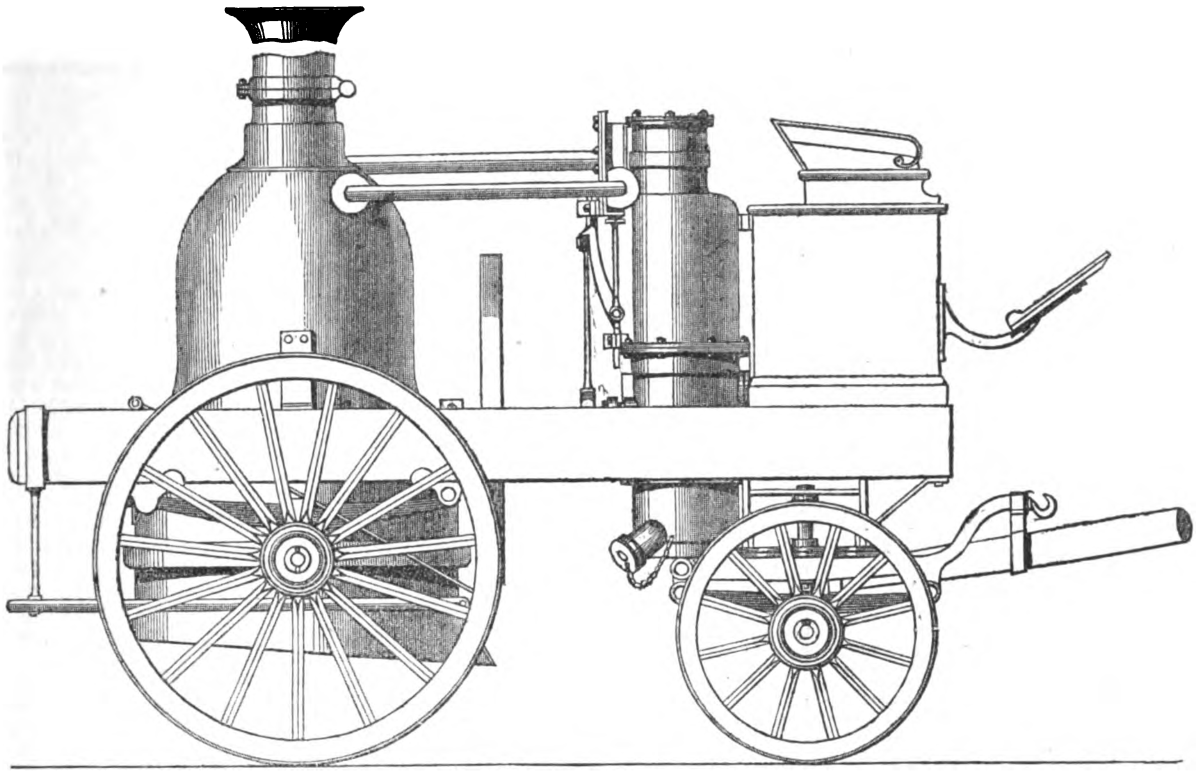


Fig. 5.—Shand and Mason's First Engine, 1858.

It is thus described in the specification:—

According to this invention the steam cylinder which actuates the pump is inverted, and situate over the air vessel of the pump, which is made double acting, one barrel being placed above the other, and a double throw crank is placed between them. One or both of the pistons or plungers of the pump is fitted with a valve, and the piston rod of the steam cylinder is connected directly with the piston of the upper pump barrel, which latter serves as a guide to the piston rod of the steam cylinder. A connecting rod from the upper pump piston connects it

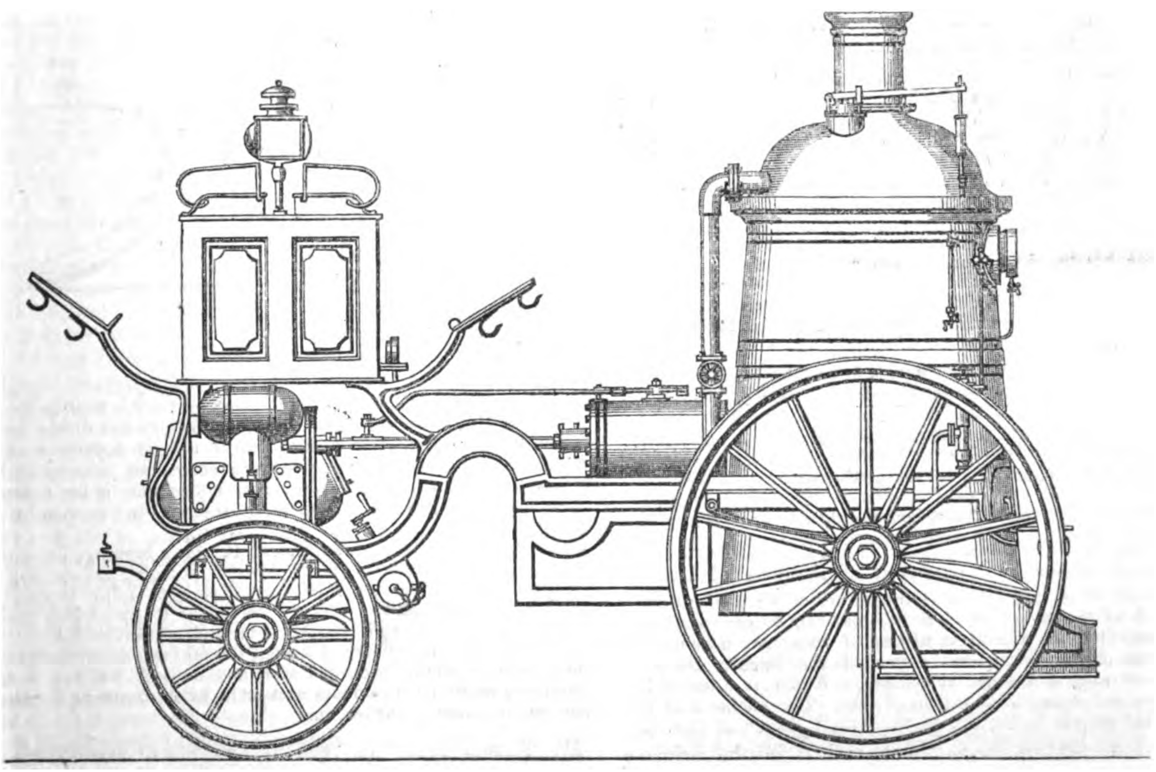


Fig. 6.—'Deluge,' Merryweather and Sons, 1861.

with the crank, while a second connecting rod connects the piston of the lower pump barrel with its throw of the crank. The slide valve of the steam cylinder is worked from eccentrics of the crank shaft outside the pumps, and the lower pump barrel is enclosed in a suction air vessel, fitted with a separate valve if necessary. A fly-wheel on the crank shaft and a feed pump are placed near the boiler. The whole is supported on a carriage consisting of a suitable framing running on travelling wheels, and furnished with springs and locking carriage. In the centre of the hind axle is placed an upright boiler, the steam pump being situate vertically between the front and hind axles, and behind the driver's seat. Beneath the seat is placed the hose reel, or a box for containing the hose and implements.

The description here given is not such as to enable any very exact idea to be formed of the engine: while the boiler, which is certainly a point of the most vital importance, is not described at all; neither are there in this case any results given of the engine's performance. We find, however, that with the next engine, noticed as having been constructed by Messrs. Shand and Mason in 1859, very fair results as regards jets thrown are said to have been attained. After telling us that in the year 1860 Mr. J. Shekleton, of Dundalk, constructed the first steam fire engine ever made in Ireland, the author proceeds,—"In July, 1860, a land steam fire engine was for the first time used by the London Fire Engine Establishment in one of the back streets of Doctors' Commons. In point of 'efficiency, simplicity, durability of parts, weight, and cost,' it was in no respect superior to Mr. Braithwaite's steam fire engine of 1829, while, in some respects, it was inferior to it. In a Report to the Committee the late Superintendent of the Brigade admitted that this engine 'required delicate handling;' and so unsatisfactory upon the whole was its performance that at the end of ten months it was withdrawn, and replaced by one of a different construction, bearing a closer resemblance to that of Mr. Braithwaite.

It is learnt from the evidence of the present Superintendent of the London Fire Engine Establishment that the weight of this first steam fire engine, with men, coals, and water, ready to run out, was 84 cwt. = 4 tons 4 cwt., and that it took three horses to draw it.

The various steps in the progress of steam fire engine manufacture thenceforth are most carefully noted, including the production of Mr. Roberts's "Lucy," the floating steam fire engine constructed by Messrs. Merryweather and Sons for the warehouse of the Tyne Docks, from the designs of Mr. E. Field, C.E., the "Deluge" land steam fire engine constructed in 1861 by the same firm from designs by the same gentleman, three steam fire engines in the same year by Messrs. Shand & Mason, to run on the rails of the London and North Western Railway and numerous others, but which our space will not permit us more particularly to notice in the present number. We subjoin engraving and particulars of the "Deluge," and hope in our next to continue our notice so as to enter into the discussion of some of the questions treated by the author.

In 1861, Messrs. Merryweather and Sons constructed, from the designs of Mr. E. Field, C.E., their first land steam fire engine, the "Deluge," which was a perfect success. This engine was of 30-horse power, and had a single horizontal cylinder 9″ diameter × 15″ stroke, and a double acting horizontal pump 6½″ diameter × 15″ stroke, worked direct off the piston rod of the steam cylinder, doing away with crank shaft, crank, fly wheel, connecting rod, &c.

Fig. 6 is an engraving of the engine.

This engine has thrown water through a nozzle of 1⅛″ diameter, 10 feet over a chimney, 140 feet in height, altogether 150 feet; through a nozzle 1⅜″ to a height of 157 feet; through a 1¼″ nozzle to a height of 170 feet; through a 1⅜″ nozzle to a distance of 202 feet horizontally; and through a 1¼″ nozzle 215 feet horizontally.

(To be continued.)

STEAM POWER DOUBLED WITHOUT ADDITIONAL FUEL.—IS THIS POSSIBLE?

To the Editor of "*The Civil Engineer and Architect's Journal.*"

As PROGRESS in the arts requires us to advance from empirical and partial to rational and extended applications of science, occasional recurrence to first principles, if not always requisite, is often indispensable. For lack of appealing to them, errors, and oversights equal to errors, are apt to become established, till their real character is not suspected and hardly believed when pointed out. So it has ever been and will be. Referring to beet and cane sugar, a writer announces that the juice of the cane contains double the quantity of saccharine crystals extracted from it—that quite as much is lost in the primary manufacture as reaches the market. Passing by other examples of thoughtless waste, the same may be said of a product vastly more important to commerce and the world at large than the richest of saccharine plants—STEAM POWER. Of it the high-pressure or non-condensing engine is the popular representative, and strange to say, *the fluid positively contains double the amount of power which the best class of such engines draw or ever can draw out of it.* Hence, if operatives of the last century are rightly considered dullards for wasting materials, what in the next one may not be said of us who, after evolving with costly apparatus the most valuable of motive agents, discharge it into sinks and sewers, or the air, with half its power in it—casting out as worthless dross that in which there is not an atom of refuse or alloy. Expert and alert as we are in many things, we surely shall not be thought adepts in economising that which gives value to every material.

But are there not engineers who deny that anything like so much power is lost in waste steam? Yes, I think all with whom I have conversed emphatically dissent; and yet the fact appears as clear to other minds as that they exist, and, furthermore, that the alleged amount, so far from being an exaggeration, is largely *under* the truth. Doubtless the views of practical men should command respect; but crucial tests and natural laws, not human, opinions, are required here. Truth in too many things is obscure because not deemed worth the trouble of clearing up, but in a matter of such importance to advancing civilization as this it ought not to be left an hour in uncertainty. Nor need it be.

The subjoined propositions cover the whole ground, and what follows them will, it is presumed, suffice for their demonstration:—1. In all cases there remains *as much* power in the discharge steam as it imparted to the piston, however great that may have been. 2. In most cases *more* power, and in some cases *double the power*, may be obtained from it.

As I wish to address others beside professional men, a preliminary observation or two will not be out of place; for, though the subject is becoming an item of college education, few look *into* it, and general ideas reach little beyond the external features and movements of an engine. There is no reason why this should continue, nor will it, since whatever is uncertain about steam vanishes when thoroughly looked into, and every person of ordinary capacity can do that. Its properties are as palpable and plastic as those of other bodies. It is weighed in the same scales, and its quantities ascertained by the same measures as liquids and solids. A pound of it is a pound of water vaporised. The mode of using the measures is somewhat different, but not less rigid and correct. One holding a cubic foot of water has to be emptied and filled afresh till the number is made out; whereas with steam several feet are generally contained in the space of one, the number being indicated by the pressure—hence pressure and quantity are complements and explicatives of each other. As volume increases pressure diminishes, and *vice versa*, the quantity remaining the same. The smaller volume may comprise the larger: thus five cubic feet of the pressure of 40 lbs. on the inch contain ten feet of 20 lbs., or twenty feet of 10 lbs., all three equivalents in cost, weight, quantity, and power.

These remarks are introduced to enforce the imperfectly acknowledged truth that the power of steam is increased only by increasing its *quantity*, just as more heat is obtained by consuming more fuel, more light by turning on more gas, and as the force of a gun is increased by adding more powder to the charge. Hence, to double or treble the power of steam in a boiler, double or treble the quantity must be generated in it, for there is no increasing the natural force of the fluid.

As a source of mechanical power the atmosphere is little thought of, and still less as the recipient of all forces—Nature's receiving and reacting reservoir. A perfectly elastic medium, it softens the effects of the most violent, and responds to the smallest. To say nothing of natural forces, of which, as in the case of wind, inconceivably minute fractions only have been used, the steam incessantly rising from human applications of heat to water would, if condensed under pistons, yield a productive power equal to the muscular energy of multiplied millions of men and horses, while we of the present age are responsible for recklessly contributing vast additions to the waste. I do not allude to what ascends from domestic habitations and manufacturing processes, but to the volumes discharged from motive engines by those whose profession it is to apply force, and the best proof of whose skill is to economise it. What inference can hereafter be drawn from our employing the force that expands a volume of water into 1,750 volumes of vapour, and neglecting that which is evolved by the shrinking back of the 1,700 into one? What, but that the fact was either not known or overlooked that the negative force in fluids is equal to the positive.

Nearly all the world knows that a cylinderful of steam is discharged from a high-pressure engine at every stroke of the piston, and that from the rapidity of the strokes and the high temperature of the fluid, little is lost in passing through the cylinder. Now, *does* every puff of the escaping vapour contain or not an amount of power equal to that it imparted to the piston; in other words does its shrinking back into water give out power equal to that which raised it out of water, and as fully as a falling weight gives back that which raised it? The answer has just been anticipated, for the question is nothing less than an appeal to the law which governs every form of force and every mode of application—the fundamental law of action and reaction. According to it the two forces are absolutely and inevitably equal. It is impossible for one to be less than the other. They are simply contractions and expansions, equivalents to each other. To exemplify: A high-pressure engine has a piston of the area of 50 square inches, and is worked with steam, say of 60 lbs. to the inch, hence $50 \times 60 = 3{,}000$ lbs. of *steam* pressure. Now if the fluid, instead of being discharged, were condensed under another piston, it would produce precisely the same result; thus, steam of 60 lbs. contains four volumes of common steam, and would dilate and fill a cylinder with a piston of 200 inches area, both cylinders of one length; hence its condensation would excite an *atmospheric* pressure of $200 \times 15 = 3{,}000$ lbs. So much for the first proposition.

If the second be thought to conflict with the first it only appears so. A cylinderful of common steam has *no* expansive force or direct action on a piston, but is all that is required to produce a vacuum under one; so that while the two forces are theoretically equal, the contracting one is practically the most productive. *More power—15 lbs. on the inch more—is obtained by condensing steam of two atmospheres and upwards* than its direct action can give out, because the expanding force acts against the atmosphere, and therefore loses (expends without return) 15 lbs. on the inch, while the contracting one, coinciding with the pressure, gains that much. Hence engines working with 30 lbs. steam, or a pressure of two atmospheres, give out only the force of one; with 60 lbs. steam the force is that of 45 lbs.; of 90, that of 75 lbs., and so on. The term "most cases" in the proposition might be changed for "all cases," and the "some cases" scarcely needs a formal exposition. An engine with a piston of 50 inches area, and using 30 lbs. steam, has, of course, an available force of only 15 lbs. steam; hence $50 \times 15 = 750$ lbs. of steam pressure; but the same steam condensed under a piston of 100 inches area would yield double that amount in atmospheric pressure; it would be $100 \times 15 = 1{,}500$ lbs.

Perhaps it will be said this is no new discovery. Granted; but it is a great truth, nevertheless, and one hitherto overlooked or not appreciated. Adopt it and it will be found surpassingly more effective and profitable than the numerous wire-drawings of subordinate devices.

What is the expense of thus saving waste steam? As the force of a high-pressure engine is deemed to be worth much more than the fuel it costs, an equal additional amount should be held cheap at the same price. Instead of that, however, it is offered as much cheaper as cold water is cheaper than coal. The expense consists in the application of that which may almost everywhere be had for nothing. To decline the advantage offered is to prefer partial results at a great cost to full results at a smaller one; but when the superior productiveness of the shrinking over the swelling force becomes generally known, it will scarcely be much longer neglected. With a separate condenser, the judgment that consigned Newcomen's engine to desuetude will have to be revised.

To save steam power is to save that which is more valuable than silver or gold. To be careful of evolving and parsimonious in expending it is a virtue—to waste it, a crime. Its economy has relation to the welfare of nations, and henceforth their rise and decline will be influenced by it. It has a direct bearing on a subject of increasing anxiety with European statesmen,—the prospective exhaustion of British coal-fields. The cost of the world's steam power in coal is enormous, and is rapidly increasing. To lose half the power in steam is to waste half the fuel. To save steam is to save coal; and to double the available power of steam is to save half the coal.

And yet 50 per cent. seems less than what ought to be saved. In the first part of this paper it is declared that steam contains more than double the power got out of its direct action; and it may now be added that not more than *one-third* of it has been realised in either condensing or non-condensing engines. This fact, no doubt incredible to many, is incontrovertible. (See *Journal of the Franklin Institute* for July, 1865.)

Another point shows that, instead of anticipating the future in making the most of our steam, we are lamentably in the rear. It is stated that 90 per cent. of the heat is lost in waste steam. To common observation it would appear never to be less, as the piston acts but as a momentary check to the fluid's passage from the boiler to the waste pipe. Of course every particle dispersed carries off power; and to save it every particle must be liquified *within* the engine, for the power and the vapour live and expire together.

The mode proposed to utilise the whole force consists principally in adding an atmospheric cylinder to the steam cylinder, as much larger than the latter as the tension of the steam used is above atmospheric pressure, as in the specification and drawings of Benjamin Laurence's English patent for increasing the mechanical value of steam as a motive agent, dated March 17, 1865.

THOMAS EWBANK,
Late U.S. Commissioner of Patents.

New York, June 5, 1866.

ROOF OF CRYSTAL PALACE, SYDENHAM.

(*With an Engraving.*)

In this Journal for April last a paper appeared upon Arched Roofs, by C. R. Von Wessely, containing, among others, a description in detail of the Sydenham Crystal Palace Roof (see page 107 ante), accompanied by an illustration (Plate 14) of the roof of the centre transept. We now supply a plate of details of one rib of that roof, and would refer our readers to the description at page 107 of the April number, for particulars of these details, in addition to the following references to the plate now given:—

(*References to Plate 25.*)

Fig. 1. Detail of distance struts.
Fig. 2. Detail of springing of main rib.
Fig. 3. Shoe for connecting hanging rods from 6ft. purlins to intermediate rafters.
Fig. 4. Shoe for connecting hanging rods from 3ft. purlins to intermediate rafters.
Fig. 5. Detail of diagonal bracing between ribs 24 feet apart.
A. Junction ring.
B. Wrought-iron hoops, 1in. square, shrunk on hot.
Fig. 6. General arrangement of connection of main rib with purlins, and of skylight.—These main ribs are arranged in pairs 24 feet apart, and between each pair there is an interval of 72 feet.
Fig. 7. Section of gutter and of intermediate rafter.
C.C. angle-irons, 2in. by 2in. by ¼in., ½in. rivets.
D. ¼in. plate.
Fig. 8. Detail of gutter at outlet, shewing outlet, bracket.
Fig. 9. Detail of ornamental joint-cover at intersection of the diagonals with radial struts.
Fig. 10. Detail of ornamental joint-cover at intersection of the diagonals only.
Fig. 11. Detail of shoes for rib rafter.
Fig. 12. Sectional plan of ditto.

WILLIAMSPORT SUSPENSION BRIDGE, U.S. AMERICA.

By Alfred P. Boller, C.E.

This bridge crosses the Susquehanna River at the foot of Market street in the above city, and at a point where the river is nearly 1000 feet wide. It was thrown open for travel during the beginning of last December, replacing the former wooden bridge which was entirely swept away by the great flood of the previous March. The whole bridge cost less than 40,000 dols., and its construction occupied about four months. The cables supporting the structure festoon the river, as it were, in five spans, each 200 feet in length, the intermediate towers resting upon the masonry of the former piers. The general plan of bridge is known as the "Murphy Military Suspension

Bridge," embodying some marked improvements and advantages which will appear further on.

The Cables, having a common versed sine of 20 feet, consist of five wire ropes for each side, of an inch and a quarter diameter, and are continuous from anchorage to anchorage. They were hauled over from one side of the river to the other by means of a windlass, and raised to their positions on the towers by ordinary block and tackle. The whole ten were stretched over the river and adjusted to place in little less than a week's time. The ends of the cables are secured in forged wrought iron thimbles, the wires being frayed out by means of tightly driven sprags, the interstices remaining being filled with lead poured in, and well hammered. The thimbles are connected with the turn-buckles, which are 18 inches long, by means of forged inch and three-quarter bolts, with eyes on one end, and swivel-heads at the other. The turn-buckles screw upon 2 inch rods, which pass entirely through the masonry.

The Anchor Masonry is below the line of cables and above the foundation proper, a trapezium in form, 15 feet long in the line of slope, the front face being 8 feet 3 inches high, and the back 2 feet 8 inches. Upon this slope the anchor irons, consisting of five 2 inch rods, were laid, and solid masonry 3 feet high built upon them. The uniform width of the anchorage is 8 feet. The whole masonry is built of heavy flagging stones, 6 inches thick and upwards, and is thoroughly grouted from top to bottom. Each anchoring mass contains thirty-six perches of masonry. The pressure is distributed over the masonry by means of four vertical 7 inch Phœnix beams, against which and at their centre two parallel and horizontal 9 inch beams bear, separated enough to let the ends of the 2 inch rods pass between, and cast iron washers, for the nut to be screwed up against, complete the fastening.

The Towers, 27 feet high, supporting the cables, are in the form of a frustrum of a pyramid, battering at the rate of one inch to the foot. They are built of white pine 12 × 12 posts, mortised at their base into sills 12 × 14 resting upon the tops of the piers and abutments, which sills are connected at proper intervals by ties mortised into them. The hollow spaces between the sills and ties are filled in with cement masonry. These sills are continuous, *i.e.* each pair of towers is framed into the same set of sills. The legs of the towers are stiffened by having ties mortised into them and pinned with oak pins. The caps are mortised into the tops of the posts, the shoulders of the mortise being made square with them. Resting upon these caps are the saddles, also of white pine, in three pieces; the centre one of which (16 inches deep) is bolted into each cap by one inch bolts. Each pair of towers are united together at the top by means of a 10 × 12 tie beam, bolted to the under side of the caps by means of the same bolts that secure the centre saddle pieces. An inch and a half bolt passes through each pair of caps for attaching the truss rods to.

The Roadway is 18 feet wide in the clear, and is attached to the cables by means of white pine posts, 7 inches square, hung together, in pairs, with an inch space between them for the truss rods to pass through. These suspenders are so arranged as to divide each span into ten panels, all of which are 20 feet from centre to centre. These suspenders have a slightly greater batter than the legs of the towers, so as to slope towards the chord line of the cables when freely suspended. The cables are spread in passing over the towers, but cluster at the suspension posts, passing between them, and bear against oak saddles sunk into daps in the posts, and an inch bolt passing through both posts and saddles completes the attachment. Nine inches from their lower ends, the posts are clasped by two floor beams, 6 × 14 each, bolted to them, and running far enough past the posts to support foot-walks on either side. These floor-beams support the stringers.

The outside stringers are packed chords, bolted to the floor-beams, and are packed in two pieces breaking joint, each piece being 5 × 12 inches scantling. There is one joint for each panel, which joint is always over a floor-beam. The three inch plank that composes the flooring is laid upon these stringers and spiked to them. *The sway or lateral bracing* is formed of $1\frac{1}{8}$ inch rods in four pieces to each panel, starting from the upper series of bolts that fasten the floor beams and the posts together, to which they are attached by means of an eye, and through which the above described bolts pass. At the point where they would intersect they are cut off, passing into a ring of half-inch flat iron, against which the ends are screwed up and adjusted. *The truss rods* pass between the pairs of suspension posts, and are all of one inch round iron. For three panels each way from the towers, the tops and bottoms of the suspension posts are connected directly with the bases and tops of towers. The rods of the last panels (those that incline downwards) are secured to the bottoms of towers on their opposite sides; in other words, they pass through the nearest legs of the towers, and are screwed up against the legs on the further side. They thus act as an additional tie and stiffener for the bases of the towers. The ends of the truss rods are screwed up against oak blocks, bearing against the floor-beams and the feet of the suspension posts. In order to allow for the stretching of the cables, a camber of 12 inches for each span was framed into the bridge, and adds very much to the general appearance. It is intended eventually to put the foot-walk on, to pass through the towers and provided for in construction in the elongation of the floor-beams. The railing will be a substantial Howe truss 4 feet high. At present the bridge is subjected to a heavy amount of traffic, such as stone, lumber, cattle, etc., and it gives evidence to a surprising degree of stiffness due entirely to the peculiar system of trussing, in making the verticals act by thrust, and the diagonals by tension. This general arrangement for suspension bridges was first practised by Mr. John Murphy, C.E., over the Gauley, in West Virginia, and also at Franklin, Pennsylvania. But he used his diagonals to truss each panel separately, instead of trussing panels by attaching the diagonals to fixed points, as is the case in the above-described bridge, where the diagonals are secured to the *towers* for *six* panels out of ten in each span. *Without* the aid of the trussed railing, the effect of a heavy team passing over the bridge can hardly be felt until it strikes the span that we may be standing on, further than the slight tremor inseparable from all bridge superstructure, especially those of the suspension class. Without considerable modifications, the above construction for suspension bridges is inapplicable to spans much above 200 feet.—*Franklin Journal.*

New Arrangement of Bar Vice.—At a recent meeting of the Franklin Institute of Philadelphia, a new arrangement of parallel jaw or bar vice, the invention of Mr. Linus Yale, was described. This tool is designed to obviate a difficulty existing in all ordinary vices, the jaws of which are moved by a screw, viz.: the time lost in opening and closing the jaws by the tedious process of turning the screw. In some kinds of work, such, for instance, as the manufacture of locks, the case of the lock requires to be held edgeways, and then flatways. This necessitates the jaws being opened through considerable distance, and then closed as each change is made in the way of holding. Mr. Yale, in noticing his workmen at this kind of work, found that 12 per cent. of their time was spent in screwing and unscrewing the vice. This instrument has a nut and screw with the bar, as usual, but the nut is not always attached to the bed or stationary jaw of the vice. To this jaw, in the under part of the guide, is a rack with ratchet teeth. The nut is square, and has teeth on its under side corresponding to the teeth in the rack. The nut, when screwed to the back end of the bar, rides up an inclined plane, which so elevates it above the rack, that its teeth cannot engage therein. In this position the moveable jaw can be pushed back and forth, *i. e.*, opened or closed rapidly by hand without turning the screw. Placing a piece of work in the vice, as, for instance, a piece of wood about three-eighths of an inch thick, the jaw can be pushed quickly up to it, and then one turn of the screw draws down the nut into the rack teeth, and a part of a turn will secure the work as firmly as if screwed in an ordinary vice. The same amount of back turns of the screw release it, and then the jaws can be opened wide to receive the block edgeways. With about three inches open, one turn will again fasten it. The vice can be used as an ordinary vice, by drawing out the moveable jaw to any required distance, and then screwing it all the way home. It will, within the range just referred to, act as if the nut was fast to the stationary jaw. The rack in this vice is not rigid. It has a spring back of it so arranged as to allow one-eighth inch end motion. This enables the workman, when filing to a template, to adjust his work to the template with a slight pressure of the jaws, the moveable jaw being elastic, as it were. It can be pulled back about one-sixteenth of an inch, yet the work is held firm enough to adjust. Workmen will appreciate this; for they are aware that in a rigid vice the work must be either very fast or very loose.

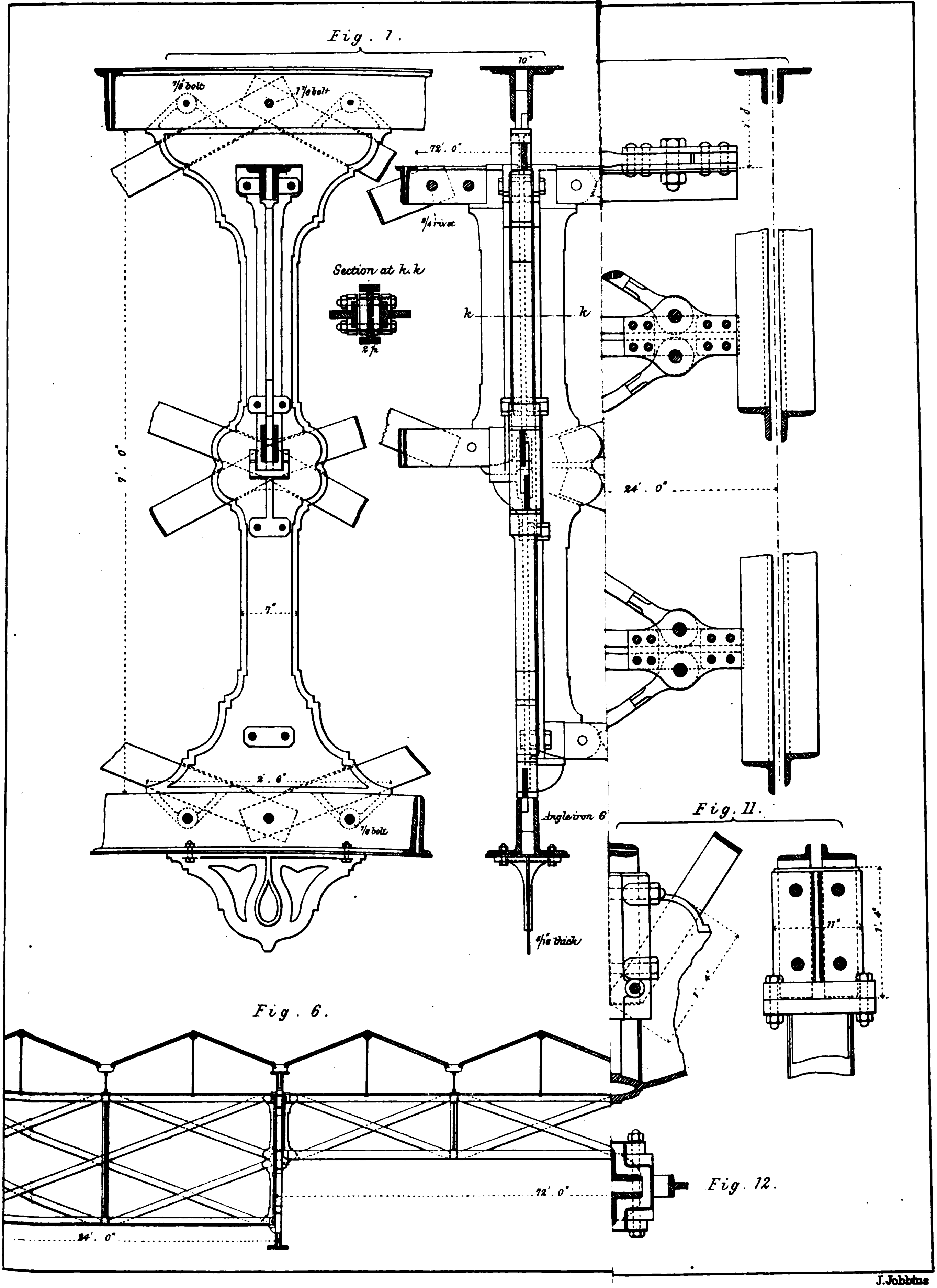


Fig. 7.

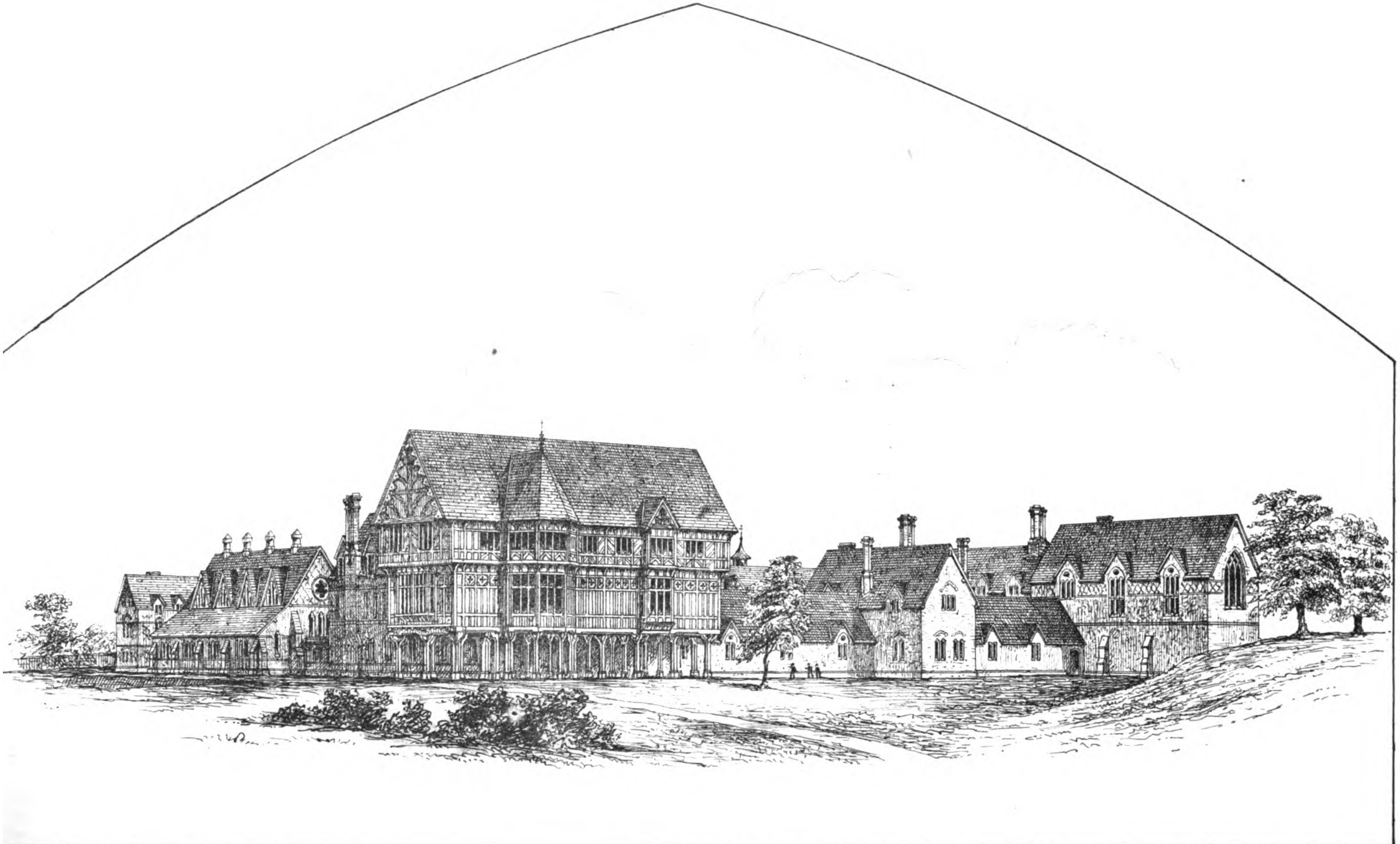
Fig. 6.

Fig. 11.

Fig. 12.

J. Jobbins

Pl. 27.



J. DRAYTON WYATT DEL. ET LITH.

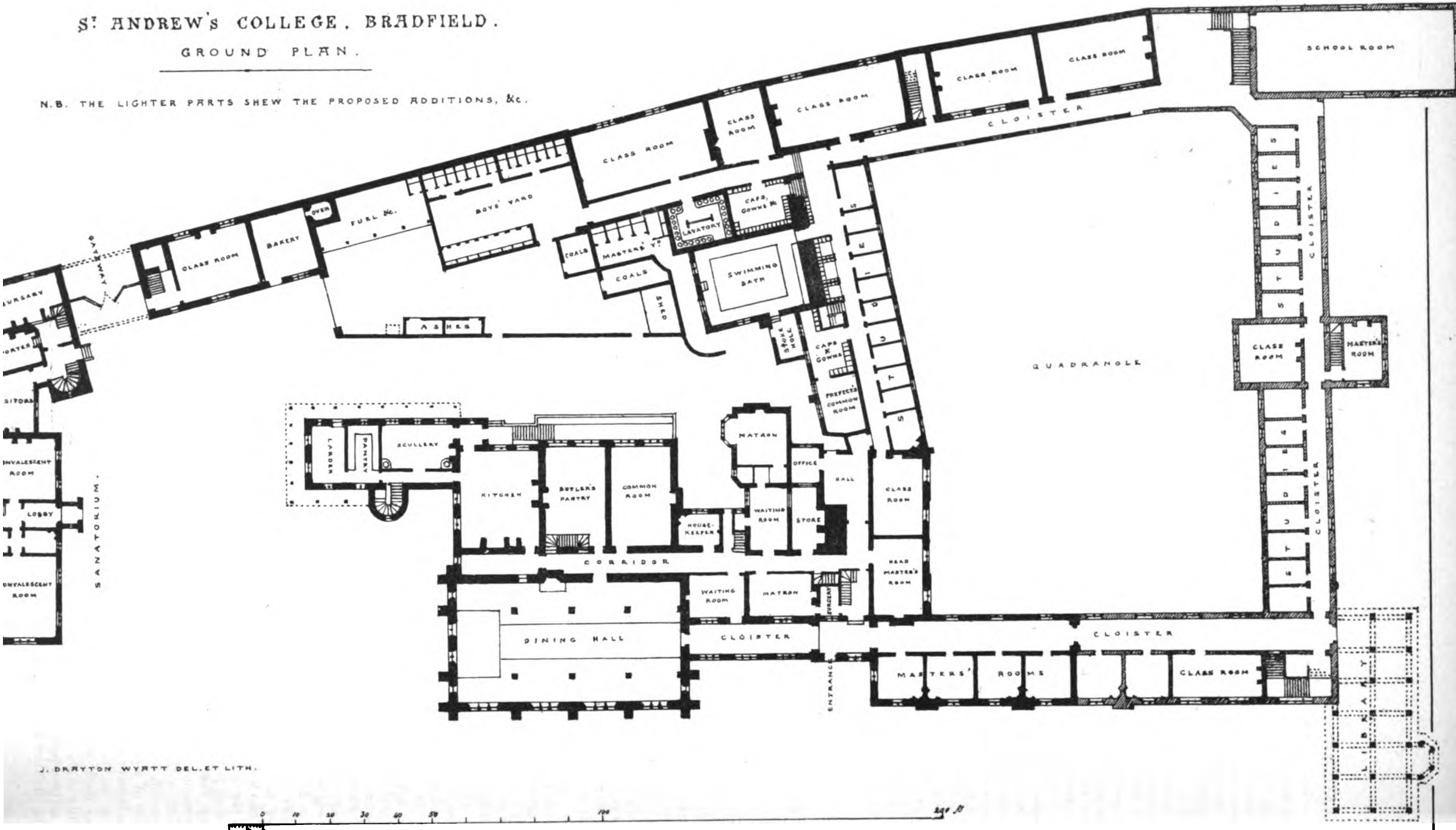
St. ANDREW'S COLLEGE. BRADFIELD.

WITH THE PROPOSED NEW LIBRARY, STUDIES, AND SCHOOLROOM.

S^t. ANDREW's COLLEGE, BRADFIELD.

GROUND PLAN.

N.B. THE LIGHTER PARTS SHEW THE PROPOSED ADDITIONS, &c.



J. DRAYTON WYATT DEL. ET LITH.

ST. ANDREW'S COLLEGE, BRADFIELD.

(With Engravings.)

BRADFIELD, a village a few miles south of Pangbourne, on the Great Western Railway, and situate among some of the most delightful scenery of Berkshire, is especially worthy of the visit of the architectural tourist, on account of its quaint old parish church, and the college which almost adjoins it. The latter subject is illustrated to some extent by the accompanying view and plan. The original "college" (which is a comparatively modern institution) existed in the building about the centre of the plan, and was of a homely character. By degrees, however, as the institution flourished under the energetic management of its warden, other portions were successively added, from the designs and under the general superintendence of Mr. G. Gilbert Scott; further works are yet contemplated, as indicated in the view. Of the more important additions may be mentioned the large "dining hall," which, with its open timber roof, has quite a mediæval aspect; several masters' rooms; an extensive wing, and other portions executed in half-timber work; and a "sanatorium," detached from the other buildings, the walls of which are of red brickwork, with black-header patterns. It is now proposed to complete an extensive quadrangle by the erection of a large school-room and class-rooms, with a series of "studies." At one angle of this plan will be a "library," constructed in half-timber work, with rich barge boards, the design of which is based on that of the old town-halls of the west of England. The lower part will be open, so as to serve for shelter when required. The roof of this, as well as of the other additions, will be covered with tiles.

PUBLIC MONUMENTS IN BELGIUM.

THE Belgium authorities exhibit great regard for their public works of art and monuments. A central commission is entrusted with their keeping and also with the consideration of all questions, theoretical as well as practical, touching their preservation. The report of the proceedings of this commission, embracing rather more than twelvemonths' labour, has recently appeared, and deserves attention.

It appears that the commission has more than twelve hundred subjects before them; that the project for the restoration of public works presented to them included nearly two hundred; and that the works undertaken in consequence absorbed nearly £120,000. In addition to this the commission had to examine more than two hundred other projects for new buildings, and a still larger sum was expended on that account. The funds to meet these expenses were contributed partly by the Government and partly by local authorities.

The report refers to the efforts made by the commission to clear away all buildings abutting on churches, as a precautionary measure, as well as in the interest of art. It was found on inspection that the inhabitants were in the habit of cutting away buttresses, undermining walls, and injuring foundations by the sinking of wells.

Under the head of the decoration of religious edifices the report mentions the discovery in many churches of old mural paintings, covered up for long years beneath coats of paint or whitewash. Extensive decorations are proposed to be executed in old buildings; and amongst others the church of St. Jacques-sur-Caudenberg is to be commenced next year. Amongst other useful services done or proposed to be done, are the creation of a special atelier, under the auspices of the Government, for the restoration of ancient paintings, the formation of a complete catalogue of the works of art existing in public buildings, and the repair of the old gates of the town of Antwerp.

An interesting portion of the report is that which records the discussion by the members of the commission of several important questions submitted to it by provincial committees in communication with the central body. The Committee of Brabant proposed, first, that every artist submitting a plan for the restoration of a public monument should be required at the same time to furnish a memoir in support of his proposal; and secondly, that in the case of new buildings the commission should confine itself solely to the consideration of the estimates and the solidity of the construction, leaving the entire responsibility, in an artistic point of view, with the artist himself. It is not surprising that the novelty of the propositions should have met with considerable opposition, and that the opinion of the majority was averse to both; it being argued against the latter that the commission, in renouncing all control over the esthetic value of the plan submitted to it, would be giving up its most important prerogative. It should be mentioned that the commission is only empowered to discuss the subjects submitted to it, the decision being left to the Government.

Another proposition was that a series of general instructions should be drawn up on the restoration and preservation of public monuments, and transmitted to all the administrations charged with such duties. This subject was discussed at length. One member considered that the reproduction of the very complete instructions published in France by the Committee of Monuments would be all sufficient. In opposition to this it was argued that Belgium was in a peculiar archæological position; that she was, as it were, at the confluence of various styles, and the restoration of many of her monuments would present many points which had not been provided for in the French instructions; that many excellent architects were not archæologists; and it would be useful therefore to establish certain general rules for the restoration of monuments in different styles; the architect who planned a new building should be left absolutely free, but it was not so when the restoration of an ancient monument was in question; in such a case his duty was to conform rigorously to the idea of the author of the work. The opponents of the proposition argued that architects were already far too much trammelled, and that, with the exception of the material parts of the construction, no general rules could be laid down. The only useful instructions would be such as were given to the architect in each individual case. On the other hand it was urged that the intention of the proposal was not to interfere with the independence of architects. The instructions would not be for them alone but for local administrations, for ecclesiastical authorities, and for all those who are occupied, directly or indirectly, with the preservation and restoration of public monuments.

A proposal was made for the establishment of a central school of architecture at Brussels, but it was opposed upon the ground that such a measure would tend to diminish the attention paid to architecture in the academies, and to centralize the study. Other members of the commision, on the contrary, agreed with what had recently been done in France on this head, and supported the proposition as tending to strengthen architectural teaching, which in the academies was very incomplete.

Several questions set down for discussion on the programme of the commission itself were of general interest. The first was:—Whether, in order to preserve archæological traditions in all their purity, a distinction should be drawn in certain cases between ancient monuments and additions which have been made to them at various times. It was stated, in a memorandum attached to the question, that the new portions of buildings erected in past ages, were distinguished from the older parts, in consequence of the general practice of completing an edifice in the style in use at the time of such additions, without consideration of the original style of the building. This statement was contested, and instances were quoted in which the new portions of ancient buildings had been built in the style of the original epoch. The result of the discussion was to draw forth an admission that the statement appended to the question had been couched in terms too absolute, and that certainly if, in past times, architects entrusted with the completion or extension of buildings conformed to the original style, such practice was quite exceptional; in far the greater number of cases, the new constructor took no heed of the older parts.

Another question set down for consideration was—In what case may an artist, in decorating a mediæval edifice, either by painting or sculpture, give to his figures costumes differing from those of the epoch to which the edifice belonged? It was asserted, on the one hand, that the figures might be dressed in the costumes which they really wore; and, on the other that the costumes should be those of the time of the erection of the edifice, no matter when the persons represented may have lived. The commission, however, adopted the following view of the case:—That there were distinctions to be made as to the course to be taken, which could not be stated in absolute terms; when the work to be done was the addition of new to ancient statues, in order to complete the sculptural decoration of an edifice, it was the duty of the artist to reproduce even the anachronisms committed by the ancient artists, but that in the case of edifices having no sculpture, or of new buildings, the costumes adopted should be those of the time in which the personages lived.

The fourth question set down for consideration had reference to the duty of the Government as regards the preservation of private houses presenting a public interest, either in an artistic or historical point of view; but as the Belgian Government had already taken the initiative in this matter, the subject was allowed to drop.

The remaining question was whether an architect entrusted with the restoration of a building should be specially remunerated for drawings of the building in its former condition, in order that the State might become possessed of such drawings, which might be engraved and published on a uniform plan. This interesting subject was, however, adjourned to next year.

The discussion of subjects touching so intimately the preservation of the edifices and works of art of past ages shows how lively is the archæological sentiment in Belgium.

THE NEW GRAND OPERA HOUSE, PARIS.

THE works of the new opera are proceeding sufficiently rapidly for the proposed inauguration, on New Year's Day, 1869. The sum said to be devoted to the purpose is one million sterling, of which three-fifths, if not more, have already been expended. It would perhaps be a little hazardous to say that there will not be required a certain postcript to the estimates. The employment of the twenty-five millions of francs is thus apportioned:—For iron work, two millions; marble, eight millions; sculpture, and other works of art, fifteen millions. Of course this is but a rough division.

The paintings in the interior are to be entrusted to MM. Baudry, Boulanger, Barrias, Delaunay, Gérôme, and Pils. It is said that the designs for these internal decorations, which have been submitted to the judgment of M. Garnier, the architect of the work, amount to several thousands in number.

The list of the statues and busts which are to decorate the exterior of the building and the vestibule is published officially. On the principal façade will be medallions of the composers, Cimarosa, Pergolesi, Bach, and Haydn. In the grand vestibule four seated statues of the four chiefs of the schools of Italy, France, Germany, and England—Lulli, Rameau, Gluck, and Handel.

In the seven *œils de bœuf*, or small circular windows, are to be seven bronze busts, gilt; the centre will be that of Mozart, born 1756, and those of the other composers will be placed on each hand according to the dates of their birth; thus to the right of Mozart will be Beethoven, born 1770; Auber, 1782; and Rossini, 1792; and on the left Spontini, 1774; Meyerbeer, 1794; and Halévy, 1799. On the return of the façade busts of two librettists—Quinault and Scribe. On the two lateral façades are to be placed twenty-four busts in chronological order. On one side Monteverde, Durante, Jomelli, Monsigny, Gretry, Sacchini, Lesueur, Berton, Boieldieu, Herold, Donizetti, and Verdi; on the other Cambert, Campra, Jean Jacques Rousseau, Philidor, Piccini, Parsiello, Cherubini, Méhul, Nicolo, Weber, Bellini, and Adam. In one of the foyers are to be placed busts of celebrated architects, or others connected with opera.

Among the sculptors employed are M. Carpeaux, whose fronton for the *Pavillon de Flora* of the Tuileries has attracted so much well-deserved admiration.

Respecting the decoration of the interior, it is reported that M. Meissonnier has made proposals for departing from his micrographic style and executing colossal works on the walls of the salon in the rear of the Emperor's box.

The following are the dimensions of the new opera house. The stage is in all more than 165 feet in height, the space being divided equal between the stage proper and the spaces below and above, giving 55 feet to each. The stage will be nearly 170 feet wide and about 114 deep. The principal boxes will have behind each an anti-chamber three times the size of the box itself; and the passages behind the boxes will be 20 feet wide. The immense importance of wide passages in theatres and all large public buildings, not only with respect to comfort and ventilation, but also as means of escape in case of fire or panic of any kind, cannot be too often insisted on. No one who contemplates building a new theatre, especially for popular entertainments, should fail to visit the new Châtelet Theatre in Paris; the passages and lobbies of this beautiful theatre are large enough to drive a brougham along, and even in parts to turn it round, and the staircases are in keeping with these magnificent proportions. Another feature deserving attention in the same building is the fine public foyer, or saloon, with its terrace overlooking the Place du Châtelet and the Seine. The plans of the new opera-house hold out the expectation that in the matter of entrances, public and special staircases, vestibules, lobbies and corridors, the new theatre will surpass any now in existence. The Emperor's entrance has a covered arcade, so that the Imperial carriages may set down under shelter, in fact almost within the house itself.

THE BIRKENHEAD DOCKWORKS.

THE Birkenhead Docks are constructed in a creek of the Mersey, formerly known as Wallasey Pool, and the first act of Parliament authorising their construction was obtained in 1844, on plans prepared by the late eminent engineer, Mr. J. M. Rendel. By an agreement made in 1855, afterwards confirmed by acts of Parliament, the original projectors transferred the property to the Corporation of Liverpool, who subsequently vested it in the Mersey Docks and Harbour Board, and thenceforth it became incorporated with the great estate under the control and management of that body. At the time the board became possessed of the property not much progress had been made in the development of the works, for the total area of water space then opened and in use amounted to little more than about seven acres. One of the most important features of this great system is that of the large dock called the Great Float, having an area of 112 acres, a length of 1½ mile, and quayage to the extent of four miles. This is sub-divided into the east and west floats by a passage 100 feet in width, crossed by an iron swing-bridge. Branching from the west float on its southern side are two basins attached to the extensive engineering establishment of Messrs. Peto, Betts, and Co., and the copper ore works belong to Messrs. Logan and Co. On the same side are two graving docks, each 750 feet in length, having accommodation and appliances for repairing ships of the largest class; coal yards, and coal hoists worked by hydraulic machinery, and coal tips for barges are placed on the margin of the South Quay; also a powerful crane, capable of lifting 60 tons. A basin and landing slip for the discharge of timber is provided on the south side. On the southern side of the east float the establishment for the testing of chain cables and anchors forms an important feature. Two machines capable of testing up to 300 and 200 tons respectively, have been at work here since April, 1863, and additional machines specially suited for the testing of anchors, and for experimental work, are about to be supplied. The establishment occupies a large area, and possesses railway conveniences, water frontage, and powerful hydraulic crane accommodation of the most complete description. The testing machines are worked by hydraulic power, and have been fitted up by Messrs. Sir Wm. G. Armstrong & Co., in the best manner, and with the latest and most improved appliances. Three large stacks of warehousse for general merchandise, and a capacious closed shed for the storage and protection of goods, stand on the south quay of the east float, also the goods station of the Birkenhead and Chester Railway Company, with its extensive warehouse and shed accommodation. On the north side, a range of quay space 250 feet in width, bounded by a wide marginal road, extends the whole length of the float. Special accommodation for the corn trade is being provided on the north quay of the east float, in the formation of a canal dock, and by the construction of four extensive piles of warehouses six stories high. The copper ore works of Messrs. Todd, Naylor, & Co., are situated at the western extremity of the north quay, and doubtless other establishments of a similar character will arise. A line of railway in connection with the main systems of the country traverses the quays surrounding the docks.

The river frontage of these docks is nearly one mile in length, and the openings which give access to the system are of the most complete character. Of these the most important are the great northern entrances completed and opened in June last. They comprise an outer basin or embayment of 4½ acres area, opening from the river, and leading to a lock 350 feet in length and 100 feet in width; and two lesser locks of 50 feet and 30 feet in width respectively. These entrances communicate with a dock 8½ acres area, named "The Alfred Dock." This is connected with the Great Float by passages and locks of similar width to those of the outer entrances just described. Iron swing bridges, with double roads and railways, cross the inner entrances, and a complete system of hydraulic machinery is provided for opening and shutting the dock gates and bridges, regulating the sluicing apparatus, and for working the capstans on the dock quays. The sills of these entrances are laid sufficiently low to admit of the reception of the largest class of vessels during all tides in the year. The masonry is for the most part of granite from the quarries in Scotland belonging to the dock board, supplemented by ashlar from the Penryn quarries in Cornwall. As specimens of masonry, they are of the most substantial description. The character of work is that originally introduced by the late engineers Messrs. Jesse and John Bernard Hartley, and has been continued by Mr. George Fosbery Lyster, the present engineer to the estate.

The entrance to the Great Float, on the southern margin of the estate, was through the Morpeth and Egerton Docks, two small dock of about seven acres, constructed by the former proprietors, which formed the sole amount of dock accommodation at Birkenhead when the property passed into the hands of the Mersey Board. The outer of these two docks, the Morpeth Dock, is now closed for alterations; and the Egerton Dock is temporarily occupied by the London and North-western and Great Western Railway Companies. The New Morpeth Lock is a finished work, 400 feet in length and 85 feet in width, and can, should necessity arise, be used as a graving dock. An enlargement of the Morpeth Dock has been partly completed, and for a short time, in connection with the Morpeth Lock, was open and in use. It was this dock which received her Majesty's ship Agincourt, for the purpose of being fitted out after she was launched from the building yard of Messrs. Laird, at Birkenhead.

The Great Low-water Basin, which is about to be converted into a wet dock, occupies a position nearly midway of the river frontage of the estate; and the land to the southward, called the South Reserve, to the amount of 110,000 superficial yards, is held on lease by the London and North-western and Great Western Railway Companies for stations, on which it is contemplated to construct canels, sheds and warehouse accommodation, &c., for the carrying on of the important traffic which is being rapidly developed. The North reserve is another large area of land lying towards Seacombe, and is covered on its shore margin with shipbuilding yards of the most extensive and convenient description.

The total area of the Birkenhead estate is 497 acres, of which 167 acres is water space, with nine miles of quayage, the remainder being appropriated to quays, warehouses, sheds, business yards, and roads. The expenditure by the Mersey Board since the incorporation, in 1858, of the property with that of the Liverpool estate, has been about £5,000,000, which is evidence sufficient of the energy and perseverance, as well as the wealth and disposition, of the board to accomplish the important task confided to them.

The Liverpool docks are so well known that it is unnecessary to describe them. From 1709, when the first Dock act was obtained, to the present time, they have increased from a small and insignificant dock of four acres, formerly occupying the site of the existing Custom House, to the vast range of accommodation six miles in length now created on the river. They cover an area of 1034 acres, having 255 acres of water space, with 18 miles of quays. During this onward course of a century and a half Liverpool has advanced from a small town of no great importance to the position of the first port in the kingdom. The expansion of the docks north and south has been followed by a corresponding growth and development of Liverpool, as well as given rise and permanency to other towns in a wide circuit.

ON THE SCULPTURE IN WESTMINSTER ABBEY.

By Professor Westmacott, R.A.

In reviewing the sculpture in Westminster Abbey, it will be proper that the first remarks should be directed to that particular phase of the art, the Gothic, which is found in connection with the older style of architecture of which the building is so fine an example. Though this sacred edifice has, for many generations, been made the resting-place and the receptacle of the monuments of some of the most remarkable historical personages who have illustrated the annals of England, and thereby has claims to the attention of all who take pride in reflecting on the greatness and glory of our country, yet the interest of the intelligent visitor is chiefly and primarily drawn to those remains which can be associated with the earlier foundation. At a subsequent stage of our remarks, the sculpture of the later periods will be considered with relation to the state of art at their respective dates; but it is to the Gothic sculpture that attention will be directed in the first instance; and it will be right to show how this is to be judged and estimated.

The sculpture of the true Gothic period of architecture in this country, dating, that is, from the thirteenth century, and lasting till the middle of the sixteenth century of our era, is remarkable for a character exclusively its own. Generally speaking it exhibits,—like all the attempts at art by inexperienced workmen,—extreme rudeness in its execution; a disregard of rules of art, in proportion and anatomy, and, for the most part want of beauty. The earliest attempts in sculpture, only a few centuries old, cannot, however, be placed in the same interesting category with the extremely archaic monuments of Assyria, Egypt, Greece, Etruria, Asia Minor, and other ancient nations, dating, it may be said, thousands of years since. Neither as monuments of fine art can Gothic works be allowed to take rank in illustrating the history of sculpture (proper); seeing that they throw no light whatever on the progress of imitative art, as a means of expressing ideas or sentiment by beautiful forms. Gothic sculpture never, at any time, achieved a development that placed it in the same high position that had been attained by the great schools of the art; for, though it had fallen into neglect and disuse, it must be remembered that sculpture had been brought to the highest state of perfection sixteen or seventeen hundred years before the so-called Gothic school had any existence.

Assuming the essential conditions of fine and good sculpture to be refined expression, perfection of form and of physical beauty in all its parts, truth to nature in her boundless variety, and what is understood as *style* in treatment, with fine execution, it must be admitted, even by its warmest admirers, that Gothic or Mediæval sculpture must always occupy in these respects an inferior position. Any interest it possesses,—and this is very great,—must then be sought for in qualities quite distinct from that which attaches, in the first place, to primitive works, of remote antiquity, or in the next, that is accorded to the excellence of the art exhibited; for it has, in fact, neither of these recommendations. That Gothic sculpture must be judged as an art *sui generis*, and not by the standard of progress and development, like other fine art, is seen in the curious fact of its maintaining, like the Egyptian and other prescriptive sculpture, its own marked and characteristic idiosyncracy as *Gothic*. So truly is this the case that it is remarkable that, in modern imitations of Gothic architecture, this peculiarity of a school of sculpture is always more or less attempted, as a *sine quâ non* of character, though the progress of art and the advanced knowledge of the properties which constitute excellence must make it plain to those who adopt such peculiarities that the art so exercised is not truthful as an expression of the present age, and, therefore, in this respect, it is retrogressive and unreal. This does not apply to the form of Gothic sculpture; for this, it will be seen in the course of our remarks, was much modified, according to the comparative skill or increased practice of the workmen,—varieties especially observable at Wells, Lincoln, Salisbury, Exeter, and in other of the English ecclesiastical buildings. It refers rather, or entirely, to the *manner* of treatment. Here, with much that merits high praise, in its forms, it is constantly in antagonism to sound art principles, and exhibits an utter defiance of those rules of fitness and propriety which should essentially regulate an imitative art. If the human form is the object of imitation, it requires but little argument to show that the aim of the true artist should be to choose such conditions as will most correctly display that form, or, at any rate, that there should not be a studied effort to put into distorted and impossible action.

Portions or parts of the figure, for instance, should not be made to perform functions for which they are unfitted, and of which they are incapable in nature; nor should the most perfect work of creation be represented truncated or in pieces, and so fulfilling, with the most complacent expression, ignoble and even repulsive and degrading offices. Yet, in true Gothic all this occurs, and is imitated as characteristic of the style. Figures represented as standing, kneeling, or sitting, are squeezed into the hollow mouldings of arched doorways, in *tiers*, one over the other; though in the apex of the arch the upper figures may by this arrangement be nearly if not quite horizontal. Again the most distorted attitudes are given to others, to make them fit into angles or spandrels; figures, also, in parts or entire, are made to project suddenly at right angles from the walls, to support roof-timbers, or to act as brackets, while their draperies, clinging close, show no natural movement, but, instead of hanging or floating, are fixed horizontally in folds parallel to the figure. In like manner, heads of angels, saints, kings, bishops, and even females are made to bear weights, as brackets under columns, or as ornamental terminations to dripstones, over windows or doorways, for draining off the rainwater. Now, in Gothic these anomalies and the grotesques, and even indecency, that are seen in gargoyles, or draining-pipes on roofs, and in stall seats and other parts of ecclesiastical buildings, are distinctly intentional. They are not, like the crude attempts of the archaic sculptors, in consequence of entire ignorance, or of primitive rudeness of art; for they occasionly are found associated with a very advanced feeling for a certain kind of beauty, both of form and expression. In the heads of dripstone terminations, and occasionally in drapery, there is evidence of unquestionable power in these respects, sufficient, at any rate, to show that the strange, grotesque employment of these sculptured forms was a part of the system of the old true Gothic design, and belonged to it; herein contrasting unfavourably and to itself fatally, with the perfect sculpture which decorated architecture of the ancients—that of the Parthenon, at Athens, for instance, of which we possess the original examples.

It has been necessary to make these few preliminary observations on this peculiar feature in Gothic sculpture in order to explain much that appears anomalous in its practice. Ignorant of the true principles of sculpture, and rude and inexperienced in execution, as were the artists or carvers of the age, they yet were not so primitive, so blind, and so ignorant, as not to know that the human face was not intended to carry the weight of a column or a rafter; and, therefore, it is reasonable to assume that the fantastic uses to which the human figure was applied, formed an essential element in Gothic design. There will be enough to arrest attention in expression, pleasing forms, and, especially, in the graceful though peculiar treatment of drapery found in their works, to claim for some of the Gothic artists a large amount of our admiration; but we may not shut our eyes to the curious proofs that exhibit these, to us, contradictory and inconsistent features of their art-system; showing, beyond dispute, that they were considered as marks of the style, and proper to it. It is this which makes Gothic sculpture false and conventional, as a phase of art. Notwithstanding certain remarkable qualities it possesses, and to which it will be our pleasing duty to direct attention, it never can be classed as a branch of fine or perfect sculpture; and, for this reason, it never has been and never can be placed before students, like the remains of the great schools of Greece, as profitable guides for them to follow.

It must be a matter of surprise, even making every allowance for the very natural prejudice against using or imitating *heathen* types in the employment of sculpture for Christian purposes and illustration, why, in early times, the imitative arts in connexion with our purer religion should everywhere be found in so rude and barbarous a state. As before observed, it was no newly invented art; and, however neglected its practice had been, still monuments and remains of ancient and superior art abounded, especially in Italy. The missionaries, priests, and monks, who first spread the doctrines of Christianity, had all come from these southern countries where such remains were to be seen, on all sides; and it must ever seem strange that, when sculpture and painting were required in the service of the Faith, no higher or nobler ideas of the beauty and dignity appropriate to holy subjects and persons should have existed than such gaunt and uncomely productions as many of those that have reached us.

It is equally unintelligible that such poor art should be found associated in England with what has been called, by its admirers, the highest form of ecclesiastical architecture, the Pointed or Early English. It is difficult to conceive architects achieving excellence in their own art who were insensible to the glaring deficiencies of the arts employed in connection with their productions. It is rather suggestive that all the arts, architecture as well as painting and sculpture, were, at that time, merely in a state of movement, and not practised on any fixed or recognized principles. The constant changes taking place in Gothic architecture itself during the short period of its existence (scarcely three hundred years), from the Romanesque to Pointed, from Pointed to Decorated, and from Decorated to Perpendicular, when, according to the best judges of Gothic, the style was fatally declining, point to this conclusion.

This however, is a subject not now to be discussed. There can be no common ground of argument at between the two branches of art. Sculpture and painting, being strictly imitative must be judged by an existing and admitted standard, Nature. In architecture there is no such sure guide, nor, indeed, any guide at all, of the kind. Judging by the varieties in the forms and mode of its outward presentation, the degree of popularity or admiration each has obtained, in different localities, may not improbably be mainly referred to fancy and fashion. This is not so with the imitative arts. Here there is a foundation, and a standard which is of all time, and it is also the highest as well as the safest that can be offered for our guidance.

The sculpture in Westminster Abbey must be regarded under various aspects. First, in its relation to the architecture simply as accessorial decoration. Secondly, for the subjects represented; when it is employed to illustrate Scripture, historical or legendary scenes and incidents. Thirdly, as memorial sculpture; especially in its application to monuments to the dead, in tombs and similar erections.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

The annual conversazione of the Royal Institute of British Architects was held in their rooms, Conduit-street, Hanover-square, on the 20th ult., when, in addit on to a large assemblage of members of the Institute, the following were among the guests present:—The Earl of Effingham; Lord Talbot de Malahide; Lord Ernest Bruce; Vice-Chancellor Sir W. P. Wood; Sir John Boileau; Admiral Sir G. Back: Mr. Babbage, and a considerable number of Members of the Archæological Institute, then assembled in London for their Annual Congress, also attended the Conversazione, A large collection of works of art was exhibited, among which were the following:—Two volumes of drawings and prints, illustrative of the topography of Ancient London, lent by the Corporation of the City of London; a collection of very curious and interesting drawings of the Palace at Westminster, lent by Mr. J. Dunn Gardiner; a large drawing of Inigo Jones's designs for the Palace at Whitehall, and other works, contributed by W. Tite, M.P., past President; a series of photographs and drawings of St. Paul's Cathedral, lent by F. C. Penrose, Fellow, Architect to the Cathedral; a collection of drawings of various parts of Westminster Abbey, lent by G. Gilbert Scott, Fellow, R.A., and numerous drawings of buildings of Modern London, exhibited by Messrs. D. Brandon and T. Hayter Lewis, Vice-Presidents. Sidney Smirke, R.A.; D. Burton, F.R.S.; A. Ashpital, G. E. Street, A.R.A., Horace Jones, City Architect; E. I'Anson, J. P. St. Aubin, G. Somers Clarke, J. Peacock, R. H. Shout, R. Brandon, J. Thomson, W. Slater, E. Woodthorpe, W. White, W. Burges, H. Carr, J. T. Perry, E. Bassett Keeling, Skinner Prout, Matthew Noble, and others. A very interesting collection of drawings and sketches of buildings in Egypt, by R. B. Spiers, was also among the attractions of the conversazione.

Permeability of Iron.—The master of the mint, Mr. Graham, the well known chemist, has made a very important discovery, which he has announced in a paper read at the closing meeting of the Royal Society's session. He has discovered that iron at a low red heat absorbs a considerable quantity of carbonic oxide; and that, contrary to long-standing belief, this gas does not act on the suface of the metal only, but permeates its entire substance. Having taken up the gas, the iron will retain it for any length of time, and in this condition it is best adapted for conversion into steel, as, by the permeation of the carbonic oxide, the subsequent process of carbonization is largely facilitated. Hence arises the suggestion that the process of acieration would be best accomplished by changes of temperature; a low red heat to fill the iron with carbonic oxide, after which it may be put away, if required, to await the final process, at a high temperature, of conversion into steel.

THE FESTINIOG RAILWAY.

The Festiniog Railway, or tram-road, was originally constructed under the Act 2 Will. IV., cap. 48 (23 May, 1832), and shortly after the passing of that Act. It commenced at a quay, near Portmadoc, in the parish of Ynys-cynhainain, in the county of Carnarvon; and after running for thirteen miles through a wild, hilly and beautiful country, terminated at the slate quarries of Rhiwtryfdw and Duffws, in the parish of Festiniog, in the county of Merioneth. The objects of its construction were to open out "a more direct, easy, cheap, and commodious communication between the interior of the principal district of slate and other quarries of the county of Merioneth, and the various shipping places at and within the said several counties of Carnarvon and Merioneth;" and to "greatly facilitate the conveyance of coals, and other heavy articles to the several slate and other quarries and mines in the said district, and the conveyance of the slates, copper, and other ores, and other productions of the said slate and other quarries and mines, and of the surrounding country, to the sea side," and that it should be otherwise "a work of great public utility."

The Festiniog Railway Company, having been duly incorporated, received power to make the railway, or tram-road, and to construct the necessary works; but upon the conditions that the railway was not to pass within eighty yards of Plas-tan-y-bwlch, that no stones or materials were to be raised within half a mile, or any buildings erected within one mile of Plas-tan-y-bwlch, and that all steam engines employed were to consume their own smoke.

The lands or grounds to be taken or used for the purposes specified in the Act, were not to exceed four yards in width, except where it was necessary for carriages or waggons to "turn, remain, or pass each other," or for buildings or appliances to be erected, or for embankments or cuttings to be made, or for wharves, or goods stations; and no work, or building was to be above sixty yards in breadth at any place, except on commons or waste lands, or by consent of owners.

The Company was not to occupy more than was absolutely necessary of the Traeth Mawr embankment near Portmadoc; the gauge between the rails was not to exceed three feet upon that embankment; the surface of the embankment was not to be disturbed more than one foot in depth, and the ordinary traffic upon it was not to be interrupted.

The estimated cost of the line was £24,185 10s. and the Company was authorised to raise £10,000 by loan. Powers were afterwards granted to raise further sums of £12,000 by shares, and £4,000 by loan, so that the total Parliamentary capital of the Company is £50,185 10s.

The population of the district, in 1832, was very limited, and the line was therefore laid out in an economical manner, and on a gauge of only two feet between the rails. But from time to time, as the traffic increased, many of the curves have been eased, diversions have been made, at great expense, for the sake of obtaining better gradients, and avoiding steep inclines; and improvements have been effected in the permanent way, though without any alteration of the gauge. The difference in level between the terminus at Portmadoc, and the mountain terminus at Dinas is 700 feet, and the average gradient for 12¼ miles, from that mountain terminus, to the Traeth Mawr embankment near Portmadoc, is 1 in 92. The steepest gradient on the portion now used for passengers is 1 in 79·82, and the steepest on which locomotive engines are employed is 1 in 60. Some of the curves are exceedingly sharp, having radii varying respectively from 2 chains to 4 chains The maximum super-elevation allowed for the outer rail, on a curve of 2 chains, is 2½ inches, for a speed of 8 miles per hour.

As the slate quarries are at different altitudes in the mountains, the slates are first brought down the quarry inclines to the railway, and the trucks are then collected and forwarded in trains to Portmadoc. These trains, sometimes composed of fifty trucks or sixty trucks each, run down by the force of gravity, and are in charge of breaksmen.

Until 1863, the empty trucks, or trucks loaded with coals, goods, furniture, materials, machinery, and tools for the quarries and the neighbourhood, were drawn up by horses, which were brought down in the trains, as on some of the colliery or mineral lines in the North of England.

As the traffic increased, and after the railway had been much improved, the practicability of employing locomotive engines on so narrow a gauge was frequently discussed; but the project was more than once abandoned, in consequence of the apparent difficulties, and of the adverse opinions expressed by the Engineers who were consulted. At length the continued increase of the slate traffic, and of the trade of the neighbourhood, caused it to be revived; and Mr. England was employed, under Mr. C. E. Spooner, the Secretary and Engineer of the Company, to design an engine for the purpose. Two locomotive engines were accordingly placed upon the line in June, 1863, and were found to work so successfully that others have since been supplied. The Company now possesses four engines, which have run, (up to February, 1865), 57,000 miles without leaving the rails.

During the past autumn the Company carried passengers experimentally, without taking fares, and at the commencement of the present year, the line was regularly opened for passenger traffic. In ascending from Portmadoc, the passenger-carriages are drawn by the engines with other vehicles, the passenger-carriages being placed between the empty slate-trucks, which are always last in the trains, and the goods-wagons, which are next behind the tender. In descending, the loaded slate-trucks, with empty goods-trucks attached behind them, run first in a train by themselves; the engine follows, tender first; and the passenger-vehicles, detached from the engine and tender, and at some little distance behind them, bring up the rear, with a break van in front, and a guard on a platform outside it. The speed is limited to about six miles per hour, in passing round the sharpest curves, and ten miles per hour on other parts of the line. The passenger-guard, standing outside his van, is always ready to slacken speed, by the application of his break, in approaching level crossings and sharp curves, or in obedience to a signal, or in the event of an obstruction on the line; and the different trains, or portions of the trains, are able to follow each other, at the above moderate speeds, more closely than could be done, with safety, on ordinary railroads.

The engines, though on a much smaller scale, are of a somewhat similar pattern to those which have been found so useful by contractors. The wheels are 4 in number, and are coupled together, 5 feet apart, and are 2 feet in diameter. The cylinders, which are placed outside the framing, are 8 inches in diameter, with a length of stroke of 12 inches, and are only 6 inches above the rails. The maximum working pressure of the steam is 200 lbs. to the square inch. Water is carried in tanks surrounding the boilers, and coal in small four-wheeled tenders. The heaviest of these engines weighs 7½ tons in working order, and the cost was £900 each. The average load taken up, at a speed of about 10 miles per hour on the ascending journey, is 50 tons, including the weights of the carriages and trucks, but exclusive of the weights of the engine and tender. In fact, the actual performance of the engines, exclusive of considerable shunting, is to convey daily, on the up journey to Portmadoc, along the Traeth Mawr embankment, average loads of 260 tons of slate, all the empty slate trucks from Portmadoc, 50 tons of goods, and 100 passengers, besides parcels, at an expenditure of 17 cwt. of coal and coke for two engines, or about 0·75 lb. per ton per mile, the average ascending gradient for 12¼ miles being 1 in 92, and there being a level portion for about three quarters of a mile near Portmadoc.

The high pressure at which these engines are worked, combined with the small driving wheels, gives them a surprising amount of power for their size, and adapts them well for convenience in starting and for working at slow speeds. The centre of gravity also has been kept as low as possible, with a view to steadiness on so narrow a gauge. But their short wheel-base, and the weight which overhangs the trailing wheels, imparts more or less of a jumping motion in running, which might be avoided by the addition of trailing wheels, working, perhaps, in radial axle-boxes, to steady them. Efficient safety-guards, similar in form to snow-ploughs, have been added in front of the engines, behind the tenders, and under the platforms of the break vans.

The passenger-carriages are necessarily of a different construction from those in ordinary use on railways, and are also low. Their dimensions are 6 feet 6 inches high in the middle above the rails, 10 feet long, and 6 feet 3 inches wide, outside measurement. Each carriage has 4 wheels, 1 foot 6 inches in diameter and 4 feet apart, from centre to centre of the axles. There is a longitudinal partition down the centre, and the passengers sit back to back, so as to avoid causing an overhanging weight outside the rails. The second and third-class carriages, cost £100 each, and do not differ from the first-class carriages, which cost £120 each, except in their fittings. The springs are volute, and the axle-boxes, which are under the seats, are easily lubricated on the removal of a small door opposite to them. Each carriage will convey 10 passengers. No platforms are required, as the floors of the carriages are only 9 inches above the rails; and, there being no break in the longitudinal partitions, the passengers get in and out through the doors on both sides.

There are also some open cars for summer use, of similar construction as regards the under-framing, and of similar length, to the above carriages; but without sides and roof. The passengers are strapped into these carriages by means of longitudinal and cross-straps.

It is a question whether longer carriages on 8 wheels and bogie frames might not be used for sharp curves on other lines of unusually narrow gauge with advantage. But it is considered, that carriages of greater length than 13 feet would be inconvenient for moving about at the stations. If the curves on the line had not had any radii of less than 5 chains, the length of 13 feet, with 6 feet 6 inches centres for the axles, would have been adopted. The couplings are central, similar to the screw couplings in common use, are 15 inches above the rails, and work upon volute springs. The buffers are also central, are 4½ inches above the couplings, and work against a curved spring, 2 feet long. The system, which the Author has observed to work successfully on the Continent, of a single link, with a double spring connected with each draw-bar, would probably be found well suited to act at the same time as buffer and coupling, at slow speeds, on railways of this description.

The permanent way is now laid with rails weighing 30lbs. to the lineal yard, and in lengths of 18 feet and 21 feet. The rails are supported in cast iron chairs, which weigh 13 lbs. at the joints, and 10 lbs. each in the intermediate spaces. The sleepers are of larch, 4 feet 6 inches long, and averaging 10 inches by 5 inches in section under the joints of the rails, and 9 inches by 4½ inches elsewhere. They are placed 1 foot 6 inches apart, on each side of the joints of the rails, and 2 feet 8 inches apart in the intermediate spaces. The rails are secured in the chairs by wooden keys, and the chairs are fixed to the sleepers by wrought-iron spikes, 4½ inches long by ⅝ inch diameter.

There are 17 bridges under, and 5 (foot) bridges over the railway, as well as numerous stone viaducts across the valleys. Most of the smaller openings are covered by girders, or rather slabs, of slate. There are also two tunnels, one 60 yards long, and the other 730 yards long; the former through hard shale, and the latter through syenite rock, which is sufficiently solid to require no lining.

The Company has, of course, had many difficulties to contend with in transforming a horse-tramway, thirty-three years old, into a passenger line worked by steam locomotives; and not the least of these difficulties has arisen from the narrowness of the works. The stone walls, with which the greater part of the line is fenced, as well as the abutments of the bridges and the tunnels, leave less width than it would be desirable to provide, on any lines of an extra-narrow gauge which may be constructed in future. The carriages, being 6 feet 3 inches wide, overhang the rails by about 2 feet on each side; and this renders it desirable that the works at the sides of the line should be at least 4 feet 6 inches from the rails, and that a total minimum space of 11 feet 6 inches, or 12 feet, should be preserved in the clear between the abutments of bridges and other works, for a single line of rails. These dimensions would, of course, vary with differences in the width of the gauge and the width of the carriages, it being desirable, on all new lines, that a minimum distance of 2 feet 6 inches should be preserved between the sides of the carriages and the works; and the width of the works would therefore depend, not so much upon the gauge of the rails, as upon the dimensions of the carriages employed upon them.

In like manner, where the line is doubled, or where sidings occur, it is necessary that an intermediate space of 7 feet should be allowed, to admit of the doors of the carriages in one train swinging clear of the vehicles of another train, and for other reasons; their dimensions also varying according to different widths of gauge and carriages.

The Author conceives that the employment of locomotive engines on this little railway, and the opening of it for passenger traffic, are not only highly interesting experiments, but are likely also to be followed by important results. There can be no doubt, that this country owes her abounding prosperity of recent years mainly to the rapid development of railway communication, and that the increase of that prosperity in future years will depend much upon the facilities for, or, in other words, upon the cheapness and rapidity of transport which may be provided for passengers and produce, between all parts of the kingdom. These further facilities must be derived, partly from improved carrying powers on some of the existing railways, and partly from the construction of new railways. Every new line in an agricultural, a manufacturing, or a mineral district, tends to stimulate production, to provide means of employment for an increasing population, to add to the supply of food, and to bring into use sources of wealth which would otherwise lie dormant. There are still, doubtless, numerous districts where railways on a gauge of 4 feet 8½ inches may be profitably made; and, indeed, the number of miles of such railways annually projected and carried out has, of late, been increasing rather than diminishing. Although only 477 miles were opened for traffic during the past year as against 771 miles for 1863, yet 4,270 miles were projected for the present session, against 3,099 miles for the session of 1864. But there are also many other districts in which lines of cheaper construction are required. Railways on the gauge of 4 feet 8½ inches can hardly be made more economically than at present, as far as regards the permanent way, or the works. Cheap lines necessitate steep gradients, which require heavy engines, and heavy engines require substantial bridges and a strong permanent way. On the other hand, with a narrower gauge, lighter rails and sleepers, less ballast, and cheaper works generally may be employed; sharper curves may be laid down; very heavy gradients may, particularly in mountainous districts, be more cheaply avoided; and lighter engines, with lighter vehicles, may be made to do all the work required, where high speed is not demanded, and where the traffic is not heavy.

The Norwegian government, as appears from an interesting report by Mr. C. D. Fox, has constructed, and has in full operation, two lines, the one from Grundsett to Hamar, 24 miles long, and the other from Throndhjein to Storen, 30 miles long, both on a gauge of 3 feet 6 inches. The former, with gradients of 1 in 70, and curves of 1,000 feet radius, through a moderately easy country, has cost, including rolling stock and stations, £3,000 per mile. The latter, through a more difficult country, with gradients of 1 in 42 and curves of 700 feet to 1,000 feet radius, has cost £6,000 per mile. The rails weigh 37 lbs. to the lineal yard, and are fished at the joints. The sleepers are of native pine timber, 2 feet 6 inches apart, 6 feet 6 inches long, and 9 inches by 4½ inches in section, and the rails are secured to them by dog spikes only. The engines weigh 14 tons, in steam, and the carriages are 9 feet 3 inches high, and 6 feet 6 inches wide. The speed is about 15 miles per hour, including stoppages. The Norwegian government is so pleased with the result, that an additional length of 56 miles of this gauge is now in course of construction, and no other gauge is contemplated for the traffic of that country.

It is, however, illegal at present to construct any passenger lines in Great Britain on a narrower gauge than 4 feet 8½ inches, or in Ireland than 5 feet 3 inches. The Act 9 & 10 Vict. cap. 87, provides (sect. 1), "that after the passing of this Act it shall not be lawful (except as hereinafter excepted [with reference to broad gauge railways]) to construct any railway for the conveyance of passengers on any gauge other than 4 feet 8½ inches in Great Britain and 5 feet 3 inches in Ireland;" and (sect. 6), "that if any railways used for the conveyance of passengers shall be constructed or altered contrary to the provisions of this Act, the Company authorized to construct the railway, or in the case of any demise or lease of such railway, the Company for the time being having the control of the works of such railway, shall forfeit ten pounds for every mile of such railway which shall be so unlawfully constructed, or altered, during every day that the same shall continue so unlawfully constructed or altered;" and sect. 7 gives power to the Commissioners of Woods, &c., or to the Board of Trade, to abate, or remove such railways, so constructed, or altered, contrary to the provisions of the Act.

It would therefore appear to be necessary, before constructing any railways for passengers on a less gauge than 4 feet 8½ inches, or before attempting to open for passenger traffic any railways so constructed subsequently to the year 1846 (in which the above Act was passed), to endeavour to obtain, if not its repeal, at least a modification of its provisions. That Act was passed after the Report of the Gauge Commissioners, when there was a strong feeling against break of gauge, and when there was no immediate prospect of a third and narrower gauge being extensively required. But there is now an increasing demand for branch railways of a minor class. Many coal and mineral lines are in use on a narrower gauge than 4 feet 8½ inches, and others are about to be constructed with ultimate views of passenger traffic. It would therefore be an advantage if some smaller gauge were recognized; for however objectionable the existence of different gauges on important through lines of communication may be, it is quite otherwise with respect to the use of a narrower gauge for feeding branches, in districts where a similar gauge to those main lines would not be commercially practicable. Passengers change carriages, under any system, at the junctions of less important branches; and it is considerably cheaper to transfer heavy goods from one railway truck to another, than to cart them for several miles, perhaps over indifferent roads. The Festiniog Railway, on which the original gauge has necessarily been maintained, in consequence not only of its own works, but also of those of the tramways and quarry inclines running into it, is an extreme example, outdone only by the little engine which does the work of the shops at Crewe on a gauge of 18 inches; and the cost of that railway, under the peculiar circumstances of its original construction and subsequent alterations, cannot be taken as a guide for the future. A gauge somewhat wider than 2 feet would probably be desirable on any line to be now constructed, and it would hardly be worth while to desert the gauge of 4 feet 8½ inches in Great Britain for any gauge wider than 2 feet 6 inches. But whatever the exact gauge, whether 2 feet 6 inches, or 3 feet, or any other dimension that might be considered most suitable for lines of minimum traffic, there can be no question, that a system of branch lines, costing two-thirds of the branches now ordinarily constructed, and worked and maintained at three-fourths of the expense of those branches, would be of decided benefit to Great Britain and Ireland, and would be most valuable in India and in the colonies; in fact wherever there are people to travel, produce to be transported, or resources to be developed, where it would not be commercially profitable to incur the expense, in the first instance, of a first class railway.

Captain Tyler said, having been called upon officially to inspect this railway, he thought a brief description of it might be interesting, and he hoped that description would be the means of calling forth a discussion of great use, in elucidating the important question, whether it was desirable to have a narrower gauge in this country, under peculiar circumstances of locality, and having regard to the nature of the traffic. There were already in Wales, a number of different gauges used on tramways for bringing slates and minerals down to the ports of shipment; and in other countries different gauges were springing up. In Queensland, he had been informed, 100 miles were in course of construction on the gauge of 3 feet 6 inches, and 200 miles more were projected on the same gauge. It was important to ascertain, what would be a suitable gauge in those instances where the traffic was not likely to be large. Farmers were now using portable railways, for transporting the produce of their fields, for bringing in their harvests, spreading manure, &c., and there seemed no reason why districts, which could not support a railway on the gauge of 4 feet 8½ inches, should be altogether deprived of the advantages of railway communication. The question of gauge was, in one sense, a question of speed. Speaking roughly, on a railway of 2-feet gauge, with 2-feet driving wheels, travelling might be made as safe at 20 miles per hour as on the Great Western, with its 7-feet gauge and 7-feet driving wheels, at 70 miles per hour. He had travelled on parts of this little line at the rate of 30 miles per hour with every feeling of safety. He regretted the unavoidable absence of Mr. Spooner, because it prevented him thanking that gentleman, in the presence of the meeting, for the information afforded during the preparation of this Paper, and because, if he had been present, he would have been able to give further information on the subject. Mr. Spooner took great interest in this line, and was accustomed to travel on it along the Traeth Mawr embankment in a boat carriage, not inappropriately named "Ni l'un ni l'autre," being carried along by a sail. The preliminary expenses in first applying locomotive engines, and making numerous adaptations on so narrow a gauge, were considerable; but since the line had been in working order the following results were shown.

STATEMENT of the COMPARATIVE COST of WORKING the FESTINIOG RAILWAY by HORSES, and by LOCOMOTIVE POWER.

By Horses.

	£	s.	d.
Contract for the carriage of slates and minerals, 70,000 tons at 8d., the Contractor finding labour, grease, and oil ...	2,333	0	0
Contract per ton on 9,000 tons of coals, train, and other merchandise, ditto, at 3s.; the draught being ditto less journey ...	1,350	0	0
No passengers, and no cost for porterage ...	...		
	£3,683	0	0

By Locomotives.

Locomotive department (wages) ...	740	0	0
Materials for repairs of locomotive tender and van ...	200	0	0
Fuel, oil, and grease required for working traffic, including oil for signal lamps, &c. ...	686	0	0
Additional expenses and wages, keeping train in repair, over above amount by horse power ...	296	0	0
Additional cost in keeping up permanent way ...	680	0	0
Additional attendance in signal men on the horse system ...	334	0	0
Cost of working train by Locomotive ...	2,886	0	0
Cost of working train by Horses ...	3,683	0	0
Difference in favour working by Locomotive nearly 22 per cent.	£797	0	0

Mr. G. W. Hemans said, he had seen this railway, when worked by horse-power, about three years ago, and was glad to hear now, that it confirmed the impression he then entertained, that the project of working it by locomotive power would be successful. The idea of using locomotives arose from the competition branch line, which was contemplated by the owners of the ordinary gauge lines, leading along the Welsh coast, and which branch was to penetrate into the slate district. He was called upon to examine as to the propriety of this branch line on the ordinary gauge, for the purposes of the slate quarry, and the result of his observation was, that for those purposes that gauge was unsuitable, and that no better thing could be devised than the existing 2-feet gauge. The small wagons on this gauge were carried over steep inclinations, of 1 in 12 and 1 in 15; and in some places of as much as 1 in 5, or in 6, so as to penetrate into every part of the immense slate quarries of Festiniog. The slates brought down on these extensive ramifications were expected, if the ordinary gauge branch were constructed, to be delivered at the foot of the inclines, to be there gathered together, and the narrow wagons would be hoisted into broad gauge wagons and taken to the port. This would clearly have proved a great inconvenience, and the project of using locomotives on the 2-feet gauge, as far as the foot of the steep inclines, seemed so feasible that he gave it his warm support; and the consequence of the opposition to the broad gauge branch was, that it was withdrawn, and the project of working the narrow gauge by locomotives was carried out. He thought the attainment of a fair speed by the narrow gauge locomotive was, to a great extent, as safe as on the broad gauge, provided the wheel base were properly proportioned to the engine. With regard to the economy of the working, another question arose. As to the general principle, whether it was desirable to encourage very narrow gauge lines in positions of this kind, it depended upon the nature of the traffic. He doubted whether that system could be extensively used for passengers; but where there was a large amount of mineral traffic coming out of narrow galleries, all going in one direction, and but a small passenger traffic going in either direction, he had no doubt a system of narrow gauge railways might be advantageously adopted. He thought it a matter worthy of legislative inquiry, whether this system might not be beneficially extended upon some well-considered gauge. At the same time, as a general principle, there was great objection to alteration of gauge. As regarded Ireland, the adoption of the gauge of 5 feet 3 inches had not produced beneficial results.

Sir Charles Fox remarked that he had had a great deal to do with railways of various gauges. It was a subject to which he had given more attention than perhaps any other. He thought break of gauge was a serious matter; and yet it was difficult to say there never should be break of gauge. As joint engineer of the Indian tramway, with regard to which line a question arose as to what gauge should be adopted, he wrote a long report, in which he advised that that company's lines should not be made tramways, but light railways; and, as in almost all cases such lines would be tributary to main lines, the gauge of which he believed was 5 feet 6 inches, he advised that the tributary branches should be laid to the same gauge; but he coupled that advice with what he thought, was an important condition, which was, that the load upon each pair of driving wheels of the engine to run on such lines should be limited to the greatest load that could by possibility come upon any pair, of wheels in a train. He calculated 6 tons on each pair of wheels, and he did so for this reason; he considered that the tributary lines in India, if intended to pay, ought to be worked by the rolling stock of the parent lines. All the rolling stock of the parent lines, except the locomotives, might with safety be carried on rails of not more than 35 lbs. to the yard; but there must be locomotives of not more than about 18 tons on three pairs of wheels, or if of 24 tons, on four pairs of wheels, thus equalising the total load by placing 6 tons on each pair of wheels. But, whether the gauge was 3 feet 6 inches, 4 feet 6 inches, or 5 feet 6 inches, the rolling stock need not be comparatively heavier in proportion to the greater width of the gauge: and if the weight were restricted to 6 tons on each pair of wheels, the light permanent way would be able to do the work. The report to which he alluded, after being considered by the directors, was not acted upon. The line between Arconum and Conjeveram, forming a junction with the Madras main line, was of the gauge of 3 feet 6 inches; but since then, the governments of the three Presidencies came to the determination that no tributaries to main lines should in future be of any other gauge than 5 feet 6 inches. The only condition on which a narrower gauge was to be permitted, being where the line was not tributary to a main line; and even that, he believed, was not yet fully determined upon. His own opinion was, that the Government would adhere, in all cases, to the resolution requiring the gauge of 5 feet 6 inches. On the other hand, the objection to a uniform gauge for both main line and tributary branch was, as alleged by the managers of the companies, that they had no proper control over their servants; and that if a man was accustomed to drive an engine of 30 tons on the main line, he could, if he chose, run the same engine on to the lighter road, very much to its injury; whereas, having a different gauge effectually prevented this being done. He thought that there should be no separate establishment for the repair of those engines, but that all the locomotives should be the property of the parent company; the engines could then go to the same shops to be repaired, which would be a convenient and economical arrangement, particularly on a short branch. On the line to which he had referred, he had been obliged to send out all the tools necessary for the repair of the engines of 3 feet 6 inches gauge, whereas if the gauge of 5 feet 6 inches had been adopted, arrangements might have been made for the whole of the rolling stock to be repaired by the parent company, under an agreement with the branch undertaking. He thought it was more important to limit the weight on the driving wheels than to fix any particular gauge, the latter being a matter which must be determined by the circumstances of each case. After a good deal of consideration on the subject, he thought if he had now to establish a gauge to be used all over the world, he should fix it at 5 feet 4 inches. The Irish gauge of 5 feet 3 inches was a very good gauge. The Indian gauge of 5 feet 6 inches was also a good gauge, but it necessitated a rather heavy rolling stock; while the gauge of 4 feet 8½ inches was in his opinion too narrow. At the same time, unless there was some strong reason for departing from the universal gauge of any country, he would follow out that gauge in even the light tributary lines.

With respect to Queensland, the government of that colony had decided beforehand upon making its lines on the gauge of 3 feet 6 inches, and the plans were referred to him for confirmation: more than 100 miles were now being constructed, and authority had been obtained for 200 miles more, the "matériel" of which was now being prepared. In the case of the Indian Branch of 3 feet 6 inches gauge, all the "matériel" and rolling stock had been sent out from England, the sleepers being of teak. The line was laid upon an old road, which was granted to the Company by the Government, and which required some alterations in its curves and gradients. The total cost, including rolling stock, would be not quite £3,500 a mile.

With regard to the radiating axle boxes referred to in the Paper, and which had been adopted for sharp curves on the Norwegian lines, he was so satisfied with them that he was sending such boxes out to Queensland. He believed, that on the Queensland railway, 5 chains was the sharpest curve, and that 1 in 40 was the steepest inclination: that the weight of the rails was 40lbs. to the yard, and that the engines with six wheels did not exceed 15 tons, in steam, ready for work, exclusive of their tenders, carrying fuel and water.

The most important reason for using the narrow gauge, in this instance was for the construction of circuitous lines through mountain ranges, where it was impossible, except at very great cost, to have curves of long radius. If it had not been for the sharpe curves, he would not have recommended the narrow gauge for the Queensland lines; and it must be borne in mind that these being the first railways in that colony, there was no existing gauge to which the gauge of these lines had to be adapted. He hoped, however, that his remarks did not lead to the supposition that he would lay down a railway, with a gauge of 5 feet 6 inches, to a slate quarry in Wales; his observations applied only to such lines as were tributary to main systems of railways.

Mr. Peter Bruff remarked, that all the Norwegian lines alluded to, were isolated. The original line made by Mr. Stephenson and Mr. Bidder, had been extended to the confines of Sweden, and was entirely constructed on the gauge of 4 feet 8½ inches, with which the other lines of the country were never likely to be brought into communication. Radiating axle boxes, he understood, had been recently introduced on the Norwegian lines with considerable success; the weight of rails generally adopted was 37lbs. to the yard, laid in lengths of 21 feet, the rails being flat-bottomed, 3½ inches high, with a base of 3 inches, laid on cross sleepers, and fish-jointed. In some cases a plated joint had been used, which, from the experience obtained in England, was not considered a desirable arrangement. Upon the subject of narrow gauge Norwegian railways, he had, however, received a communication from Mr. Pihl, who, in 1856, was entrusted by the Norwegian Government with the task of supplying railway communication between Throndhjein (about 350 miles northward of Christiana) and Storen, the point from which two main carriage roads ran south; and between Hamar, on the Lake Mjosen, about 56 English miles north of Christiana (with which it was in direct communication by rail and steamer), proceeding eastward to Eleverum, upon which the traffic of the Glommen Valley converged. Mr. Pihl stated, that he determined, from the difficulties of the country and the smallness of the traffic to be accommodated, that he should not be justified in recommending such an outlay as would be involved by the formation of a railway as ordinarily constructed; he therefore recommended a gauge of 3 feet 6 inches. This was adopted by the Government and confirmed by the legislature (Storthing) in 1857, and shortly afterwards the works of both lines were proceeded with.

The works upon the Hamar line, being the more easy of construction, were sufficiently advanced to be used for goods traffic in the summer of 1861. The total cost of this line, for 24½ English miles, had amounted to about £3,000 per English mile. This included a large iron bridge, on stone piers, about 900 feet long, for ordinary road purposes only; the rolling stock of 3 locomotives, 6 passenger carriages, 3 break vans, and 50 goods wagons, with the necessary ballast wagons and tools for repairs; also two terminal stations, and six intermediate stations and stopping places, a carriage shed and a small repairing shop. Although the works were not of a heavy character, there were nevertheless many difficulties to contend with, the line having to ascend upwards of 400 feet, and to cross extensive and deep swamps.

The Throndhjein line of 31½ English miles, running through a difficult country, required many heavy works of construction, among which were numerous large bridges, some being from 70 feet to 100 feet high, several cuttings containing from 50,000 cubic yards to 70,000 cubic yards each, and others through rock of more than 30 feet in depth. The cost of this line was necessarily greater than the former, in all about £5,000 per English mile, including 4 engines, 8 passenger carriages, 3 break vans, 60 goods and plank wagons, besides 20 ballast trucks, with the necessary implements for the repairs. There were besides the terminal stations, six intermediate stations and three stopping platforms. At Throndhjein there were also goods and carriage sheds, and a workshop for the repair of the rolling stock. This line had to cross a ridge more than 500 feet in height, in the first Norwegian mile from Throndhjein. The greater part of this distance was constructed on one side of the ridge with gradients of 1 in 42 and 1 in 65, and on the other side of 1 in 52, the curvature being of about 900 feet radius; whereas on the other portion of the line, where the gradients were seldom more than 1 in 100, curves of 750 feet were frequently resorted to. The width at the formation level in cuttings and on embankments was 13 feet nearly; the slopes, according to circumstances, were from 1¼ to 1, to 3 to 1. The ballast was 8 feet wide at the top, and 1 foot 9 inches in thickness; the sleepers were of half round pine, 6 feet 6 inches long, placed 2 feet 6 inches apart on the curves and steep gradients, and 2 feet 9 inches apart on the straighter portions of the line. The rails were flat-bottomed and fished at the joints in the usual way, 3½ inches in height, and weighing 37lbs. per yard, except on the steep inclines, where rails of 41 lbs. per yard were laid. The rails were fastened to the sleepers by dog-spikes only, no bolts or bottom plates being used. Ransomes' chilled crossings, and Wild's self-actingswitches were used throughout. The bridges were all of timber,except where large rivers had to be crossed, and spans of from 50 feet to 100 feet were required, in which case stone piers were carried up above flood level. The superstructure made use of in those cases was Howe's system of trellise work, with iron suspending rods. The rolling stock consisted of tank engines with three pair of wheels, two pairs being coupled for drivers, these having an available weight for traction of from 11 tons to 12 tons, out of the 14 tons to 15 tons, the total weight. The last engines procured were provided with bogies, on Bissel's or Adams' system. The cylinders were 10 inches in diameter, with a length of stroke of 18 inches, and the driving wheels were 3 feet in diameter. All the engines were made in England, with the exception of one made at Throndjein, and were working efficiently. The passenger carriages were constructed to carry the usual number of passengers, as in England, and were arranged for two classes only, the compartments being fitted up as first and third. The goods wagons were made to carry 5 tons, and were only a few inches narrower than the ordinary kind, these widths being obtained by having the springs attached to brackets inside the sole bars, thereby allowing the lowering of the body, and in consequence, the centre of gravity. The buffers were all central, and 2 feet 6 inches above the rail level, and served also as draw-bars. The couplings on those last constructed were self-acting when the wagons were brought together. As this narrow gauge allowed a correspondingly larger wheel base than the ordinary gauge, the wagons ran very steadily. Some of the wagons were constructed to carry planks 24½ feet long, and had a length of wheel base of 13 feet.

The usual rate of speed was about 15 miles per hour, including stoppages, and the trains ran quite as steadily on this line as on the broader gauges. The traffic on these lines, though considerably below that of the lowest of the English lines, had already fully paid the working expenses, while the impulse given to the development of the resources of the country must undoubtedly, in course of time, produce a corresponding and satisfactory increase of revenue.

In order to show the economy of construction, Mr. Pihl mentioned that simultaneously with the construction of these lines, an extension of about 50 English miles was constructed, from the old trunk line built by Messrs. Stephenson and Bidder in 1850-53 to the Swedish frontier, of the ordinary gauge of 4 feet 8½ inches, the cost of which was about £6,400 per English mile, the rate of wages and the class of work being, as nearly as possible, of the same description.

In addition to the two narrow gauge lines described, there was in course of construction, another line of the same gauge, between the town of Drammer and the Lake Randsfjorden, about 57 English miles in length, besides several branch lines in preparation. None of these several lines would ever have been made, had not the small cost justified and encouraged the undertakings.

(To be concluded in our next.)

GEOLOGY AS APPLIED TO ARCHITECTURE.*

By John Cumming, F.G.S.

(Continued from page 211.)

To crumble away is the very nature of stone; indeed, every formation has been produced by the weathering of a preceding bed of rock, either by wind or rain, mechanically or chemically, or by both, or by the beating of seas or rivers on the surface. We cannot expect, then, that the same materials, hewn and placed in a building, will more successfully withstand similar influences. All, however, are not open to the same amount of destruction, and the selection of the most enduring is possible. Sandstones are met with, as we have already seen, in almost every stratum, but very few of them are of any value for constructional purposes. Sandstone in every case consists of larger or smaller particles of silica or flint, held together either by mere aggregation, by calcareous cement, or by oxide or carbonate of iron, and sometimes by silicious cement; the last-named are always the best and most indestructible. The most homogeneous examples should be selected, and those free from iron. Sandstones, however, do not generally commend themselves for enduring qualities; but occasionally examples have been employed that have stood the test of centuries and remained uninjured. At the time when the Houses of Parliament were about to be erected, a committee was appointed to decide upon the most useful and lasting stone to build them with, and the prominent buildings of this country were examined as to their state of preservation and the length of time which had elapsed since their erection. Of the 11th century, Chepstow Castle, partly built of old red sandstone, is decomposed; Durham Castle the same; Fountains Abbey and Kirkstall Abbey, both much decomposed; and the only 11th century work mentioned as being built of sandstone, which is still sound, is Richmond Castle, even the mouldings and carvings of which are said to be in a perfect state. The examination was conducted through the prominent buildings of the 12th, 13th, 14th, 15th, and 16th centuries, and the result was not sufficiently satisfactory to induce the committee to recommend sandstone for its durability.

The sandstones used at the present time are better than those formerly employed. The Craigleith sandstone, from the carboniferous formation in the vicinity of Edinburgh, is the most satisfactory, as it contains 98 per cent. of silica, and only about 1 per cent. of carbonate of lime. The sandstones from the Millstone Grit of Yorkshire are good, and where used have lasted for centuries. A very hard and lasting stone (if well selected and used in dry places) is the firestone from the Greensand Rocks. In the neighbourhood of Godstone and Nutfield many buildings are constructed of it, and appear to last well. The same quarry, however, often yields various qualities of stone. Patteson Court, Nutfield, the residence of Mr. Norman Wilkinson, is built of this stone from a quarry on the property. The older portion of the house is in perfect condition: the more recent, although built of stone from the same quarry, is flaking off and crumbling away rapidly. The sandstones from the Wealden formation, notwithstanding some of them appear very hard, soon crumble to pieces, and should on no account be used for any building intended to last. This stone has little or no cementing material in it, unless (as in some cases) carbonate of iron, which would be better absent. Sandstone may sometimes be employed in situations where moisture is the rule, when in exposed places it would be liable to destruction by the atmosphere. In selecting sandstone for building, and, indeed, any stone, it is well to observe in any adjacent quarry how the undisturbed surfaces have behaved themselves on exposure to the weather. Experience must of course decide, for many sandstones that are soft in the quarry (when newly cut) become hard and very good afterwards. Limestones for building purposes may be classified as Portland and Bath oolites, magnesian limestone from the Permian formation, and the various carbonates of lime, such as marbles. Foremost of all stands the Portland stone for colour, durability, and ease of working, but not for cast. Even this stone must be carefully selected. Many beds of stone are found in Portland, not all of which yield the material which has made the island famous. The best stone is denominated the White bed, and the terms Cap, Kerf, Roach, are applied to the remainder. The Roach beds consist of open stone, containing the casts of numberless shells, and is used with success in submarine works, but they are not good for surface works. In many cases where Portland stone has failed in London, the material has been obtained from the western side of the island. These instances should warn the architect to state specifically the bed of stone he wishes to employ and the quarry from whence it is to be obtained. St. Paul's Cathedral, Greenwich Hospital, St. Bartholomew's Hospital, the west towers of Westminster Abbey, are all built of Portland oolite and are in good condition. The magnesian limestone has commended itself to architects for its fine colour, ease of working, and tolerable endurance. There is no building stone, however, that differs so much in quality as the magnesian limestone. This is well illustrated by the Houses of Parliament. In 1839 a Commission was formed to enquire what was the best and most enduring stone to employ for their erection. The geology, the chemistry, the mechanical science, the experience of the country, were well represented. Hundreds of buildings, whose dates extended from the 10th to the present century, were examined. These buildings were of sandstone and limestone, and careful statistics were obtained. After mature deliberation, magnesian limestone was selected, upon the strength of the fact that Southwell Church, Nottingham (built in the 10th century of that stone from Bolsover and Mansfield), Bolsover Castle, 1629, and other edifices, had stood the test of centuries, and were perfect still. The opinion of the Commission is given in the following words:—

> We feel bound to state that, for durability as sustained in Southwell Church, for crystalline character, &c., and for advantage of colour, the magnesian limestone, of Bolsover Moor, is the most fit to be employed in the proposed Houses of Parliament.

And these gentlemen arrived at the above conclusion after well considering about 30 or 40 varieties of building stones, and examining hundreds of buildings in which they were used. Stone from the quarries of Anston was afterwards found useful when large blocks were needed, at the suggestion of the late Mr. C. H. Smith. The Marquis of Bredalbane made the offer of any quantity of granite from the neighbourhood of Oban, and it would seem almost a pity it was not accepted.

Twenty-two years have elapsed since the selection of stone from Bolsover Moor and its neighbourhood; and then it became necessary to inquire into the cause of the decay of the stone of which the Houses of Parliament were built. The evidence shewed that Southwell Minster, upon the perfect state of which so much reliance had been placed, was not built of Bolsover stone, but of Mansfield stone. Large quantities of stone were used from Anston because large blocks were more easily obtained. Care was not taken to select particular beds; the softest stone was sometimes wittingly selected because it was easier to work; and sufficient importance was not given to the employment of the best stone in positions where damp and raindrip were sure to exercise their baneful influence, in combination with the chemical disintegrators of a London atmosphere.

Most of the evil might have been obviated if a competent person had been employed to examine every block of stone sent from the quarries. Such a man was Mr. C. H. Smith, and £150 a year was offered to him for the work,—a paltry sum, indeed; but he was willing to undertake the work. When ready to commence he inquired who was to pay him; and as the architect said the Government would, and the Government said the architect ought, Mr. Smith, seeing no prospect of remuneration, did nothing further in the matter. No one was appointed, and of course the office of inspector was neglected.

Anston stone has stood well in the Geological Museum, Jermyn Street, but very badly in the Hall in Lincoln's Inn, both built at the same time, from the same quarry. The evidence of Mr. Grissell proved that in the latter building, the foreman unchecked deliberately selected the softest stone; hence the decay. In the former, Sir H. De la Beche selected the stone himself. You will perhaps say the failure of the geologists, chemists, &c., to select durable stone, militates against my theory of the usefulness of such knowledge as they possessed, but the mistakes of our forefathers are our lesson books, and no more instructive comment on the question we are discussing can possibly be obtained than the Blue Books of 1839 and 1861, containing all that is known or can be said upon the subject. The committee of 1861 elicited the following statement from three chemists, Hoffman, Franklin, and Abel,

* Read before the Architectural Association, 1st June, 1866.

who were appointed to examine into the reason of the decay of building stones, and it is so interesting that I think I shall be pardoned if I give it entire.

Regarded from a purely chemical point of view, the difference in the resisting power to corrosive agents of different stones, would appear at first sight to depend entirely upon their chemical composition; but even a moderate acquaintance with the properties of the components of such building-stones demonstrates that there are other conditions at least equally instrumental in determining the degree of permanence of different stones.

It is a well-established fact, that the *same* chemical substance exhibits, in different conditions, a great variation in its behaviour with chemical agents. Numerous examples might be quoted in illustration of this. Thus, marble and chalk are chemically identical, but, owing to the difference in their physical structure, the one being crystalline and the other amorphous, the former is much less readily acted upon by acids than the latter. Again, artificial peroxide of iron is readily soluble in acids; peroxide of iron, in the form of hæmatite, is attacked with difficulty by acids; and the same oxide, after exposure to a powerful heat, is almost entirely insoluble in acids. The influence of aggregation in these instances, and in numerous others which might be quoted, is obvious and generally admitted by chemists, however different and imperfect may be their views regarding the connexion between physical condition and chemical effect.

The observations just made regarding the behaviour of substances, such as enter into the composition of building-stones, cannot but apply with equal force to the aggregates of such components—to the building-stones themselves.

The atmospheric influences to which building-stones are subject are many of them essentially chemical actions, involving processes analogous to or identical with those performed in the laboratory, although, from the extreme dilution of the chemical agents, as existing in the atmosphere, they must necessarily be of a very gradual character.

There are few instances in which the influence of the state of aggregation upon the permanence of a building-stone is more apparent than in that of the dolomitic limestone, used in the construction of the new Houses of Parliament. Here, in one and the same block of stone of comparatively small dimensions, we find certain portions of the surface powerfully disintegrated, while others appear in a perfectly sound condition. Chemical analysis has hitherto failed to establish any important difference in the composition of sound portions of such stones, and those parts which are subject to decay; it is therefore legitimate to attribute the unequal permanence of the stone, under atmospheric influences, to such structural differences as may be comprehended under the term—state of aggregation.

Before proceeding to an examination of the particular character of the decay observed in the stones of the New Houses of Parliament, it may perhaps be desirable to glance at the nature of the changes to which building-stones generally are subject under atmospheric influences. Under normal conditions these changes must be ascribed to the action of the oxygen, carbonic acid, nitric acid and water in the atmosphere. In the air of towns, however, there are certain other constituents, such as several acids of sulphur, and occasionally hydrochloric acid, which cannot fail to exert an additional disintegrating influence upon building-stones.

The action of oxygen must be of comparatively a subordinate character, its effects being confined to constituents which occur but rarely, and generally in limited proportions in building-stones; such as the sulphides of iron, and the protoxides of iron and manganese; these compounds, being very prone to oxidation, would tend to disintegrate the stones by the absorption of oxygen. Of far greater importance are the effects of carbonic acid and water. Carbonic acid, in the presence of water, is a powerful solvent; it not only corrodes the calcareous and magnesian carbonates (more or less powerfully according to their state of aggregation), whether they form the principal constituents of the stone, or are only present as cementing materials, but is capable even of attaching and gradually decomposing the hardest and most indestructible rocks.

In the case of the calcareous and magnesian constituents of stones, carbonic acid acts by transforming the insoluble earthy carbonates into soluble bi-carbonates, which are thus removed from the substance of the stone; whilst its influence on silicious rocks consists in the elimination of the alkaline bases, in the form of carbonates, and the separation of the silica in a more or less friable condition. The weathering of granites, and their gradual transformation into the several varieties of porcelain clay, affords an interesting illustration of the latter kind of action. In the changes just mentioned, the carbonic acid and water are equally concerned; the water serving not only as a vehicle for the introduction of the carbonic acid into the pores of the stones, but also as a solvent for the products of its action. There are changes, however, to which building-stones are subject, in which water is the sole agent, and which are more of a mechanical than of a chemical character. The expansion which water undergoes on freezing, and the irresistible force which it then exerts are well known; it is obvious that water freezing within the pores of a stone must exercise a disintegrating action not less powerful than those above referred to.

Recent researches have demonstrated that nitric acid is a frequent and perhaps even a normal constituent of the atmosphere, and, as such, must undoubtedly assist in the destruction of magnesian and calcareous stones; but the proportions in which this acid has been found, are so minute, hat it need not be dwelt upon as an important destructive agent. This emark, however, does not apply to the acids referred to above, as existing in the atmosphere of towns. The quantity of sulphur-acids in the air of towns, where a considerable amount of coal is consumed, is quite appreciable. According to the determinations of Dr. Angus Smith, the air of Manchester contains an average proportion, corresponding to one part of sulphuric acid in every 100,000 parts of air, which in the centre of the town, rises to 25 parts in 100,000. No numerical data exist with regard to the proportion of sulphur-acids in the London atmosphere, but it can scarcely be doubted that, in the neighbourhood of the New Houses of Parliament, they are present to an extent equal to the average amount found in the Manchester air; they must, therefore, be regarded as among the more important agents destructive to stone, which are present in the London atmosphere.

A few observations remain to be offered regarding the particular nature of the decay manifesting itself in some of the stone of the new Houses of Parliament. It has already been pointed out that, so far as our experience goes, we are inclined to attribute the local character of the decay to structural differences, obtaining in different parts of the stone. The general structure and the composition of the stone in the new Houses of Parliament render it moreover amenable to all the sources of disintegration which we have above enumerated, with the exception perhaps of oxygen, which can scarcely produce any appreciable alteration in dolomite. Thus, the chemical action of carbonic and sulphuric acids, in combination with water, will gradually dissolve and remove the carbonates of lime and magnesia, whilst the porous nature of the stone renders it liable to the mechanical effects of water under the influence of frost. The presence of sulphuric acid in the air of towns appears, in the case of magnesian limestone, to bring into play another process of destruction. This acid not only corrodes and renders soluble, as we have pointed out, the earthy carbonates (in which respect it resembles carbonic acids in its effects) but, forming with magnesia a readily crystallizable salt, the well-known sulphate of magnesia, remarkable for the large proportion of water of crystallization which it fixes, it gives rise, in addition, to a mechanical destruction of the stone precisely similar to that produced by freezing water. The powerful mechanical effects resulting from the solidification of water, induced by crystallization, are well known, although it would appear that they have not hitherto been sufficiently appreciated as auxiliaries in the process of disintegration of stone. The analogy between the solidification of water, by freezing and by crystallization, is perfectly obvious, and a French chemist has suggested, as a means of recognising stones liable to disintegration by frost, to immerse them in a solution of sulphate of soda, and to note the subsequent effects of its crystallization within the stone.

We have ourselves recently had occasion to observe some phenomena which go far to elucidate these destructive effects of crystallization. The exfoliations exhibited by many of the fictile vases deposited in the British Museum were found to be due to the formation and crystallization, within the substance of the vessels, of nitrate of lime. Again, in experiments on the preservation of fabrics by impregnation with saline substances, it was found that the crystallization of sulphate of magnesia within the material, produced a disintegrating effect upon the fibres, sufficient greatly to weaken the material.

In conclusion, we would remark, that the effect attributed to the crystallization of the sulphate of magnesia, in assisting the decay of dolomitic stones, and more particularly of those used in the construction of the New Houses of Parliament, is borne out by the existence of a marked efflorescence of sulphate of magnesia upon those portions of the stone where exfoliation has taken place.

We have, &c.
A. W. Hofmann.
E. Frankland.
F. A. Abel.

Numerous processes have been patented, and some have been tried, for clothing stone buildings with a silicious coating, so as to exclude the action of moisture, the chemical action of the atmosphere, and the mechanical action of frost; but none, I believe, have quite equalled the expectations of their inventors. I will not enter into the merits of any of these processes, as they do not strictly belong to my subject.

The action of frost upon stone may be illustrated by the method employed by the quarrymen of the North. Instead of using the powder for blasting (a certain quantity of which is served out to them) in anticipation of a frost they cut channels in the stone to be detached, and fill them with water in the evening, and generally the expansion of the water in the act of congelation effects the purpose.

A point, the importance of which is too often ignored and neglected in the employment of stone for building, is that of placing each stone upon its natural bed. All rocks have been deposited either grain by grain or layer by layer. It is quite certain, then, that force applied to them will act more readily on the plane of stratification than upon the transverse section. If stones of no great adhesion in their particles be built into an edifice on end, it is equally clear that frost will act upon them, detaching layer by layer more readily than if the ends only of the layers were exposed to its action. There are numerous examples in Oxford of the carelessness shewn in this particular, and by the small-poxed aspect of several buildings we are warned to use as much circumspection as possible in this respect, to prevent similar results in the present day.

To obtain a complete knowledge of the available building stones of the British Isles is easy. At the Museum of Practical Geology in Jermyn-street, there are cubes of nearly all the stones that have been used in building the principal edifices in the kingdom in past and present times. Those who wish to see how the varieties of stone may be employed for architectural purposes should visit the Oxford Museum. Professor Philips thus describes the stones of which the building is composed; he says—

Though the stone of which the Museum is built, and the marbles which are employed in the internal decoration, can hardly be regarded as a part of the collection of rocks, they must be included among the objects to which the student of geology should devote some attention; and were indeed in part selected for the purpose of adding to the illustrations of that science.

Some variety of colour in the front of the building was desired by the architect; and in the interior one hundred and twenty-seven polished shafts, which the structure required, gave opportunity for exhibiting a specimen of almost every kind of British marble.

The wall-stone for the exterior of the building was obtained chiefly from the quarries in the Great Oolite at Box, near Bath: it is varied by red sandstone from Bristol, and marlstone of a green tint from Hornton. The cornice round the tower is of Irish mountain limestone. In the arch of the porch, red Irish limestone, green marlstone of Hornton, and white Italian marble, are employed. Slabs of Portland stone have been placed in the spandrils for carving.

In the interior, brick is used in the lower colonnade, and in the walls of the court, the arches of which contain red sandstone from Bristol, and a somewhat softer stone, of paler tint, from Coventry. The court is paved with yellow and red stone from Mansfield, and grey stone from the Forest of Dean. The shafts to the arches of the corridors are formed of varieties of English, Welsh, Scottish, Irish and Jersey rocks. The bases of all the shafts, and the capitals of those in the lower corridor, are of Caen stone. The sculpture of the capitals and corbels is intended to represent examples of the principal natural orders of plants: the ornamental carving on the bases is taken from British plants.

Geology and architecture have here united to produce much to admire artistically, and more, if possible, to educate to a just appreciation of the combined power of art and science.

A knowledge of geology will be found useful to the architect when called upon to suggest places in which to sink wells. The site of buildings in the country often depends upon the ease with which a supply of water can be obtained. Numberless are the cases in which neglect in this particular has caused great inconvenience and outlay. What is the meaning of a spring? It is rain water that has found its way into the permeable strata of the earth, and by some impediment, as a fault in the stratefication, a thinning out of the water-bearing seam, or the basin-like form of some of the depositions has been pent up, as it were, and wherever a fissure or vent, either naturally or artificially produced is made, the water bursts forth. Wells are of several kinds, all depending, however, upon the relative position of the strata from whence they proceed. Thus, if we have an inclined stratum of impervious clay, over which there is a deposit of sand-sandstone or porous limestone, and then again a bed of clay, nature has provided a main that has only to be tapped to produce a supply, commensurate with its size and the level at which it is tapped. If again this main in one spot or other has slipped down, producing what is technically called a fault, that is to say, when the porous bed is stopped by the juxtaposition of one of the clay beds, we have a reservior, and, in this case, the water will rise through any aperture in the superincumbent mass till it acquires the level of the highest unobstructed part of the water-bearing seam.

Artesian wells, so called from Artois in France (where at one time great success attended the method of procuring a water supply), have much to recommend them. The rationale of their action is simple. Let us take London and the neighbourhood. In a depression in the chalk of a basin-like form are deposited alternating beds of sand, gravel, and clay. Water falling on the upturned edges of the more porous of these fills them, but the water cannot escape to reach its own level, for the clay above retains it. In the Artesian well this stratum of clay is tapped, and by a small opening, the water eagerly rises till it finds the level of the whole supply in that one porous stratum. Sometimes when a large supply of water is required the boring is continued through all the tertiary beds till the chalk is reached, and here, from the enormous area of chalk exposed to the rain fall, a permanent yield of water may be relied on.

One well at Lellers, in France, sunk in 1126, has yielded the same quantity of water unremittingly. In 1833, at Grenoble, a well was sunk to supply Paris with water, and at 1800 feet from the surface a supply was reached yielding nearly one million gallons per diem, the first rush of water rising 120 feet above the surface.

The Artesian wells in London and its vicinity are numerous, and vary from 200 to 500 feet in depth. To attempt (as has been done) to make these borings without a knowledge of the geology of the district will nearly always result in disappointment and lamentable failure.

Some beds having a free egress at their lowest extremities, instead of yielding water, act as mere drains, and sometimes carry off what can ill be spared. A case occurred some few years since which will illustrate this. A gentleman, encouraged by the success of a neighbour, sunk a well in his garden, and obtained but a moderate supply of water, and this not permanent. He had reached a stratum of stiff clay on which rested a thin bed of sand. Determined to seek a larger spring he sunk his well at considerable cost through the clay. You may conceive his dismay, when, at one hundred feet, he discovered that he had lost his first spring and had not gained a second. Why? Because he had virtually made a hole in the bottom of his well and drained it into a stratum of sand thirsting for all the water it could get. The operation of draining wet lands has often been facilitated by the application of this fact in geology, and thereby the cost of conveyance through pipes to a distance has been saved.

On the importance of geology, in ascertaining the positions in which water will most likely be met with in the strata of the earth, General Portlock remarks—"If we were in a country in which we desired to know whether it would be possible to find water, our geological knowledge of stratification would enable us to predict that after penetrating a certain portion of porous strata, we should find a bed of clay retaining water, and hence that, by artesian boring we should procure it; but, if on the other hand, we knew that there was nothing but a great mass of sand, and we were not aware that there was any clayey or other stratum capable of holding up the water we should know that it would be useless under such circumstances to seek for it. In like manner, we should not look for water in granitic rocks. I recollect an instance myself at Fort Henry, in Upper Canada, where there was a great desire to sink a well in the fort. Resort was had to that old expedient of which perhaps all have heard, the turning stick and the knowing man, having held his stick in his hand of course it turned round, and at the place to which it pointed it was assumed water would be found. The authorities were so deeply impressed with the accuracy and certainty of this mode of discovering the presence of water, that orders were given to sink the well. This was in a solid mass of granite. The difficulties were great and the expense enormous; but who could doubt the infallibility of the stick? Hence, not certainly wisely, though energetically, the attempt was persevered in till it became absolutely necessary to stop, an instance which will show you how important it is to have some little notion of the principles of the science."

Serious evils have arisen for the want of careful geological investigation in the proper disposal of cesspits and cesspools. Should a well and a cesspool each be sunk in the same stratum, and the cesspool occupy the higher part of that stratum, it is easy to see that the well must suffer. But you say, we take care that the cesspool is at a distance and not so deep as the well. Such precautions avail nothing very often, for the thin water-bearing beds sometimes occupy various levels even in a small area. I know that such pits and pools are supposed to be made water-tight, but are they always so? Do they always keep so? This is a question of vital importance in a country visited by pestilence, the predisposing causes of which are bad water and bad air. In making cuttings, digging wells, or in any other operation affecting water-bearing beds, it is necessary to see that in looking to your own interests you do not damage those of your neighbour. Many litigations and serious losses have arisen from a want of the knowledge of geology in such cases. One example will sufficiently illustrate this. "In 1843, the Leeds and Thirsk Railway Company projected a tunnel through the Bramhope Hills, from which issue the springs and streams that partly supply the Eccup Reservoir, belonging to the Leeds Waterworks Company. In 1845, Mr. Curley, a civil engineer and also a geologist, was instructed by the water company to make a model of the district, for the purpose of illustrating the geological and engineering evidence required in opposing the railway bill before the committees of both Houses of Parliament, and by which they succeeded in getting a clause introduced for compensating the water company for any loss of water they should sustain through the railway works. The strata are part of the Millstone Grit formation. There is a porous bed and another impervious to water. The rain therefore falling on the hills, passes through until it reaches the impervious bed, along the top of which it flows and issues at the outcrop in springs which supply the reservoir. The porous bed being cut through by the railway works, the water was intercepted and carried into the tunnel, drying up the springs, as had been predicted by Mr. Curley. The pumping of the water alone out of the tunnel during its construction cost the contractor nearly as much as all the other works connected with it put together. Thus, the water company, by employing the aid of geology, was saved from a severe loss, whilst both the contractor for the tunnel and the railway company, by ignoring that aid, incurred heavy expenses."

A knowledge of geology will enable the architect to determine if the soil on which he intends to build will give a good foundation or not. Captain Hatton, from whom I have just quoted, speaks of the case of Fort Elson, at Portsmouth, as follows:—"During the construction of Fort Elson, at Portsmouth, part of the escarp wall subsided, and slipped forwards, the clay being squeezed up in front of it, as is shown in the diagram. This was owing to its having been built upon the London clay. The treacherous nature of this clay, and its great tendency to slip and be squeezed out when any weight is put upon it, is well known to geologists, and I may add, to railway directors and engineers, the cuttings in it being always a source of trouble and expense. When the South Eastern Railway was first made the slips in the cuttings through this formation were so great as occasionally to stop up the line; and even now the vibration produced by the passage of trains often causes slides to take place, or loosens portions in such a way that the next shower brings them down. If then the weight alone of the fort, and that even before it was finished, was sufficient to make the foundations give way, what might we expect to have happened after a day's heavy firing from it, and after a battering from the enemy's guns? Precautions have now been taken against these accidents; but, if the knowledge of geologists on the subject had been used, the expense of pulling down the sunken portion of the wall and repairing it would have been saved."

In finding limestone wherewith to make cement, sand for mortar, slates for roofing, &c., geology will be found to render material assistance. When the inland fortifications were being constructed for the defence of Portsmouth, cement was wanted for the construction of the new forts. This cement was made from nodules of calcareous clay called septaria, which come originally out of the London clay; but at Harwich, from whence the principal supply is obtained, they have been washed out of the clay and are dredged up in large quantities from the sea. Now the forts at Portsmouth are built on the same London clay in which these septaria are found; but, in ignorance of their nature, they were actually broken up to mend the roads, while others were brought by rail to make cement. At Torry Foot, near Aberdeen, a case was given me by the Rev. James Crombie, author of "the Geology of Bræmar," relative to the necessity of geological inquiry where building materials are wanted. In the erection of the fortress of Torry Foot, near Aberdeen, instead of taking gravel from the neighbourhood, sand for mortar was taken from the sea-shore, quite saturated with salt. The consequence was that, when frost set in or the guns were fired, it trickled down from between the blocks of granite like the sand in an hour-glass.

Road materials especially call for the knowledge of the science we are discussing, to ascertain the fitness or the reverse of the adjacent rocks for the purpose. Geology having determined the stratum upon which the road is to be carried, the material wherewith to metal it must be sought. Tough stones are preferable to hard ones, flint is hard and easily broken, some limestone is tough but soft, chert which is a kind of flint, is both tough and hard. Granite and many of the early rocks make excellent roads, but their selection requires great care. Syenite is often the very best metalling a road can have, but is not everywhere to be had. The materials used in the construction of the road in the Crimea from Balaclava to the front, were whatever happened to be nearest. These from the harbour to the top of the plateau were oolitic limestones and sandstones, and all the rest of the way soft tertiary rocks. Now the whole of these, with the exception of a hard crystalline limestone in the oolitic series, are very inferior materials for roads, and when there is much heavy traffic, as was the case in the Crimea, are sure to be soon ground down into mud. But the beach outside the harbour of Balaclava is composed of compact greenstone, the very best road-making material known; so much so, that large quantities of it are brought from the Channel Islands for the streets of London; and if a geological survey of the country had been made this must have been found, and a good military road would in all probability have been with it. The instance I have quoted shews the value of a made knowledge of geology to the engineer. I might, were it necessary, multiply cases in which geology if pressed into the service of the architect, would amply repay him the time spent on its study.

I hope that the little insight I have given you of this science in its application to architecture may beget a desire to dive deeper into and learn more of a study that cannot fail to interest all who pursue it. A little knowledge of geology will not be found a dangerous, but a very useful thing to the modern architect.

THE TELEGRAPHIC SYSTEM.

On the first day in the present year great reductions were made in the telegraphic tariff between various states of the continent, and the *Journal des Débats* has seized the occasion to show how wide-spread the system has become, and what means of communication now exist in Europe and between that and other parts of the world. It appears that on the 1st of January there existed nearly seven thousand telegraphic offices in Europe. Two lines connected Europe and Africa, one going from Marsala, in Sicily, to Biserta, in Tunis, and being in connection through the lines in the latter country with Algeria; the other line extends from Malta to Bengazhi, in Tripoli, and is then continued to Alexandria, in Egypt, by a cable which runs along the coast. This second line was intended to make part of the great one to India, but the difficulty of preserving a cable on the coral reefs of the Arabian gulf made it necessary to seek another course; its use is therefore limited to communication between Europe and Egypt. The last named country is also connected with Europe, as well as with Asia, by a line which traverses Syria, touching at Jerusalem, Aleppo, Tripoli, Beyrout, crossing the Bosphorus, and joining the lines of Turkey, in Europe.

Dispatches for India may be sent by two routes. The first is by means of the Italian lines, the cable which connects Otranto and Vallona, and the lines of Turkey, in Europe and Asia, and reaching to Bassora on the Persian Gulf it then passes by means of cable submerged along the coast as of that gulf and of the gulf of Oman, and is connected with Indian lines at Kurrachee. The second route is by way of Russia, the Caucasus, and Persia, to Bassora. The Indian telegraphs possess one hundred and sixty-one stations, and the island of Ceylon four.

Dispatches for China are now sent by way of Russia, and are transmitted through the lines of Russia proper and Siberia to the Tartar frontier town of Kiachta. From this point they are carried by the Chinese post to Pekin, a journey which occupies fifteen days.

America is not yet brought into telegraphic relations with Europe, but Russia and America are conjointly at work in establishing a line by way of Siberia and Behring's Straits. The third attempt to lay the great transatlantic cable, as is well known, is now occupying the attention of the whole world; and another line, long projected, that of M. Balectrini, is expected to be carried out shortly, through the co-operation of several continental states with the United States Government, or an American company.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

PRESIDENT'S ADDRESS.

(*Concluded from page* 193.)

AMONG the vast works recently executed or being proceeded with at home, the main drainage of London and the Thames embankment stand prominently forward; the former beyond all precedent the noblest, and so far most successful work of municipal sewerage ever produced; for antiquarian rubbish as to the cloacæ of ancient Rome seems to rest on no foundation of reality, and from personal examination I can state my own view to be that the so-called *Cloaca maxima* was never intended for a sewer at all.

The water of the Thames already begins to sparkle under even its partial defecation. There is good ground for wishing that the outfalls, however, were removed farther down the river, and the Essex sewage project of Messrs. Bateman and Hemans, if carried out, will be attended with that advantageous result as respects the greater portion of the discharge from the northern sewers.

Like projects are mooted for the south side of the Thames, and it may be said that in all probability the final completion, under the able conduct of Mr. Bazalgette, of the whole main drainage system, will not tardily result in vast improvements and extensions of the methods of distributing sewage as manure over large tracts of arable and pasture land, to be ultimately followed by the general defecation of our rivers and streams all over the country, and the utilization of the manure now poisoning them as water sources.

The Thames embankment, which now shows itself above water in several places, is remarkable, not by magnitude alone, but by the rapidity which has been conferred upon its execution, by the most extensive and complete system of contractor's steam plant ever before applied upon any work. Scores of small and moveable engines, applied to hoisting, leading, dredging, pumping, mortar and concrete mixing, and numerous other purposes, have here reduced the work of years, if done by manual labour, to that of a few months.

The employment of wrought-iron caissons for sinking to, or for obtaining foundations, have here, as well as at several of our new bridges on the Thames, and more particularly in the two bridges at Blackfriars, under the direction of Mr. Joseph Cubitt, proved of the most inestimable service as methods of construction in water.

In strata analogous to the London clay, where beds of stones or boulders are unknown, the probability is that the experience of the last two years has finally put an end to the old form of coffer-dam for pier foundations, but where pervious, unequal, and stony strata are encountered, the double row of timber or of iron piling will no doubt continue in use.

Besides the Westminster new bridge, the work of Mr. Page, and beyond question, as measured by capaciousness and convenience, both for water passage and for traffic, the finest of existing London bridges, the Thames has but recently been spanned by the Charing Cross and the New Cannon Street railway bridges, both of iron, and both founded on cylindrical hollow pile piers, and also by the fine railway bridge by Mr. Baker at Putney, and a new structure leading to the Victoria station is in progress at Battersea. In the form of suspension bridges it has accepted the Lambeth Bridge, conspicuous by its ugliness, though said to be, like a plain but well dowered bridge, in a financial point of view a success; and another, on the peculiar stiffened construction of Mr. Ordish, has been projected at Battersea.

The rivers of the Continent have within a few years past been crossed by many bridges for railway or for road traffic, embracing some of the noblest structures of the sort in the world. Among these may be specially noticed the railway lattice bridge of Dirschau, on the Vistula, which connects the Russian and Prussian systems of railways, in six spans, each of which is but thirty feet short of those of the Britannia bridge, and in the construction of which the great economy residing in the lattice, as contrasted with the tubular or box girder system, has been strikingly shown. The bridge of Maintz, upon the Rhine, is a fine example of construction in tension trussing upon the great scale.

Upon the same great river we may not pass without notice the fine bridge at Kehl and Strasbourg, the last great work of Emile Vuigner, whose death last year every engineer deplores. Nor can we omit the noble railway iron bridge at Bordeaux, the design of which, though on a much larger scale, resembles that of the Charing Cross bridge over the Thames, and of that over the Foyle at Londonderry, which has been carried out by Mr. Hawkshaw, in near accordance with the designs furnished anteriorly by myself to the Londonderry bridge commissioners.

Among the works or projects at home of the hour that in virtue of their magnitude or novelty claim a word of notice, may be mentioned the iron viaduct by Mr. Brunlees, now erecting over the historical Solway Frith, for giving improved communication, between the English and Scottish railway systems, of more than a mile and quarter long, an exposed structure, the main lateral stability of which is given by its covering platform of buckled plates.

In project only as yet, but likely to become accomplished works, we have the gigantic railway viaducts intended to cross the Frith of Forth, and that proposed by Mr. Fowler across the Severn below Gloucester.

Steam ferries, to carry railway trains unbroken across the English Channel, and so to unite the English and Continental systems, have found projectors sanguine enough to propose them, and no doubt they are probabilities of the future.

To the same distant, though probably less distant, horizon in time, belongs Mr. Bateman's bold project for the supply of London with two hundred million gallons of water per day, to be abstracted from another and a distant river basin, viz., from the upper reaches of the river Severn.

Second to none of these in ultimate importance to mankind, and in the immediate interest which it justly excites, is the Atlantic telegraph, now gathering its strength afresh, after a second defeat, for what we hope may prove a final conquest over natural difficulties. Let us observe, however, that the misfortunes of the Atlantic cable cannot in any strictness be said to have been due to natural obstacles. They are all traceable to defective insulation, arising from mal-construction in the cable itself; and whenever a perfectly insulated cable shall have been made, that without any hitches or hauling up by the way shall have been once paid out, its being laid safely, and as a result the establishment of telegraphic communication between the old and new worlds, is a matter of almost perfect certainty. Improvements daily taking place in the hands of electrical engineers as to the methods of transmitting signals and accelerating these greatly, give a reasonable expectation that when completed this undertaking will prove remunerative.

Human power over both cold and heat in their applications to the arts of industry has received lately not unimportant accessions. The ice-producing or freezing process of M. Carré by ammonia, of Harrison and Siebé by ether, and of Kirk by expanded air, have already found important applications in chemical and other manufactures, and perhaps ere long as refrigerators for the brewer; while the methods of heating by gas burnt with only its exact equivalent of air, brought prominently and practically into use in the arts by the classical researches and labours of Ebelman, have received fresh interest from those of Deville, who has shown that the most refractory metals can be fuzed by the heat of gas furnaces; and based on this, and on the freedom of gas flame from the impurities evolved from coal fuel, has pointed out applications to the metallurgy of iron in particular of the highest importance—not second, indeed, to the improvements made by the application of machinery to the puddling process, which has recently become in France and in South Wales an accomplished end.

While thus referring to the progress of foreign technology, a word may be given to note the improvements in relation to public health effected in public baths and lavatories, and in the heating and ventilation of public buildings in France: the latter are largely indebted to the labours of Morin, whose able work on the subject appeared at Paris the year before last. Nor should we wholly pass the new processes of sugar manufacture invented by Kessler, and perfected by M. Demiautes, by treatment with the acid phosphate of lime, which seems likely to prove of great importance.

Having thus dwelt upon the progress and improvements making in other lands, I will now refer to our engineering progress in this country.

Our past president, Mr. Mullins, has given us an admirable *resumé* of the later history of civil engineering in this country, extending over about two centuries. It embraces nearly all that the practising engineer need perhaps care for. I cannot but wish, however, that some one yet would give us the much earlier history of engineering in Ireland which blends into that of its domestic, ecclesiastical, and military architecture. For notwithstanding what we owe to Petrie (whose recent loss we still regret), to Wilkinson, and others, we remain in want of one to tell us, with the same loving zeal and earnestness that Viollett le Duc has given the history of the military architecture of France between the eleventh and thirteenth centuries, who and what were the men who, for example, reared the perfect-jointed ashlar of the tower of Clonmacnoise, the quaint cloisters of Muckruss, and the walls of Jerpoint; who delicately chiselled, six centuries ago, the limestone mullions of Howth Abbey; by whom the groining of Clare, Galway, and the Spanish doorways of the old City of the Tribes were drawn; who designed and constructed the defiant walls and castles of Limerick, Tredagh, and Carrickfergus; whose taste decided the flowing lines of the palatial buildings at Kilmallock; who planned the many residential fortalices of Elizabeth's reign; or later still, who designed and fixed the details of Strafford's palace at Naas, with its Dutch brick and coloured tiles and its brickwork, even now, in its tenantless ruin, the delight of the modern mason's eye.

These would be noble memories, gentlemen, to call up, though even these cannot be without occasional bitterness and regrets, for much even of the architectural history of this country is stained with violence and bloodshed; and when these must be referred to it had best be with the outspoken truth with which Prendergast has lately told one of its saddest stories. But while the historian or the archæologist has occasion to refer to old antagonisms, and does it truthfully, for the heart-burnings they have left to our own day can never be repressed or removed by falsification or palliation of wrong on any side, let us all now, as practical and thinking men, say of them, "The past is past," nor dream of redeeming its errors by flying into new ones; for if our own profession, which is one with progress itself, or if any art or trade is to root and prosper in this land, it can be alone upon the basis of genuine tranquillity, and the abandonment by every class of every chimera.

The social circumstances of Ireland are exceptional, and peculiarly unfavourable, in some respects, for the development of engineering or industrial works.

No great staple manufacture has rooted in the soil, with the exception of that of linen in the north. With few large cities or towns (which have been in the history of all countries the centres from which arts and industries have spread); almost without a middle class, to connect property in land and capital with labour; and with a labouring population almost wholly agricultural, and perhaps more deplorably ignorant of everything that relates to industrial arts or commerce than any civilized people in Europe—what wonder is it, even apart from the difficulties of polemics and politics, which I do not wish to refer to further here, that in money-returning products, Ireland stands at the lowest point of the commercial scale; that even the very crudest articles of manufacture, if not imported, are produced generally of the most wretched quality, so that, for example, from one end of Ireland to the other scarcely a good *brick* can be purchased, and that the streets of this city are even paved with "setts" imported from Wales, while better material, from which skilled labour might have fashioned them, exists in abundance within forty miles of Dublin.

The law of progress in every country is from pasturage to agriculture, thence to commerce, and ultimately to manufactures. Yet here we find a return to pasturage, the one stage above nomadic life, advocated; and such is the prevalent want of knowledge of the conditions of manufacturing success or failure, that when a fitful gleam of prosperity induces some little stir, projects as chimerical and baseless as a plate glass manufacture, a beet-root sugar or a peat paraffin company, find subscribers and supporters, whose notions, when by the remorseless logic of events confounded, serve long to damp or prevent every well-placed and considered enterprise.

For there are many sorts of manufacture, many industries of arts, that may be attempted in Ireland, bearing in view its actualities, both natural and social, with rational grounds and good hope of success. I must not detain you with particulars, but I may say in illustration that to give the best hope of commercial success, industrial enterprise here should seek to bring forth the crude riches that nature has placed *below* the surface of Ireland, and subject these to such primary transformation as may make them in the first place articles of export, ultimately perhaps of manufacture; and that no industry which is either wholly exotic and refined in character, or which demands a large supply of the higher order of skilled labour is likely to prove permanently successful.

An improved systematization of the railway traffic of this country and reduction of rates, as advocated by so much concurrent and independent testimony before the parliamentary commission on railway fares of last session, if carried out upon comprehensive principles, would not only permit and awaken many such enterprises, but it is indispensable preliminary to their success. Nothing also could better tend to develope the completion of the network of the Irish railway system, necessary to bring all parts of the island into contact with the points of import and export, which are so much confined to the northern, eastern, and part of the southern coasts. In the existing state of Ireland and of the railway interests belonging to it, it may be said with certainty that the system of county guarantees is nugatory as promoting public works in railways.

I have, early in this address, alluded to the bad policy with which (as it appears to me) nearly all promotion or even direction of public works was about fifteen years since abandoned in this country. In one special department this abandonment seemed suicidal, and it appears to me that the time has fully come when the government in this country might wisely and with great advantages retrace its steps. I allude to the stoppage of the arterial drainage of Ireland. I shall not go into any of the vexed particulars of that time, but these are the main facts:—The Acts under which the arterial drainage was affected, wisely framed by the legislature, and on the whole not unwisely nor incapably administered, though brought face to face with the tremendous fiscal and social convulsion of the potato famine, were set aside and their operation suspended in permanence by an act of the executive, moved to it by the clamour of Irish landowners, who some of them no doubt found themselves in a position of financial difficulty through the pressure of the times, from which this course presented in so far the readiest but the most shortsighted exit. Not only were works in progress brought to hasty or abortive conclusions, and mature projects abandoned, but no sufficient provision was made for the effective future maintenance of those completed.

Now here is a class of works that no *laissée faire* policy, even though it were applied to the richest country in Europe, can get effected, which even in England, where self-government is supposed to do all things, has stood almost stock still. They were being carried out in a country here covered by millions of acres still of wet and sterile bog, with a climate exaggeratedly declared to be so moist as to be only fit for pasturage, and from which the culture of *wheat* (the very type amongst crops of social advancement) is disappearing: and yet these great drainages were showing distinct meteorological signs of ameliorating this condition of climate at the very time they were suddenly abandoned.

Everything seems to point out that at the present time, after due consideration and amendment of the Arterial Drainage Act, so as to adapt them to those changes which circumstances and the lapse of years have produced, those works might with the greatest advantage, public and private, be now resumed.

I have detained you long in thus looking back upon the shadowy side of the landscape. We, however, who are familiar with the country know that it here and there is not devoid of sunshine also. Though there are few important public or private works of engineering recently begun and completed to which we can refer, there are yet some which have been growing year by year in importance, to which we may advert with satisfaction. Among these some of our harbour works stand prominent.

The port of Dublin affords a fine example of the success that can attend a single well-devised work in harbour engineering; for although the steam-dredging operations so long carried on by the Ballast Corporation have considerably deepened the channel of the river Liffey itself, it is chiefly by the direction given to the tidal scour by the Clontarf wall, suggested by Chapman and carried out by Giles and the elder Halpin, that the increased depth of water upon the bar has been produced. The steam dredging operations upon the river have been conducted with improved appliances by the existing engineer of the corporation, our fellow-member, Mr. B. B. Stoney, who has had constructed iron hopper barges for removing by steam tonnage the dredged material to suitable places of deposit of the unprecedentedly large size of 1,000 tons burthen.

Belfast harbour is another favourable example of harbour engineering under circumstances of considerable difficulty and complexity, an excellent account of which has up to a rather late date been given here by my predecessor, Mr. M. Mullins, V.P. At the present time vessels drawing 22 feet of water can come up to the town at high water of ordinary springs, so that the effect of the works executed has been practically to more than double the available harbour depth, and to give the town a fine chain of docks and basins, with a wharfage of nearly 8,000 feet, and at a very small outlay under the circumstances.

I am indebted for an excellent history of the various projects and works for the improvement of Belfast harbour to my friend Mr. George Smith, C.E., now consulting engineer to the port, and who for twenty-seven years held the responsible position, of its acting engineer:—

The harbour of Belfast was originally in the creek or river that runs down the centre of High Street, and empties itself into the river Lagan. It is now covered over as a sewer.

The first mention of Belfast as a place of trade is in the charter of James I., where the inhabitants are allowed to embody a guild of freemen, and to erect a wharf or quay. An impetus was given to the trade in 1637 by the purchase, on the part of the Crown, of the exclusive privileges enjoyed by Carrickfergus to one-third of the duties on goods imported into that town, and other monopolies. For a century after the trade was confined to this small river. In 1720 a *quay*, from the mouth of the creek to the Long Bridge (now the Queen's Bridge) was built, and now forms part of Donegal Quay, extending from the Queen's Bridge to the foot of High Street. This was the commencement of the present harbour.

As the trade of the port increased, the dues upon shipping became of importance to the Government, and they appear to have given considerable attention to the subject, and early in the present century they obtained reports from the most eminent engineers of that day, with the view of procuring greater security for the shipping and the revenue of the port.

But as the Government would only grant the merchants temporary assistance. by way of loan, they found themselves thrown on their own resources; and from the time that Mr. Rennie reported to the commencement of the works of improvement in 1839, the harbour committee had designs for docks from the most celebrated engineers of the day, as well as from others of lesser note, and some by anonymous authors.

The engineers that were consulted by the authorities were Mr. Killaly, the Messrs. Rennie, Mr. Telford, Mr. Walker, and Mr. Cubitt. Mr. Rhodes furnished a report at the request of an association of merchants entitling themselves, 'the committee of the proposed ship canal and floating docks.' Mr. Woodhouse, the resident engineer of the committee, also reported, but it was merely in confirmation and adoption in part of Messrs. Walker and Burges' report, &c. The following propositions were contained in most of the plans:—

1. For turning the river Lagan in front of the town into floating docks, and connecting them with the Bay of Belfast by a canal with locks.

2. For making floating docks on the reclaimed land, or slob, near the town, and connecting them with the bay as before, leaving the river opposite the town in its natural state.

3. For making floating docks on the slobs and reclaimed land as before, and connecting them with the bay by straightening and deepening the natural river, so as not to interfere with the ebb and flow of the tidal waters.

If the system of lockage which was contained in the two first propositions had been adopted, the present tonnage of the port could never have been arrived at.

Independently of the limited nature of the traffic that could be passed through a lock in the course of a day, the cost of Mr. Rennie's scheme in 1821, and afterwards in 1826, in which he makes the entrance of his canal at Whiteabbey, was upwards of half a million, while the tonnage of the port was under £1,000. It must have been wholly completed before any part of it could have been used.

It was a favourite scheme with the late Marquis of Donegal, then Chairman of the Harbour Board, as well as with the directors of the Lagan Navigation Company, one of whom was also a very active member of the Harbour Board, that the river above the Long Bridge, which was nearly empty when the tide was out, should always be maintained at high water level, that it might be an ornamental sheet of water to his residence at Ormeau with the Marquis, and with the company that it would enable barges to navigate the river and enter there at all times. The strong influence that could be brought to bear in this direction may account for there being so many schemes for damming up the river.

The improvements in Belfast harbour, from their commencement to the present time, have been carried out under my superintendence, in accordance with the designs of Messrs. Walker and Burges, which were in conformity with the principle contained in the statement No. 3.

The plans of Messrs. Walker and Burges were adopted by the Harbour Committee in 1830, and confirmed by Act of Parliament in 1831; but in consequence of the difficulty they experienced in raising money this Act was allowed to expire, but was renewed in 1837. It was under the powers of this Act that the improvements have been carried out, although it has been superseded by the Act of 1847, which is now the one in operation.

The works were commenced in February, 1839, by Mr. Dargan, who undertook the formation of the first section of the Victoria Channel; cost, £32,000. The slopes of the cut were shown in the drawings to be 2½ to 1, but in consequence of the very soft nature of the clay, or slitch, they were altered very considerably.

The second section of the channel was commenced. In consequence of the very soft nature of the soil we had to go through (the same as the first section), the slopes were made 5 to 1, the depth of cutting being from 13 to 14 feet on the general level of the slob. The cost of this work, including all expenses, was £42,696.

It was very gratifying to find, after several years' experience, that the dimensions of the channel were so well adjusted to the velocity of the water flowing through it that no silting up had taken place for several years; what dredging has taken place in it has been caused by adjoining works, principally the enclosure of the slob on the county Down side of the river. Before commencing the channel vessels drawing more than 5 feet water could not get up to the town at low water, but on its completion there were from 10 to 11 feet, and from the upper end of the channel downwards towards Garmoyle there is now not less than 13 feet at low water, and at high water spring tides 22 feet.

In looking at the plan of Belfast harbour, it will be seen that Garmoyle is a deep pool commencing near the Seal Channel, where it begins to deepen, and continues to do so as far as the buoys of the middle Bank, where there is 19 feet at low water; it then gradually shallows till it reaches the lighthouse, where the pool ceases, and the lough becomes of the general level. Various reasons for this formation have been given, as very little alteration, if any, has taken place in it for many years, the most favourite one being that the bottom of it is filled with springs from the land. In examining the Seal Channel in opposition to some of the railway bills, I found that wherever the Seal Channel sent out forks, or minor channels, there it immediately deepened the same as Garmoyle, which commences to deepen at the junction of the old channel of the Lagan with Joy's Channel. Do not these pools arise from the current of the two streams forming eddies at their junction, which the soft slitch of the lough is not able to withstand, and gulls itself into a hole or pool? I mention this, as there may be some novelty in the idea, but it is a very feasible one, for the ground is so soft, as I have previously stated, that it will not stand at a less slope than 5 to 1. It is causing great annoyance to our present works.

Simultaneously with the making of the Victoria Channel the river opposite the town was very much widened, as well as straightened, from the bridge downward to the upper end of the channel. The Queen's Quay was put 250 feet farther into the county of Down than the margin of the river; and on the opposite side Donegal Quay was removed 50 feet into the river, so as to gain width for sheds between it and the street.

I am sorry that I cannot give you any information respecting the *increase* in the velocity of the tide after the making of the channel. I did not take any observations till after it was opened when at half ebb it ran from ¾ to 1 mile per hour during neaps, and in freshes 1⅓ to 1¾ miles per hour. I do not think the alteration made much difference, as the tide had free scope up to the town when I took my observations; but as the banks of the river are being gradually closed in by our improvements, I expect a change is taking place.

Since the formation of the Victoria Channel upwards of 7800 feet of quays have been made or renewed, and a patent slip erected capable of taking up vessels of 1000 tons. We have works in progress that will cost £150,000, the principal being a graving dock, 450 feet long and 15 feet water on the cill at high water neaps; also a floating dock, 1400 feet long and 500 feet wide, capable of taking in vessels drawing 23 feet at neap tides.

A third harbour to the improvements of which we may point with pleasure is that of Londonderry, at present probably the most rising town and port in Ireland.

I have been favoured by my friend Mr. Thos. Stevenson, of Edinburgh, one of the engineers engaged in these improvements with the following brief account of the works, to the complete success of which I can speak from personal knowledge, having been myself intrusted by the port and harbour commissioners with the valuations of the whole of the ancient quays, frontages, and wharfage property, extending to nearly a mile in length, preparatory to their being swept away, to make room for the new quay, alongside which ships drawing more than 20 feet can lie up:—

So recently as 1854 the quays of Londonderry were owned by private individuals, each proprietor occupying a portion of the quay in front of his warehouse, and building his own quay in any direction and of any material, according to his own fancy. Each portion of quay was walled in, and there was no thoroughfare along the harbour in front of the warehouses. A more inconvenient arrangement could hardly be conceived. In 1854, however, an Act of Parliament was obtained incorporating the commissioners of the port and harbour of Londonderry, and empowering them to levy dues and borrow money for the purchase of the private quays and the construction of works on a large scale for the improvement of the port. These works were designed and carried out by Messrs. David and Thos. Stevenson, of Edinburgh. The whole of the private quays have been purchased and removed; spacious quays affording a roadway of 50 to 80 feet in width, have been formed along the harbour for a distance of 3730 feet, at a cost, including dredging vessels and the purhase of property, &c. (which amounted to about £64,000) of about £130,000. A new graving dock has also been constructed. It is 314 feet in length, and has a depth of 6 feet 9 inches at low water of spring tides, or 15 feet 9 inches at high water on the cill, and with pumping engine and other necessary appliances has cost about £24,000. The works of the quays were chiefly contracted for by Mr. M'Cormick, M.P., and Mr. M. M'Clelland and those for the dock by Mr. Hugh Kinghorn, of Leith. The whole was carried through by Mr. M'Donald, as resident engineer, under Messrs. Stevenson. The only other portion of the parliamentary work remaining to be executed is the dredging of the "flats" in the lower part of the estuary, which it is intended to deepen to the extent of 3 feet for the distance of nearly a mile, so as to afford a depth of 22 feet at high water. These dredging operations in Lough Foyle have been as yet only partially carried out. In addition to these works several lighthouses have been either built or remodelled. The Royal Mail Montreal Steam Ship Company's first-class American steamers now make Londonderry their port of "call" and "departure" for landing and embarking mails and passengers; and the ancient city of Derry, with its rapidly-increasing trade and its connection with the whole northern part of Ireland, bids fair to be soon one of the most flourishing ports in that country.

"The works were commenced in 1855, since which time the tonnage of the port has nearly doubled itself, and, as stated by the secretary in his letter of 2nd October, 1865, 'it is the general opinion of the commissioners that the same amount of accommodation has nowhere been supplied at a lesser cost, and every portion of the works still maintains as high character for stability and effectiveness as when completed.'"

The Vartry waterworks for the supply of this city, though a needlessly expensive project, will no doubt when completed afford an excellent supply. Of these some account was recently given by Mr. Neville to the meeting of the mechanical engineers in this city, which was probably listened to by the majority of our own members.

I will briefly advert to one topic more, though a little out of its proper place, inasmuch as it is one that presents the fairest opportunity of establishing in this country a new branch of manufacture and a genuine source of remunerative return, under conditions which Ireland presents peculiarly well-developed.

Henri Sainte Claire Deville, the illustrious French chemist, in the course of certain recent researches, has discovered that some compounds of hydrate of lime and hydrate of magnesia afford a cement of eminently hydraulic properties, and setting rapidly under water. He has further found that the natural dolomites, which consist of carbonate of lime and carbonate of magnesia, in proportions either of one atom of each, or of two or three atoms of the lime carbonate to one of magnesia, if calcined at a very low red heat and ground to powder, produce without any other treatment a fast setting hydraulic cement, which becomes so hard that it may be employed also as an artificial stone, which for architectural purposes retains the fine warm tint of colour of the dolomite in its natural state. Now in many parts of Ireland dolomite is abundant as a quarry rock. It can be obtained of a fine creamy white colour, and very free from iron and manganese, which would in the preparation darken its colour as a cement.

The amount of heat required for its calcination is very slight, and may with great advantage and cheapness be communicated in furnaces heated by gas evolved by the imperfect combustion of peat, employing a modification of Charles Siemens' regenerative furnace. The calcined stone can be ground by water power, and the casks for packing the cement may be a subsidiary manufacture, and even made from small native timber, but little skilled labour is required. The materials are all at hand; the product directly marketable. The process which has been given to the world by Deville is hampered with no patent. Here seem to be the conditions for at least one new industry in Ireland. Let us hope that the hint may not fall wholly unproductive.

If I have extended this address at an unreasonable length, I have had a wide scope of subjects to deal with; and while none are without points of contact to engineers, on some that have been touched upon we must, whether as connected by different ties to this country or as British subjects, feel deeply interested for they bear upon the welfare of us all.

INCRUSTATION IN MARINE BOILERS.

By P. Jensen.

(*Concluded from page 200.*)

The plan of admitting foreign substances into the boiler to neutralise the salts, or some of them, contained in the sea water, has found favour with a great many inventors; suffice it to say that nothing has appeared more likely in the eyes of practical and scientific gentlemen than soda. Mr. J. R. Napier has gone into an estimate of the commercial advantage of using soda ash for incrustations. He assumes the boiler to work at 270 deg. per square inch, and evaporating at that temperature 7½ lb. of water from 100 deg. per lb. of coal. The following is his table.—

	Mechanical method.	Chemical method.
Sea water supplied to boiler at 100 deg.	15 lb.	8·33
Water discharged at 270 deg.	7·5 lb.	·83
Water evaporated	7·5 lb.	7·5
Total heat evaporating from 100 degrees at 270 deg. = 1092 × 5-10ths T γ 32 — T₂' 34) = 1095	8215·5 deg.	8215·5 deg.
Heat discharged	1,275 deg.	142 deg.
Fuel consumed in evaporation	1 lb.	1 lb.
Fuel consumed in preventing crust	·155 lb. coal	·0172 lb. coal ·0095 lb. soda ash
Total fuel	1·155 lb. coal	1·017 lb. coal ·0085 lb. soda ash

Thus it seems, he says, that it requires only 172 lb. of coal + 85lb. of soda ash, containing 50 deg. of soda, to be as efficient in preventing crust as 1,550 of coal alone, which evaporates 7½ lb. of water from 100 deg. at 270 deg. And these methods are equally expensive when soda ash is 16·2 times dearer than coal. This ratio varies with the efficiency of the fuel and the temperature of the evaporation. In this instance the loss by blowing off amounts to 14 per cent. Now there is no doubt that soda is a very good remedy against incrustations, and it has been repeatedly recommended by eminent chemists. Unfortunately even this remedy, so simple and efficacious as it has proved, has its drawback, and that of a very serious nature. In a German scientific periodical (*Dingler's Journal*, vol. 130, p. 153, A.D. 1853), we find it mentioned that Professor R. Fresenius had recommended the use of a certain quantity of soda as a certain and cheap means for preventing incrustations where water is used that contains sulphate of lime or (plaster of Paris). He had used it some months and with very good results. The factory boiler in question that formerly used to be scaled at proportionately short intervals now remained perfectly clean, and even patches of old incrustation too hard for removal had disappeared.

But repeated trials and careful examinations had shown that a continued use of soda attacked the boiler plates very much. Dr. Zimmerman thought that all commercial soda contained more or less cyan, and that is the reason of the corrosion of the plate; Dr. Rudolph Böttger, who mentions this fact in his "Polytechnisches Notizblatt," of 1853, No. 20, says that he has made several experiments himself, according to which all commercial soda, even from the most respectable firms, contains cyannatrium, and in consequence of this discovery he warns others against using it in boilers for the purpose of preventing incrustations. It is important to bear this fact in mind at a time when we find the chief inspector of the Manchester Boiler Association recommending the use of soda in steam boilers. Besides it must be remembered that such foreign bodies introduced in the boiler produce priming with all its evils.

5. Blowing off. The original practice at sea was, it is believed, to blow off from the bottom only, which was not found efficacious. Subsequently, additional blowing off from the surface was resorted to, and this first at stated intervals and subsequently continuously. Thus we find Henry Maudslay and Joshua Field, already in 1824, taking out a patent (A.D. 1824, No. 5,021) for withdrawing a fixed quantity of brine by meters of any kind; they preferred a pump with a loaded discharge valve drawing from the lowest part of the boiler. They also in this patent mention a tubular regenerator for heating the feed-water by means of the heat of the brine drawn off. These brine pumps were at one time used to some extent, but have now been superseded by the surface blow-off system, because it was found that the pumps and the regenerator got choked with salt and thus became inefficient. Blowing off from the bottom has now become almost superseded by surface blowing off, because the latter plan has been found the more efficient of the two. The impurities contained in the sea-water being, by the application of the heat of the furnace, brought out from the state of chemical solution into that of mechanical mixture in minute particles, floating about in the hot water and steam, is by the circulation of the steam and water floated to the surface in or along with the globules of steam rising to the surface and there held in suspension in the bath of steam and water till accumulating to such an extent as to subside to the bottom; or, in their downward course adhering to the surfaces coming in their way. It is hence obvious enough why it has been found advantageous to catch these impurities and blow them off before they can do any harm.

Intimately connected with the question of blowing off is that of sediment collectors. Various plans have been proposed for this purpose; but it is not proposed to enter into this subject, for the reason that applicable as they might be for many other sorts of boilers, they are not in the author's opinion as regards marine tubular boilers as now universally adopted, except in the shape of one or two common scum pans; because any comprehensive system of pipes, pans, and vessels of any sort in the water-room above the tubes, would impede the free circulation of the ascending and descending currents, and thus probably do more harm than good. The author is, however, open to correction in these remarks, by practical men having actually tried such appliances. And this leads to the consideration of probably the most important element in the prevention of incrustation in marine boilers, viz., the influence that the construction of the boiler itself has upon the subject.

If, as has been shown in the foregoing remarks, the sulphate of lime becomes all but insoluble in sea-water at a pressure of 20lb. per square inch above the atmosphere, such as is now commonly used in marine boilers, and if it is a fact, nevertheless, that incrustation can be prevented in some boilers by means of proper and assiduous care while no amount of care will prevent it in others, then we must arrive at the conclusion that the construction of the boiler, next to proper and convenient means of constantly observing the state of the water and careful attention to it, forms the most important point in the inquiry. You may build marine boilers of very much the same general internal and external appearance to a superficial observer, and still one is a good and the other is a bad boiler to keep clean and to scale. It is obvious that it is only by the rapid and free circulation of the water and steam that we are enabled to work with salt water at all. It is further probable that but for the circumstance that the circulation becomes more rapid as you increase the working pressure, and consequently the temperature, that higher pressures than 20lb., going even as high as 40lb., have been found practical in salt water. The chief principle to be aimed at seems this, wherever the greatest heat is communicated to the plates there also ought to be the greatest facility given for a rapid circulation, and secondly, make the boiler accessible in all its internal parts, and especially in those most vital, viz., those in which scale when formed is most injurious and dangerous, which are those exposed to the greatest heat. The scanty room generally allotted to marine boilers makes it a difficult task for the designer to meet the above requirements without at the same time losing sight of other important considerations, such as economy and strength. The common multitubular marine boiler may be so designed, and this does not happen very often, that it gives little trouble to the engineer in charge to keep clean and scale it: the tubes must not be too close upon each other, and not too many rows in the vertical line, ample room must be left for a man to get in to clean the furnace crown, the back tube-plate, and the spaces between the tubes. The plan of inclining the back tube-plate somewhat so as to allow the steam to escape more freely from the same has found favor with many engineers, and has also collateral advantages. Of late years a multitubular boiler of another description, the vertical water-tube boiler, by Mr. Martin, a chief engineer of the United States navy, has become extensively adopted in the United States navy, and possesses, no doubt, advantages as regards scaling the tubes, the water being in them, and heated products of combustion passing outside and amongst them; this circumstance renders them more easily scaled inside with circular scrapers than is practical with the tubes in our common marine boilers that want scaling outside and never can be effectually sealed by mere mechanical means. The Field boiler, now well known amongst engineers, and because of the very rapid circular in the tubes possessing the important advantage of keeping the tubes themselves and also the tubeplate in which they are inserted free from scale, ought to do well for marine purposes, one should think, although, of course, practice will answer that question. In American men-of-war, where they seem to be able to afford more boiler space than in the British navy, is often used a long circular return-tube boiler, the tubes being of large diameter (say 1ft. or more), with very ample water spaces around and between them. They are, on account of their shape, capable of working with 30lb. or 40lb. per square inch almost without staying, and also to use salt water without pressure. Many other boilers proposed or adopted for marine purposes might be mentioned, but it would be to travel beyond the subject to go into details of this question. To illustrate the importance that has at all times attached to this subject, it will be well to enumerate the more prominent patents that have been taken out in this country for preventing incrustation in boilers.

Maudslay and J. Field, 1824, No. 5021. This has been mentioned before.

W. A. Johnson, 1838, No. 7714. He proposes to put pieces of broken glass into the boiler or broken porcelain, pottery, scraps of iron, shot, steel, or other hard substances, which he thinks, by the circulation of the water, will be scoured against the sides of the boiler, and keep it clean! The circulation must be very stong indeed.

J. I. Delfossé 1843, No. 11347. He adds a compound consisting of dry tannic or gallic extract, hydrate of soda, (soda without carbonic acid) muriate of soda, and subcarbonate of potash. The proportions vary according to analysis. For locomotives and marine engines he adds this compound every two days or more.

J. I. Beale, 1848, No. 12186. He adds a compound consisting of human urine with a little caustic potass, soda or lime. Two ounces of this per cubic foot of water contained in the boiler. Marine boilers, he says, must be blown off in the usual way.

J. Horsley, 1849, No. 12592. He proposes to purify the sea water before going into the boiler, by treating it with oxalate of potash, ammonia, and phosphate of soda. For water such as is in the British Channel, he uses two drachms of oxalate potassa, to two ounces of ammonia-phosphate of soda for every gallon of water. The precipitate forms a splendid manure. But it requires a very nice analysis so as not to render the water injurious by an overdose.

B. Babington, 1850, No. 13322. He connects some more oxidisable substance than the boiler plates to the same in this way.—He solders to the sides of the boilers in the water space sheets of zinc by one edge, leaving the other edge free, and the two sides just immersed. This zinc corrodes, and by the voltaic action between the iron, the sea water, and the zinc, he thinks he prevents the incrustation.

J. Ashworth, 1851, No. 13647. To thirty-three gallons of coal tar he adds twenty-one gallons of linseed water (prepared by boiling in water 14lb. of linseed, and straining seed away), and 5lb of plumbago, or common black lead pulverised, and 8lb. of Castile soap. He uses one gallon of this per 30-horse power twice a week. He finds this prevents incrustation, so that scale only forms in thin, brittle, and porous quantities, easily swept away.

A. V. Newton, 1852, No. 14062. He uses a compound called Sidald's metallic compound, composed of tallow, or suet, 1lb., graphite or black lead, 1lb.; charcoal, fine dust, ½lb. He first melts the fat and then mixes. He then adds a gill of oil or gas tar. When using, he warms it first, and then paints the whole inside of boiler, which must also be slightly warmed. Applied to a foul boiler, the incrustation becomes softened and can be sweft off. He says it prevents the formation of new scale, and helps even to the evaporating efficiency. It should be applied once a fortnight.

F. Dam, 1852, No. 14262. He proposed to use hydrate of potash, or soda, which he dissolves in water, forming a saturated solution. He introduces it by a pipe having two cocks (like a grease-cock on a cylinder), or by means of a pump. Or he applies it to water before going in to the boiler. To ascertain the proper amount, he takes a measured quantity and adds some drops of solution as long as it makes a milky cloud. The water is then filtered, and some more solution put in, and if no more precipitation takes place the former quantity is the right one.

W. Danber, 1852, No. 589. This inventor passes all feed-water through a filter. The latter consists of powdered charcoal between surfaces of hair-cloth by preference; first, he precipitates lime by caustic baryta, or soluble salts of baryta, including sulphuret of barium, or else oxalate of ammonia. The filtering apparatus is an iron tank with perforated frames, one inside the other; the spaces are filled with powdered charcoal. For marine or condensing engines he connects the hot well and the filter by means of a pipe for supply of water, and by a small pump he supplies the requisite quantity of solution of baryta to the water as it passes from the hot well. The feed-pumps draw the filtered water off and pump it into the boiler. To say nothing else against this plan, the filter would have to be of enormous dimensions.

A. V. Newton, 1852, No. 1041. He patents a self-acting apparatus for blowing-off, regulated by the density of the sea water itself. A hydrometer floating in the boiler water combined with, and to govern, the motions of an independent mechanism, actuated by a motive force to operate valve and valves which govern discharge of liquid when its density or gravity becomes too great, or *vice versâ*, or the supply of fresh liquid, or *vice versâ*. The hydrometer, by a rather complicated arrangement, acts as a float, the rise and fall of which regulates the opening of the blow-off cock. How this apparatus would fare in a gale of wind, with the vessel pitching and rolling, does not seem to have entered the inventor's mind.

B. Dangerfield and B. Dangerfield, jun., 1853, No. 2596. They employ a concave or cup-like vessel in the interior of the boiler at water line, scum collects in this vessel and is taken off by a pipe at the bottom of same, and thence blown off. This is a very old and well-known plan.

R. Hoyle, 1854, No. 2078. He places a perforated vessel containing bark, or other suitable matter in a cistern partly filled with water, and heated by the waste steam or otherwise. The solution of bark or other matter thus formed is forced into the boiler.

G. J. Bousfield, 1854, No. 2442. The water before entering boiler is subjected to heat by waste steam in a long vessel with mud-holes. The water flows out at one end into a perforated cylinder filled with sawdust, birch twigs, or thorn of broom mixed with wheat bran. Also a lower cylinder of wire cloth or perforated plate containing horse dung. These cylinders or sieves are within a jacket, into which the steam flows and from thence into atmosphere. The water thus heated and filtered flows into a supply vessel with a float to cut off supply of feed-water to the apparatus, and with cocks and valves in such a manner that when the further incoming of the water is stopped in respect to supply vessel, and steam admitted from boiler into supply vessel to equalise the pressure, the water will flow into the boiler.

J. H. Johnson, 1854, No. 2466. Introduction of raw or tanned scraps of hide into the steam generator. For convenience sake a lot is boiled together into a soft mass, and put into the boiler in the shape of a ball, or else scraps of leather enclosed in a bag. It is preferred to use it as a powder.

J. A. Manning, 1855, No. 882. Introduces air pipes to produce currents, and thus prevents incrustation.

E. Topham, 1855, No. 1830. Applies inside near the bottom apparatus for agitating and drawing-off occasionally, a shallow scraper with one or more rods attached for working from outside. At back of boiler at bottom is an opening with a long blow-off pipe perforated at bottom; by moving the scraper to and fro the sediment is loosened and blown out. The holes in pipe collectively must be less than the area through cock; this is mainly important. For sediment too light to be precipitated he has fans that throw the scum into gutters near surface and alongside of boiler, in which lies the perforated pipe.

C. Walker, 1856, No. 340. Uses a scum-collector; a pipe with slots or holes on each side above centre line is supported at each end with its axis at the water level. It has a lever with a float at the end, so that as ebullition goes on the collector oscillates and thus exposes a number of holes for blow-off. The bottom of the tube has no holes, and from that scum is taken off by a pipe dipping into it.

R. B. Lindsay, 1856, No. 879. Applies highly heated steam or air to cause the incrustation to crack, the boiler being cold at the commencement of the process. This method has been tried with great success in the royal navy, and seems to offer great advantages wherever it can be applied.

A. C., L. C. and J. L. Casartelli, 1856, No. 2623. A salinometer consisting of two tubes, the ends of which are supported in two cocks; one cock is marked blow, and the opposite one limit; each tube contains a bead or float adjusted to certain gravities, that in tube "blow" being lightest. When density of water reaches gravity of float in tube blow, the same will rise in tube and indicate that more feed should be admitted, but the float in tube and "limit" will not rise till density exceed that of the other to a certain extent. When float in tube limit rises, water should be fed in to prevent too great density. This instrument may also be used as a water gauge. The above plan is not unlike Seaward's salinometer, patented many years ago.

H. Hobbs and E. Easton, 1857, No. 1316. Solution, or paste, composed of arsenic and soda, or other alkali, when as a liquid it is to be pumped in, and when as a paste laid on with a brush.

Paul Ingiversen, 1857, No. 1415. Burgundy pitch, alone, or mixed, with one-third charcoal or pure soot, to be applied in boiler while heated.

W. E. Newton, 1857, No. 1949. The black gum catechu is employed. To 100-horse power boiler add about $\frac{1}{4}$ lb., and allow to remain till water becomes of the colour of pale brandy; small pieces are added daily to keep it at that colour. No incrustation will then ensue. This, he says, does not choke up.

M. Guillaume Défis, 1857, No. 1976. For a boiler of 200-horse, suitable for a month.

	lb.		lb.
Crystallised salt of soda ..	60	Soot	10
Potass	40	Linseed cakes	20
Plumbago	20	Tanning	60
Ashes of vine branches ..	60	Tallow	20
„ pine wood ..	20	Flour of sulphur	4
„ walnut wood ..	60		

In addition to these, volatile ammonia may be added to remove incrustations. The above are mixed with the sea water in a paste.

J. Hall, 1857, No. 2015. Sediment collector. A series of plates one inside the other, in which are formed apertures or spaces for the passage of the water and sediment into interior of vessel, the apertures are so arranged that the aperture of one plate may alternate with an obstructing piece of metal in the next plate, and thus overcome the agitation of water passing from the boiler before it reaches the interior of the vessel.

J. Sheddon and J. Marsland, 1857, No. 2385. Washing rock soda, or carbonate of soda, or soda ash, or bicarbonate of soda, or compositions of any or either of them, either as a powder or liquid.

A. and J. Martin, 1857, No. 2945. Crystallised carbonate of soda, wood ashes, and plumbago mixed and placed in a separate vessel in connection with the boiler. For a boiler already incrustated they propose to add besides hydrochlorate of ammonia.

E. Coulon, 1858, No. 607. Plumbate and plumbites of potash and soda, and the insoluble salts of lead and chloride of zinc, added to a feed tank or to the boiler itself. He prefers to add a quantity of sand, clay, red ochre, and muriatic acid.

H. A. de Saegher, 1858, No. 888. Dried pitch melted with stearine, or common grease by application of heat; then add wood ashes and ground charcoal, and mix them well by stirring; then cool it and make it up into balls ready for use.

J. Braidwood, 1858, No. 915. A vessel connected near the water level and the bottom of the boiler, the bottom of the vessel being lower than the bottom of the boiler. A current is produced and the water absorbs matter in vessel and precipitates, and is drawn off by a cock from the very bottom of the vessel.

T. Holt and J. Brown, 1859, No. 1042. This patentee uses a feed water heater, which he also uses as a receptacle of mixture for purifying the water; he uses spent tanners' bark, bark knots, &c.

C. F. Vasserot. Extract of chesnut, or any other substance containing gallic and tannic acids.

Brooman, 1859, No. 1824. Leather or waste leather.

J. and R. Blinkhorn, 1859, No. 1833. Animal fat or grease, fullers, earth, soda mixed with neatsfoot or colza oil, night soil, and Nixey's washing powder; 1lb. per twelve hours for an 8-horse power boiler.

M. L. Lorbas, 1859, No. 2884. Amytannate of gelatine, as well as leather.

L. M. Boulard, 1860, No. 938. A case or bag of perforated sheet metal, or wire gauze, or non-metallic gauze, corresponding to the inside shape of the boiler in which it is enclosed, forming a lining, kept at a slight distance from the side by means of brackets. The meshes are finer at the bottom than at the top. The lining may be made in sections. It has been ascertained that this prevents incrustations, and loosened those already formed.

W. Allen and W. Allen, 1860, No. 1696. Ammoniacal liquid obtained from coal or gas tar. For a new boiler he paints it inside with several suits of gas tar.

C. J. Dinnery, 1860, No. 2988. Sediment collector, consisting of a horizontal tube the length of the boiler, or nearly so, with one end communicating with the boiler by a vertical tube entering at or near water level, the other end communicating with the bottom of the boiler near the fire place, by a horizontal pipe. Precipitation by simple gravitation. He says salt does not crystalize till the water is saturated with it, while the sulphate of lime crystalizes at 334 deg. Fah. It is hence easy to separate sulphate of lime, first by passing it through a worm heated to 150 deg., or you may have an apparatus for separating carbonate magnesial salts, a second for sulphate of lime, and the others for the vaporization and extraction of the salt.

R. Armstrong, 1865, No. 1472. His patent consists of a boiler with a vertical circular fire-box, with oval cross tubes, whose longest axes are horizontal in the centre and vertical at the end. He also has a plan for a feed-water heater, consisting of a cast-iron cistern, serving as foundation for boiler, to stand on; and the heat radiating from the furnace heats the feed-water. This case is divided into two unequal parts by a partition, a cross reaching to within half an inch of the cover or lid, which is to have a thick projecting convexity, to dip at least lin.

below surface of water when the larger part is fully charged with feed-water. The water expanding at the surface gradually passes over to top of partition to smaller part; the sediment settles in the larger part. He lines or lags inside of shell with wooden staves, to prevent incrustation.

P. Taylor, 1861, No. 2171. He uses pipes with long slots at the surface of boiler, or at the bottom, or both, extending the whole or greater part of the length, communicating with a discharge valve, that can be opened quickly by studs working in a spiral slot, causing a rush, which he thinks will prevent sediment.

E. H. Hughes. Twenty-five parts by weight of alum, twenty-five parts of salts of soda at 32 deg., two parts of red ochre, three-and-a-half parts of sulphuric acid, fifteen parts of brown fecula of potatoes, and thirty-five parts of distilled water; these are mixed and boiled in a certain way.

A.V. Newton, 1861, No. 2961. Tobacco, as a decoction, or else in a bag.

R. Needham, 1861, No. 3235. A longitudinal pipe at the bottom of boiler connected to a cock or valve outside. The pipe has at the bottom an aperture for entrance of mud and sediment, and at top a number of vertical pipes, each with ventilator-shaped funnel at top of water line, with mouth turning towards front of boiler, the flow of water being from the front to the back.

Grimaldi, 1861, No. 3207. A rotary boiler, which, at one time, caused a very great sensation.

J. H. Johnson, 1862, No. 196. A fluid composed of eight parts by weight of potash of commerce, or carbonate of potash, and from two to eight parts of molasses, added to 100 parts of snails' or slugs' liquor. Also apparatus for injecting the same. He has the feed distributed, so that no very unequal temperature exists anywhere.

J. Webster, 1862, No. 1903. Depositing earth and saline matter by electricity on another surface than the heating surface. He introduces a sheet of copper and a sheet of zinc, and insulates them, as far as metallic contact goes, from the plates of the boiler. It will then be found that all earthy and saline matters will be deposited on the said copper plates. In tubular boilers he uses tubes of copper and zinc in contact, which can be readily removed.

A. Delme, 1862, No. 2257. A composition made entirely of bark of oak and pine, leaves of summach tree ground, and as a powder, a decoction of this condensed in density of about 10 deg., Beaumé, and to it added a quantity of cream of tartar and spirit of turpentine. Three pints are enough for every 1,000 pints in boiler for about ten days.

J. Wilson, 1862, No. 2583. Ground malt and woody fibres; a larger proportion for marine boilers.

J. H. Johnson, 1863, No. 2808. Snail or slug liquor, 100 parts by weight, carbonate of potash eight parts, molasses or treacle two parts, leaves of aloe five parts, animal marrow two parts, extract of tar, at 12 deg. Beaumé, one part; boiled together for two hours, and then thirty strained off, when the liquor will be ready.

G. Spencer, 1863, No. 896. On some convenient part of boiler, in connection with the steam space, a close vessel furnished with a lot of diaphrams or dishes placed one over the other: through the centre or sides of each vessel he brings the feed-water pipe, so that it discharges into the top dish, from which it flows down from one to another through holes or spaces, with raised edges, not quite so deep as raised edges round edge of dish. The whole interior is in contact with steam from boiler. In addition he coats the inside of the vessel and dishes, and the inside of the boiler, with a suitable substance, such as Green's oxide paint, to prevent adhesion of deposited salts to the metal.

W. L. Winans and J. Winans, 1863, No. 1582. In vertical tubular boilers of a peculiar construction is left a space in the midst of the tubes large enough for a man to go down and clean the tubes and the tube-plates. By having a solid body of water in this place they also think the tubes will keep clean.

J. Burrell, 1864 No. 698. A salinometer, consisting of a covered tank divided into two unequal compartments, both connected to water in the boiler. The small one contains distilled water, and the large one brine, continually supplied from boiler by constant circulation. In each is a float, and each float connected to one end of a double-armed lever. The floats are weighted, so that the float in the distilled water rises, if water gets too dense, and *vice versâ*. The rocking weight shaft of lever has another lever, which actuates the scum blow-off cock; when the float in the distilled water rises the cock opens. There is also another float which actuates the feed-cocks. If a column of sea water and a column of distilled water are placed side by side the distilled water will rise one-fourth higher than the level of the brine. When the density of the brine increases the float will rise in distilled water and open the scum-cock. There is a plate of glass in front of each to observe the state of the water.

A. V. Newton, communication from G. T. Parry, Philadelphia. To destroy or prevent incrustation he uses an electrical arrangement tending to neutralise the action which induces this deposit, it having been found by experiment that positive electricity expels or throws off, while negative collects small particles; hence, when, by ebullition or otherwise, positive electricity is liberated or collects in boiler, its action is to throw down particles in the form of crystals or scales. He says he has tried it often, and has found it to answer.

After this brief notice of the more prominent patents it is intended, in conclusion, to mention some of the well-known construction of salinometers; for if it be true, as it seems to be, the prevailing opinion among marine engineers, and as it has been shown in the foregoing that, after all, we must depend more upon blowing-off than anything else to prevent incrustation in marine boilers, then the salinometer deserves more than passing notice. One of the first, in order of time, is that invented twenty-six years ago by the late eminent engineer, Mr. S. Seaward. The instrument consisted of a strong glass tube, about ⅝in. bore and 14in. long, fixed at each end in a brass frame, to which are attached four cocks, one at each end and two at the side; by the two latter cocks the instrument is attached to the front of the boiler at such a height that the water in the boiler may fill the glass tube. On opening the two cocks attached to the boiler the water will rise from the bottom of the same by a pipe from the lower cock and fill the glass; on closing these cocks and opening the upper one two balls are dropped into the tube, the first ball being adjusted to one degree heavier than the water, is intended to be maintained at in the boiler, the second ball one degree lighter; then close the upper cock, leaving the communication with the boiler open. Now if the density of the water should increase beyond the standard adopted the lower ball would rise, and if it should decrease the upper ball would sink. This is a very ingenious but rather delicate instrument, the use of which has now for many years been superseded by other contrivances. The simplest, though crudest, is one, it is believed, still extensively used in many places, and consists simply in a can or measure, sometimes detached from and sometimes attached to the boiler. This vessel is filled with water from the boiler at certain intervals for ascertaining the density; the water is allowed to cool down until a certain temperature is obtained and found by dipping a thermometer into it, and then the hydrometer graduated to that temperature is dipped in, which, by the degree of its immersion, indicates the specific gravity or density of the water. Such an instrument will, of course, fulfil the object of showing the density any time it may be required; but the operation is tedious and requires care, and handling such delicate glass instruments is not exactly the thing in rough weather, when the engineers have many parts of the machinery requiring their constant attention. The next step was the introduction of more practical and complete apparatus, the most commonly known of which is that called How's salinometer. His salinometer case contains a separate compartment for the hydrometer and thermometer, and it is easy enough at any time to let in the water from the boiler so as to fill the case, shutting off the communication with the boiler and blowing-off the surplus water, if any; the density of the water when the ebullition has ceased can be read off. But this ebullition, resulting from the reduced pressure of the atmosphere to which the water in the salinometer case now becomes subjected, causes a quantity of hot water to be thrown out of the case, thus causing the engineer to be scalded; the sudden rush of water from the boiler, if not properly checked by opening the cock very carefully, tends also to throw the hydrometer with great force against the cover, causing the danger of breaking it; nevertheless, this instrument has been and is still extensively used.

A more complete salinometer than the preceding one is the invention of Mr. Long, a chief engineer of the United States navy. The objections to How's salinometer are obviated in this instrument by the addition of another separate tube. This latter contains a smaller internal tube, by means of a cock communicating at the bottom with the water in the boiler, while the top is closed; but having small openings near the upper extremity, through which the water can escape in the outer compartment of the long tube or vessel, the steam at the same time freely disengaging itself. The long casing communicates at the bottom with the salinometer casing, which is fitted with a thermometer and a hydrometer. By this arrangement the rush of the water and the violent ebullitions is checked, and thus the density of the water can be observed without danger and inconvenience. But a more convenient and less cumbersome apparatus has been invented by Mr. Gamble, chief engineer of the steamer City of Norwich, has all the advantages of Long's, while the whole apparatus is contained in one piece, thus offering less obstruction, being more sightly, and taking up less space in the engine-room. This salinometer is now coming extensively into use, being manufactured by Messrs. Hayward, Tyler, and Co., of Whitecross-street. Closing the jam valve occasionally, and then blowing through from the boiler, enables the engineer to clear the supply pipe from any sediment; and this is an important point. The next operation on starting the salinometer afresh is to blow it through, which can be easily done by opening the jam valve and setting the handle of the four-way cock so that a line on the dial plate points straight through from the salinometer to the waste pipe; this helps the salinometer, and allows the water in the supply pipe time to cool down before entering the salinometer. 200 deg. Fah. is the temperature the hydrometer is gauged to. By the regulating screw of the jam valve this can be easily and conveniently obtained, as well as retained. Another great advantage in this practical little instrument, though it may not at first sight appear to amount to much, is the arrangement of the scales. The indications are given outside the brass face of the instrument, where they can be read off instantly. In conclusion, there is no doubt that after all blowing-off in the proper manner is the best means of preserving the boiler; that there cannot be given the engineer facility enough to do so, and that a salinometer possessing the advantages just described, which are fully borne out in practice, forms the best safeguard against the incrustation of marine boilers.

THE DEMOLITIONS AND EMBELLISHMENTS OF PARIS.

Antiquarians who desire to have a look at the last remnants of some of the most celebrated and least savory quarters of Paris must pay an early visit. The clearances for the new hospital of the Hôtel Dieu are sweeping away the rues d'Arcole, Constantine, de la Cité, the quai Napoleon, and the celebrated but wretched street the Rue des Marmousets. The pick-axe has already made its way through the rues Boucher, Etienne, Saint Germain l'Auxerrois, and a number of wretched alleys, for the course of the new street which is to lead direct from the Pont Neuf to the great central market. A great portion of the streets bordering on the Halles, with the heavy pillars of the old colonnade, the sites of the birthplace of Moliére and of the murder of Henry IV., the remnants of the old monastery and cemetery of the Innocents, are giving place to the new buildings which will complete the great market and connect it with the great circular building in which the corn market is held.

The repairs of the church of Notre Dame are nearly completed. All the side chapels are decorated and furnished with stone altars and statues of the saints to whom they are dedicated. In each are placed a crucifix, bronze and gilt candelabra in the style of the fourteenth century, and other emblems and ornaments. The great doors of the northern porch are just completed. In the centre of the parvis, or place in front of the church, is to be erected an ornamental column to replace that which formerly stood there, and from which the distances on the whole of the great roads through the country are measured.

On the south side of the river another great street to be called the Rue de Solférino, is about to be pierced, and the new Boulevard Saint Germain is to be continued to the Palais Bourbon, in which is the Chamber of the Corps Legislatif. These alterations will destroy a large number of celebrated mansions—the hôtel of the family of de Noailles, a fine old house with a noble terrace looking towards the Seine and facing the Louvre; a part of the hôtel of the Duc de Broglie, in the Rue de l'Université; and also that occupied at present by the Popes Nuncio, as well as the whole or a portion of the residences of the families of La Ferté, de Forbin, and de Luynes; the proprietor of the last named, the Duc de Luynes, having had his garden taken for the streets in question, has put up his hotel for sale. On the site of the building now occupied by the Chancellor of the Legion of Honour, it is proposed to erect a palace for the President of the Conseil d'Etat, which will occupy the angle formed by the new Rue de Solférino with the quay.

The London system of erecting places of refuge for pedestrians at the intersections of wide roads and streets is being carried out in various parts of Paris, where such means of safety had become absolutely necessary from the width of the places and the growing increase in the traffic. Many of these refuges are already completed; they consist uniformly of a piece of circular pavement, having in the centre an elegant candelabrum of large size, consisting of a beautiful casting in Florentine bronze, the stem being decorated with ornaments in bas-relief, and supporting five gas lights in elegant oval semi-opaque lanterns, four in a circle and one above; the candelabra stand on circular plinths of the stone of the Jura, between four and five feet in height, ornamented by machinery with bold mouldings and polished. In one place, where occurs the junction of the Boulevards Malesherbes and Haussmann with three streets, there are three of these useful refuges with their beautiful candelabra.

In connection with this subject may be mentioned an undertaking of the Prefect of the Seine, commenced some years since, namely, a collection of all the documents connected with the administration and public works of the city. One of the chief objects of this *bureau historique* is the compilation of a work to be entitled the "Government of Paris and the History of the Prévôté des Marchand," or trade corporation. An introductory volume has been printed, if not published, containing the plans of the work, by Baron Haussmann, and a note from the Emperor felicitating the prefect on his project of producing a general history of Paris.

PARIS UNIVERSAL EXHIBITION OF 1867.

Weights Measures, and Coins.

On the suggestion of the Metric Committee of the British Association for the Advancement of Science, and of the Council of the International Decimal Association, the Imperial Commission for the Paris Universal Exhibition have resolved to have a special exhibition of the measures, weights, and coins of all countries, and to hold conferences at the same time, with a view to the establishment of one common system throughout the world. The two scientific bodies deputed Prof. Leone Levy to proceed to Paris, to meet M. Le Play, the Commissaire-General and after a conference with the commissioners of different countries, called for the purpose, the Minister of State issued the following ordinance on the subject:—

The Imperial Commission, taking into consideration the ordinance of 20th September, 1865, which establishes a Scientific Commission, states:—

The Scientific Commission has for its object to concur in extending the use of useful discoveries, and promote reforms of international importance, such as the adoption of the same weights and measures, common scientific units, &c. Taking into consideration also the propositions of two scientific societies in England,* propositions which include, first, the project of an international exhibition of measures, weights and coins; secondly the project of a conference, to take place in 1867, for the adoption and extension of a uniform system of measures; and considering the adhesion given to the above proposition by a conference held on the 2nd and 14th May, 1866, to consult as to the means for resuming the labours of the special commission formed at the Universal Exhibition of 1855, has decreed as follows:—

Art. 1.—A special place is appropriated in the vestibule of the Palace of the Champ de Mars, to an international exhibition of measures, weights and coins of all countries.

Art. 2.—A special committee on measures, weights, and coins is established in the Scientific Commission to preside over the formation of this exhibition.

Art. 3.—The committee is besides called upon to use the most efficient means for taking advantage of the universal gathering of 1857, for the adoption and extension of a uniform system of measures, weights, and coins.

Art. 4.—To attain this object, the committee will place themselves in correspondence with the persons who have already taken part in the conferences of 1855 and 1866, and the principal persons of all countries whose assistance may be desirable.

The following are nominated members of this committee:—MM. Baudrillard, Member of the Institute, Professor at the Conservatoire des Arts et Métiers; Leone Levi, Professor of Commercial Law at King's College, London, Doctor of Political Economy, and delegate to the two above-mentioned scientific societies; Mathieu, Member of the Institute and of the Bureau des Longitudes; Peligot, Member of the Institute, Professor at the Imperial Conservatoire des Artes et Métiers, and Verifier of the Assays at the Mint.

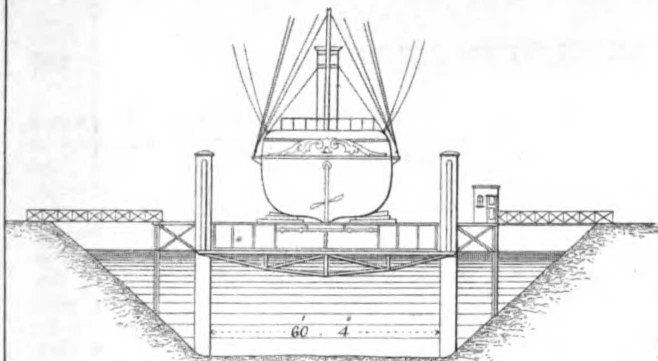
Art. 5.—Other members of the same Committee will afterwards be nominated—persons designated by the foreign commissioners of the states which will contribute to the special exhibition of measures, weights and coins.

Art. 6.—The Conseiller d'Etat Commissiare-Général is charged with the execution of the present ordinance.

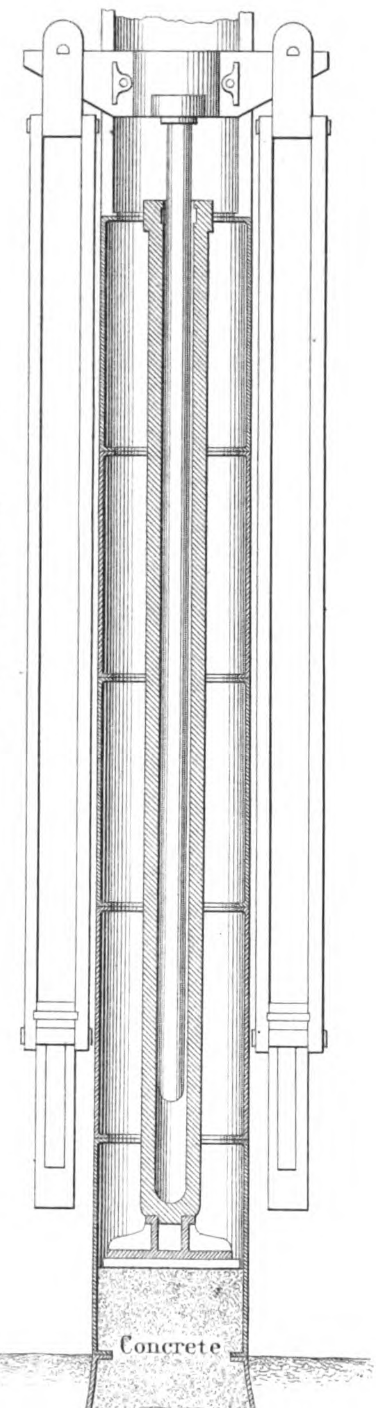
Architectural Competition.—The Architectural Society of Lyons announces a public competition, open to all nations, for a medical college to be erected on the Quay du Prince Impérial in that city. The ground to be occupied does not exceed 6,000 square métres; the plans are to consist of one of the ground floor, one of the upper story, to a scale of five in a thousand, and of an elevation to a scale of one in a hundred. The conditions are to be had on application to the Secretary of the Society, at the Palais des Beaux Arts, Lyons.

---

* Metric Committee of the British Association for the Advancement of Science; International Association for obtaining one uniform Decimal System of Measures, Weights, and Coins.

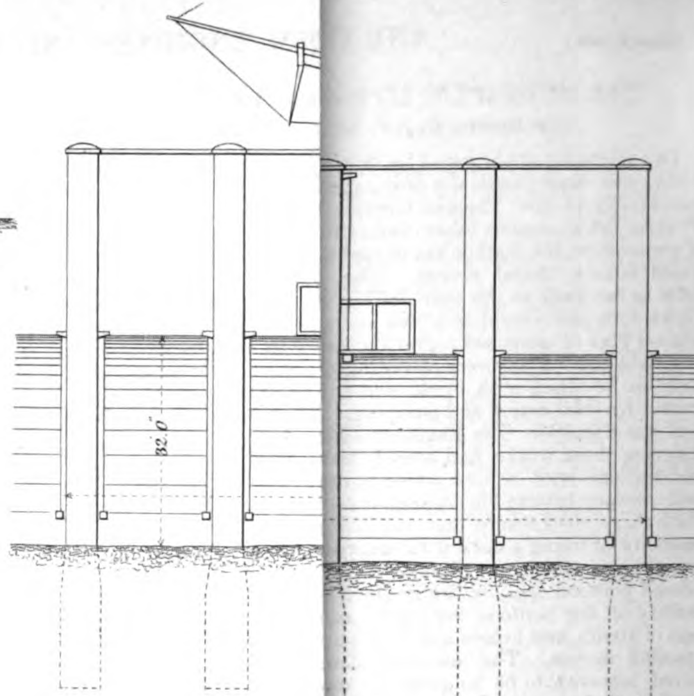


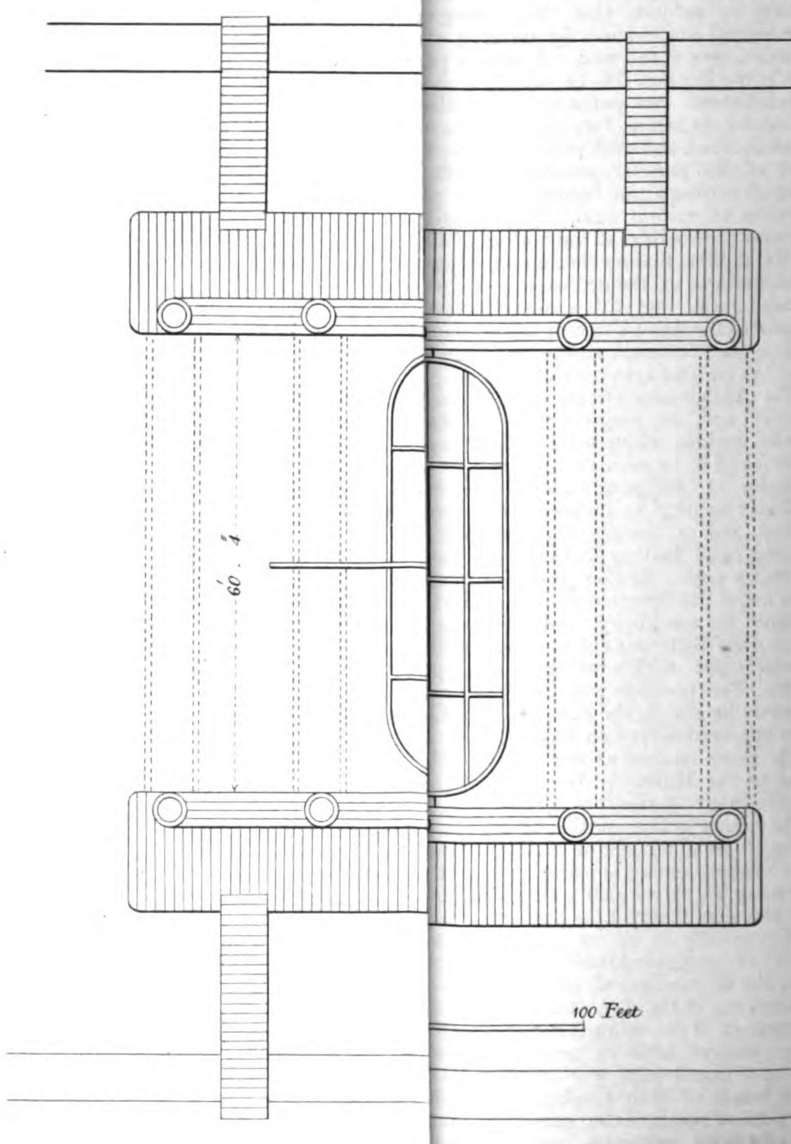
Pontoon raised in Hydraulic Lift.



Vertical Section of Column showing Position of Hydraulic Press

Scale 5 Feet — 1 Inch





THE HYDRAULIC LIFT GRAVING DOCK.

By Edwin Clark, M. Inst. C.E.

The advantages possessed by this system of docking vessels having now been practically demonstrated by long experience at the Works of the Thames Graving Dock Company, in the Victoria Docks, and as other docks on this system are in course of preparation, the Author has thought that a detailed description would form a useful record. The history of the invention dates as far back as the year 1857. At that time, the Victoria Docks were just completed, and it was part of the Engineer's original plan to construct a graving dock as an adjunct to that establishment. Plans were accordingly prepared for an ordinary dock, to be lined with brick, and to be emptied in the usual manner by tidal action and pumping. The estimated cost of the dock was £60,000. The Engineer—Mr. G. P. Bidder—who, in designing these works, had already introduced many important modifications with a view to economy, was anxious to adopt some cheaper system for docking vessels, of that large class for which these docks were laid out. Among other projects, the feasibility of lining a dock with concrete, timber, or with cast or wrought iron plates, was discussed. Mr. Stephenson suggested a closed pontoon dock, in which the horizontal position and the stability of the pontoon were to be maintained by an arrangement of struts and braces attached to the ground, and forming a parallel motion. The necessary dimensions of these struts, proved, however, to be so great, on account of their excessive length, and the great strain to which, in certain positions, they would be subject, that this arrangement, as well as other mechanical contrivances for securing stability with a submerged pontoon, was abandoned. A similar plan has since been carried out in the London Docks, where a dock on this principle was erected about two years ago. On the first attempt, however, to exhibit its action, fortunately without any vessel upon it, the pontoon filled and sank in about 22 feet of water. Some of the rods of the parallel gearing beneath having given way, and pierced through the bottom of the pontoon, it was found impossible to raise it again by pumping out the water; and it remains to this day, at the bottom of the London Docks.

Mr. Bidder, finding that no economy could be effected by any modifications of the ordinary dock, turned his attention to a floating dock; and with a view to preparing the necessary plans, requested the Author to visit the principal dockyards in England, and on the Continent, and to make himself generally acquainted with the various systems then in use.

The Author accordingly gave considerable attention to the subject, and, in conjunction with Mr. Stephenson and Mr. Bidder, various schemes for floating docks were discussed. All were found to be more or less objectionable; partly, from the difficulty of designing such large floating structures with sufficient rigidity to preserve their form under very variable strains, and to ensure that stability of flotation which was wanting in all floating docks then in use; and partly, from their enormous cost. At this juncture, it occurred to the Author, who, under the direction of Mr. Robert Stephenson, had lately designed the machinery, and superintended the raising of the tubes of the Britannia and Conway tubular bridges, that a similar process might, with advantage, be applied to the docking of a vessel. The problem was simply to raise a given weight to a moderate height, in the most rapid and economical manner, and there appeared no reason why a vessel should not be dealt with in the same manner as any other load. The weight actually lifted at the Britannia Bridge, with only three presses, was equal to that of a vessel of 1,800 tons.

The steady action of the hydraulic press, its extreme simplicity, its small amount of friction, as well as its great durability and economy, render it pre-eminently the best available power for raising heavy weights with low velocity. It is, indeed, more than probable, that had the problem of raising a vessel presented itself originally in all its present magnitude, no other power would have suggested itself; but the progress of dock improvement, like all mechanical progress, naturally kept pace with the requirements of the day, and as ships became larger a simple enlargement of the original rude method was the natural result.

The earliest kind of graving docks is illustrated by the practice of the Greeks, who ran their triremes aground on the sandy beach of their tideless sea, and then, dragging them bodily out of reach of the water, surrounded them with earthworks for their protection; an "arsenal" was thus improvised wherever required. A natural improvement, where the ground was suitable, was to prepare an inclined plane of timber to facilitate the operation. Where the tides were available, the vessels were simply beached at high water during spring tides, and there left high and dry till the following springs. The "Great Eastern" was docked in this manner in Milford Haven. In situations, however, where the formation of the beach allowed of it, a convenient bed or "grave" was dug for receiving the vessel during high water at springs, such excavation being protected from the ingress of the water at the following springs, by an artificial bank thrown up in the interval. This was the first Graving Dock. A similar dock is at the present day in use at Hong Kong, the mud bank being protected by basket fascine work. It is remarkable, that not only do all these expedients continue in their original form, but the principles involved have in no way been departed from; and a modern first-class graving dock, even now, differs in nothing, but its dimensions and details of construction from these first models.

The ordinary Dry Dock, at present in use, in tidal rivers, is generally a simple excavation, lined with timber, usually with a brick, or concrete floor, and, to exclude the tide is furnished with a gate, or floating pontoon—first introduced by General Bentham at Portsmouth dockyard. The vessel enters at high water; the entrance is then closed, and as the tide goes down, the dock empties itself through a tidal sluice, and the vessel settles down on the blocks prepared for it, being at the same time shored horizontally, to prevent its heeling over. The sluice being closed, the returning tide is excluded by the gate, and with a little pumping to keep down the leakage, the vessel is kept dry enough for access. In a tideless sea, a graving dock is precisely similar, except that the whole of the water has necessarily to be pumped out. As vessels increased in dimensions, these docks became important works. They were lined with solid masonry, the sides being constructed with steps, technically called altars, for the double purpose of affording convenient access and also for the support of the necessary struts for shoring. Pumping machinery on a large scale was added for rapidly exhausting the water, or for rendering the operation independent of tides, and a large amount of engineering skill of the highest order was displayed in improving all the details.

The following are the dimensions of one of these works, just completed at Portsmouth, sufficiently large for docking the "Minotaur," a vessel of 6,621 tons.

	Feet.	In.
Length of floor	400	0
Ditto at coping	426	0
Width at floor	35	0
Ditto at broad altar	75	9
Ditto at coping	99	0
Depth from coping to floor	33	10
Depth at H.W. springs at midships	28	4

The materials used were—

Granite to the level of the broad altar, 18 feet above the floor	135,000 cubic feet
Portland stone	26,750 "
Bricks	3,750,000 "
Concrete	135,000 "
Timber	81,000 "
Excavation	57,000 cubic yards

The inclined plane, or slip, has also received its share of improvement. In situations where the foreshore is favourable, it is peculiarly applicable for small vessels, on account of its economy. The hydraulic press has been used advantageously as a hauling power, and great improvements have been introduced in constructing the cradles and other accessories. The difficulty, however, of berthing large vessels, and the strains to which they must be liable in being dragged up an inclined rigid plane, on separate and independent frames, supported on wheels, would be a bar to its use for large vessels, if other mechanical difficulties could be overcome. No slip has hitherto been constructed for large ships, and the difficulty experienced in moving the "Great Eastern" down an inclined plane, is a fair illustration of that which would have to be encountered in dragging it up.

It will be seen from what has been stated, that a graving dock of large dimensions is, necessarily, a costly work. It must be accessible by a deep channel, and must therefore be adjacent to deep water. In a gravelly soil, or in rock penetrated by fissures, the difficulties sometimes are nearly insurmountable.

A stone dock in such situations not only requires to be as water-tight as a floating dock drawing the same depth, but must be of sufficient weight to remain sunk. This involves in its construction a large amount of material, and the greatest nicety of workmanship; while, even in favourable circumstances, the entrance, with its deep cill and masonry walls, is always a costly work. It was, doubtless, the great cost of such docks, as well as the impracticability of making them at all in some situations, which led to the use of floating docks.

Floating docks were originally built of timber and of moderate size; but the introduction of iron for shipbuilding added not only to the increased want of dock accommodation, from the frequency with which iron vessels require painting, but it also rendered more practicable the construction of floating docks of large dimensions. A dock of the earlier description was in use in the harbour of Marseilles, and was visited by the Author. It consisted of a timber pontoon with one end moveable; the sides being high enough to remain above water when the floor was sunk sufficiently deep to allow a vessel to float bodily into the interior of the pontoon. In this position, the pontoon was kept afloat by the buoyancy of the sides, which consisted of hollow boxes caulked water-tight, the vessel being properly secured immediately over the blocks prepared for it. The open end was closed by a moveable gate, and on pumping out the water, the pontoon rose with the vessel within it, which thus became accessible for repair.

An arrangement was also in use in which the boxed sides were dispensed with, by sinking the pontoon on to a prepared platform, the sides being still high enough to reach above the water level.

The same principles were applied to docks of large dimensions, constructed of wrought-iron, and furnished with pumping machinery of the most elaborate character.

In America the system attained farther development, there being timber docks on this principle at New York, Charleston, Savannah, Mobile, New Orleans, Portsmouth, and Pensacola. Mr. Stuart, who gives a full description of these works,* states, that the American Government attributed great importance to possessing the means of laying up their vessels of war out of the water, and under cover, on account of the rapid decay to which the ships were subject when afloat. They were also anxious to obviate the danger to which large vessels were exposed of being strained in the operation of launching.

To meet these views the docks at Portsmouth and Pensacola are so arranged that, after a vessel is placed on the pontoon, it may be hauled ashore on its cradle, on bedways prepared for the purpose. To effect this, the pontoon is grounded in a shallow basin on a platform constructed for it; the ways on the pontoon are thus brought on a level with the ways on shore, and the vessel is drawn ashore by a hydraulic press. Several vessels may thus be placed on the ways, or be launched with a single pontoon. The dimensions of the dock at Pensacola are:—

	Feet.	In.
Length	350	0
Breadth	105	4
Depth	38	3

The total cost was—

Floating dock	£111,140
Basin and subways	70,645
Floating gate	2,600
	£184,385

The transverse floor girders are effectively trussed. Water-tight bulkheads are introduced, both in the floor and side chambers, and the water is pumped out by two 20 H.P. engines and eighty wooden pumps, placed on the sides of the dock. It was completed in 1851.

There is yet another form in use at San Francisco and Philadelphia, known as the floating sectional dock. The pontoon, instead of being entire, is constructed in separate and independent transverse sections, called "camels," any number of which may be used according to the size of the vessel to be docked. The camels are rectangular in form, and are completely submerged, to allow the vessel to float over the keel-blocks placed upon their decks. In order to secure stability in their submerged state, they carry at each end a detached floating chamber, capable of being raised or depressed, by appropriate gearing placed in framed timber towers attached to the ends of the pontoons. As the whole is timber, the camels remain afloat even when filled, and are sunk to the required depth by raising the floating chambers, their additional weight being sufficient to sink the sections, and to maintain their stability at the same time. The water is pumped out of the camels till the vessel rests on them. They are then grounded in a basin prepared for the purpose, and the vessel hauled ashore as before.

* *Vide* "The Naval Dry Docks of the United States."

The Philadelphia Dock has nine sections, each 32 feet wide, 105 feet long, and drawing 10 feet of water with a large vessel upon them. When used together, they form a dock 300 feet long, and 105 feet wide. Their total displacement is 5,800 tons, and the cost was £170,000. They are emptied by two 20 H.P., and two 12 H.P. engines, working three pumps at each end of each section, with moveable shafting.

Floating docks are necessarily limited in their use, not only by their enormous cost in construction and manipulation, but also by their great liability to accident from the slightest mismanagement. The raising of a vessel on such a machine as that just described is really a difficult engineering operation in itself. The dock at San Francisco was seriously damaged, and Her Majesty's ship "Termagant" nearly capsized, in a recent attempt to place it on the camels.

The loss of the floating dock in the London Docks has been described, and a similar action happened to that made for Sourabaya, Java. A large dock, erected at Rio Janeiro, was found utterly unmanageable, and was never used at all. The fatal disaster which occurred with the dock at Callao will be fresh in the minds of members, and indeed the history of a large number of these docks is notoriously a history of failures or disasters.

The Thames Graving Docks.

It was with a view of meeting, as far as possible, the objections to existing systems, that the Author proposed the Hydraulic Lift Graving Dock as the most efficient and economical substitute for the requirements of the Victoria Docks.

It was ultimately constructed by a totally independent company under the "The Thames Graving Dock Company." The necessary capital, originally £105,000, was raised in shares of £1,000 each, and was privately subscribed,

The site selected was a plot of 26 acres of level land, lying between the Victoria Docks and the Thames, and below the level of high water. This site admitted of a direct entrance from the Docks, with a permanent water level, without the cost and delay of a special entrance from the river. The soil is a deep bed of bog and alluvial mud, on a substratum of gravel. The only excavation necessary was the lift pit, and its deep entrance to the dock, where a cofferdam was employed.

The depth of water in the lift is 27 feet; over the remaining water space it is only 6 feet, which is the maximum draught of the pontoons. In this shallow water space there are eight pontoon berths, separated by jetties for workshops and access; each birth being 60 feet wide, and from 300 feet to 400 feet long and surrounded by brick-retaining walls. The bottom was covered with a level layer of peat clay, to prevent leakage to the gravel beneath. A sluice through the surrounding bank renders it easy, at low water, to empty the whole of the space; but when this is done, a dam must necessarily be thrown across the upper end of the Dock, to cut off the access to the Victoria Docks. The area of shallow water is 16 acres, affording sufficient space for floating fifteen or twenty pontoons, which, it was estimated, was about the number that might be kept employed by a single lift.

The docking of a vessel consist of two distinct operations. First, the direct raising of the weight on the lift; second, the transportation of the vessel to any convenient position for its repair on the pontoon.

The lift is a direct mechanical appliance for raising the vessel by means of hydraulic presses. It consists of two rows of cast iron columns, each 5 feet in diameter at the base, and 4 feet in diameter above the ground-level, and sunk about 12 feet in the ground. The clear space between the two rows is 60 feet, and the columns are 20 feet apart from centre to centre, and are placed on each side of the excavated lift pit, in about 27 feet of water. There are sixteen columns in each row, giving a length of 310 feet to the Dock; but, as vessels may overhang at each end, there is a practical working length of 350 feet. The columns were sunk in the usual manner, three or four being thus fixed per week. When the requisite depth was attained, the base was filled with concrete, and covered with a layer of 2 inch planks, to act as a cushion for the cast iron seat on which the press rests. No great accuracy of position is required, as the suspended load tends to bring all the columns verticle, and if any column should, during use, be even sensibly thrust deeper into the soil, the ram follows its work, independent of the level of the press. The columns support no weight; but act solely as guides for the cross heads of the presses, which move in slots reaching from the top of the presses (just clear of high water) to the top of the columns. The column is covered by a cap, and each row is firmly connected together at the top by a wrought-iron framed platform, running from end to end of the Dock on each side. This platform forms a convenient permanent scaffold for raising the rams. The whole length of a column is 68 feet 6 inches. A scale is printed on each column to register the motion of the cross heads while rising or falling.

The presses and girders are managed as follows:—Each column encloses a hydraulic press of 10 inches diameter, with a length of stroke of 25 feet; the top of the press is just clear of the highest water, and it is kept in place by a collar or diaphram in the column. The rams are solid, and each carries a boiler plate cross head 7 feet 6 inches long, thus extending 1 foot 9 inches beyond the column on each side. From the ends of the cross head are suspended, by wrought iron bars, two iron girders each 65 feet long, which extend entirely across the Dock to the corresponding column and press on the opposite side. There are thus sixteen pairs of suspended girders, lying at the bottom in 27 feet of water, when the presses are lowered, but rising above the surface, when the presses are raised. They form a large wrought-iron platform, or gridiron, which can be raised or lowered at pleasure, with a vessel upon it. The detail of the machinery is identical with that employed at the Conway Tubular Bridge; and those who saw that bridge raised have only to imagine thirty-two tubes side by side instead of two, and they will have a perfect representation of the lift. The main girders are 5 feet 9 inches deep, of wrought-iron trussed with a cast iron top flange. The sectional area of each ram being 100 circular inches, a pressure of 2 tons per circular inch gives 200 tons as the lifting power of each press, or 6,400 tons for the whole lift; but to find the available lifting power, there must be deducted 620 tons, which is the weight of the rams, cross head, chains, and girders, leaving 5,780 tons for the pontoon and vessel. The presses were tested at $2\frac{1}{2}$ tons per circular inch. The girders are designed for carrying the vessel as a load at the centre, although the load is distributed by the pontoon, and the wide base used for the blocks. The water is forced into the presses immediately beneath the collars at the top, this being an accessible position.

The grouping of the presses was an important consideration. If each press were worked entirely independent of its neighbours, it is evident that precisely the same quantity of water must be thrown into each press to avoid unequal strain. Again, if the whole number were supplied from a common head, the slightest excess of weight at any part of the platform or gridiron would lower that part, the water passing back through the pipes to the presses where less pressure existed; the same difficulty would be experienced with two groups, however arranged. Stability is, however, secured by arranging the presses in three groups. One half of the whole number, occupying the upper half of the lift form one group, consisting of sixteen presses. The remaining eight presses on one side form a second group, and the opposite eight form the third group.

The presses in each group are all connected, so that perfect uniformity of pressure is secured in each as regards the individual presses; while the three groups are so arranged that their centres of action form a tripod support, upon which the pontoon is seated. As any one point of the tripod may be raised or lowered without regard to the other two, by the most simple manipulation, the pontoon can be either maintained perfectly level or any inclination can be given to it that may be desired.

Any pair of presses may be instantly cut off in the valve room by means of a plug during the operation of lifting, without interrupting the process. One or more of the end pairs is almost invariably out of use, except with vessels of the largest class. No delay, therefore, arises from the failure of a collar or pipe, and even should a press burst—which appears an impossible contingency—the water can only escape slowly through the half-inch pipe which feeds it; and by opening the escape valves in the other groups, vessels, partially raised, descend slowly and steadily into the water.

Additional provision against such a contingency has been provided, by an arrangement which gives instantaneous means, in the valve-house of isolating every press from the rest. For this purpose, a special series of valves is provided for each group, which can be closed simultaneously, by means of an eccentric shaft. This arrangement, which forms so prominent an object in the valve-house, has been found unnecessary, and will not be again employed. The force-pumps are $1\frac{7}{8}$ inch in diameter. There are twelve pumps, worked by direct action by a 50 H.P. engine; six of these pumps are used for the large group, and three pumps for each of the smaller groups. The power when required is increased by cutting off one or more of the pumps. The engine-house is, unfortunately, 112 yards from the lift, the water having to be driven all this distance through pipes only $\frac{1}{2}$ inch in diameter. On account of the distance of the engine, a valve-house, for the manipulation of the presses, is erected on the platform alongside the Dock. During an operation the engine continues to pump, and the valveman throws the water into either group, or to waste, at pleasure. The raising of a vessel occupies about twenty-five minutes. The pipes and presses are, to a considerable extent, sheltered from frost by their position; and during the severest cold, a few occasional strokes of the engine are found sufficient to keep all in motion, and prevent congelation.

The pontoons are not essential for raising, or docking a single vessel, for it is evident that the lift, as described, is all that is required for that purpose. The girders might be connected together by other longitudinal girders, so as to form a sufficiently rigid platform, or the whole might be formed into a pontoon, which would support a vessel after it was raised. Such an arrangement would be more economical and convenient than any ordinary dock, but it would accommodate only a single vessel; whereas, by the use of separate pontoons, an indefinite number of vesels may be placed afloat, whilst the most costly part of the system remains constantly available.

The following is the arrangement adopted:—An open pontoon, proportioned to the size of the vessel to be docked, is selected. Keel-blocks snd sliding bilge-blocks, adapted to her shape, form part of the pontoon, which is placed on the girders, and sunk with them to the bottom of the dock. The vessel is brought between the columns, and moored securely over the centre of the pontoon. By lifting the girders, the keel-blocks are first brought to bear under the keel of the vessel; the side-blocks are then hauled in, by chains laid for the purpose on each side the dock, and the gridiron and the pontoon, with the vessel upon it, are then all raised by the presses clear of the water. The pontoon is provided with valves in the bottom, and thus empties itself of water. The valves are closed, and the girders again lowered to the bottom, but the pontoon, with the vessel upon it, remains afloat. Thus, in about thirty minutes, a vessel, drawing 18 feet of water, is left afloat on a shallow pontoon drawing 4 feet or 6 feet, and may be taken into the shallow dock prepared for its reception. These docks are surrounded by workshops and tools, with shelter for the men close up to the bulwarks of the ship. The vessel is, in fact, brought bodily into the centre of a convenient workshop. It is taken to the smiths', or the carpenters', or the machine shops, according to the nature of the repairs required, and is moved easily from one to the other.

The number of vessels that can be thus docked is limited only by the number of pontoons, each pontoon constituting a separate and independent dock. The pontoons, which are all about 58 feet wide, vary in length and depth according to the class of vessel intended to be docked, and are rectangular in form, and open decked. The sides are vertical, and are strengthened longitudinally and transversely by wrought-iron girders, running from side to side, and from end to end, and thus forming a series of rectangular divisions. The pontoons are divided into water-tight compartments, by means of bulkheads formed of the girders, each compartment being provided with a circular valve in the bottom, closed by a screw-shaft. The transverse girders are 8 feet apart, and support the bilge-blocks on their upper flanges. In the largest pontoons these girders form inclined planes, declining in height towards the centre, to facilitate the running-in of the block-frames. There is a strong longitudinal centre girder, with a broad top flange, for supporting the keel-blocks; on each side, the two other longitudinal girders are placed equally distant, and in the line of the side blocks. There are seven pontoons at present in use, their dimensions being given in the following table:—

No.	Length.	Depth.		Net Tonnage.	Cost.
Feet.	Feet.	Feet.	Inches.	Tons.	£.
1*	241	6	2	1,750	5,130
2	241	5	6	1,650	6,086
3	201	5	6	1,450	5,725
4	201	5	6	1,450	5,683
5	157	5	0	1,100	4,100
6	134	5	0	930	3,600
7	321	7	0	3,000	10,853
		Partly constructed.			
8	281	7	0	2,450	...

The cost of the lift and other machinery was :—	£.
The lift complete and fixed, including columns, presses, girders, and pipes	20,300
The 50 H.P. condensing engine and pumps, boilers and connections, including the valve arrangement (not a necessary part of the apparatus)	3,600
The connecting pipes, including all testing, fitting, and fixing, supply of workshop tools, experiments, &c.	1,628

It may be remarked that, a high-pressure engine would be more convenient, and far more economical.

There are, doubtless, many details which may be materially improved after seven years' experience; but it is a proof of the simple character of the machinery, that no modification, or renewal, or repair of any kind has been necessary, although, at the end of last year 1,055 vessels had been lifted, of an aggregate tonnage of 712,380 tons, without a single casualty.

No remark is necessary on the calculations employed in so simple a machine. The area of each pump being 3¼ circular inches, their aggregate area is 42 circular inches. Similarly, the aggregate area of the thirty-two presses is 3,200 circular inches. The action, disregarding friction, is therefore identical with that of a lever, whose arms are respectively 42 and 3,200. The respective velocities and pressures are thus obtained by direct proportion, the power being a 50 H.P. engine on the long end of the lever, and the weight lifted being the vessel on the short end; while it may be remarked that, in a stone dock, the power employed bears no proportion to the work done, and is always immensely greater.

As regards the advantages of this pontoon, it will be seen that it differs, in many respects, from an ordinary pontoon. In the first place, it is open without a deck; the sides are no higher than is required for the load; it is not incumbered with any pumps, or machinery, or inaccessible chambers; when submerged, its stability is ensured by the presses, and, when afloat, its form gives it the greatest amount of stability possible; while the simplicity of its construction renders the cost extremely moderate. The durability may be estimated from the fact, that the effect of seven years' wear and tear is imperceptible, although, during all that period, the pontoons have never been repainted.

The pontoon affords special facilities for blocking vessels, and for access to them when blocked. This arises from the clear space which the open deck of the pontoon affords for blocks and scaffolding, and from the fact, that the keel of the vessel is everywhere accessible, on account of the deep space beneath it. This peculiarity has been found of great value, since the renewal of a keel, in an ordinary dock, is a work of great difficulty. There is, however, no feature of greater importance than the absolute freedom from strain afforded by the partial elasticity of the pontoon, and the means of balancing it by admitting water. To appreciate this, it must be borne in mind that the object in supporting a vessel out of water should evidently be to replace, as precisely as possible, the pressure which the water affords, when she is afloat. It is in this respect, that a stone dock is so deficient, and the effect on large vessel so notorious. An iron-clad vessel weighs about 20 tons per foot run; but, if divided into a series of transverse sections, the support at every section will be equivalent to the displacement of that section. At the centre of the vessel, where the bulk is large, it will be much greater than at the bow and stern; but when supported on the rigid floor of a stone dock, the stiffness distributes the weight nearly uniformly, over the whole length of the keel. Looking at the ship, then, as a girder, and the buoyancy, or the supports, as loads laid on, the girder is evidently, in the two cases, subjected to totally different strains. The superior buoyancy of the centre of a vessel frequently shows itself by the hog-back form it assumes, or by the wrinkling of the copper, and, in an ordinary dock, this last appearance, not unfrequently, indicates the strain to which vessels are subjected.

Again, the bottom of a stone dock is a narrow floor prepared for the keel-blocks, with no means of support under the sides of the vessel, where the whole weight is concentrated. As the water is lowered, the vessel rests at first solely on the keel, and the enormous and injurious strains, thus thrown on the ribs of an iron-plated vessel, may be imagined. Indeed, no greater departure from the support previously afforded by the water can be conceived. It is true, that the forest of struts always placed between the vessel and the altars on each side, do, to a great extent, replace the horizontal pressure of the water, by tending to keep the sides together; and without such support no vessel could be so docked at all, But the Author need not point out to Engineers, that in dealing with a weight of 20 tons per foot run, no vertical support of any value can be obtained by struts, which must of necessity be nearly horizontal, and which, when slightly inclined, have been known to disturb the solid masonry steps of the dock itself. As soon as the water is pumped out of the dock, proper shores are added under the bilges, but the mischief is then done, and the quantity of timber consumed in these blocks and shores is, alone, an item of cost many times greater than the whole expense of docking such a vessel on the permanent blocks of a pontoon. The whole current cost of the latter operation, including preparation of blocks, coals and staff, does not average £3 per vessel, in the Thames Graving Docks; and it is performed as follows:—

The permanent keel and bilge blocks are first packed up with reference to the form of the vessel, and secured together with "dogs." The bilge blocks move on sliding frames, and as soon as the keel touches the pontoon, the frames are drawn by chains down the channels prepared for them, and are thus made to abut solidly against the ship in a position nearly vertically beneath the sides: a ratchet prevents their return. The vessel is thus fully blocked before being lifted, and, when lowered again and left afloat, the elasticity of the pontoon secures an equable bearing on each block, and prevents any block doing more work than its neighbours. The vessel is supported at numerous points, by pressures analogous to the pressure from the water itself: it is also resting on a base 30 feet, or 40 feet wide, so that without shores its stability is beyond all question.

Again, the support is rendered proportionate to the displacement, by admitting water into the compartments, as in the American Floating Dock; thus any excess of pressure shown by the blocks is immediately remedied. When the pontoon is longer than the vessel, the end compartments are invariably left open, and only that portion of the buoyancy of the pontoon is retained which the circumstances require.

The stiffness of a pontoon depends on its depth. The amount of longitudinal stiffness necessary for a pontoon when afloat is very small; for, if the balancing by means of the water is properly regulated, no strain is thrown on the vessel from deficient rigidity. It is indeed evident, that if a pontoon were perfectly elastic, and became a mere sheet of india-rubber, that the strain would be absolutely identical with the strain in the water. It is however advisable that the strength of the pontoon, laterally, should be nearly sufficient for supporting a vessel resting entirely on the keel-blocks, as the bilge-blocks are necessarily removable. It is also necessary to retain a considerable amount of longitudinal strength, on account of the uniform character of the lifting force; this is, however, modified by cutting off one or more pair of intermediate presses; and in docks which are now in preparation, the presses are not placed at equal distances, but nearer together at the centre of the lift than at the ends. The same result may be obtained by slightly increasing the area of the centre presses. The whole subject of blocking is full of practical interest, and nothing will excite more attention, in a visit to the Docks, than the extreme facility with which the operation is performed,

* No. 1 pontoon was framed with wood in its outer compartments, and only built 5 feet high, the waling being afterwards added.

and the ease with which a single operator appears to handle these, apparently, unwieldy structures.

It is unnecessary to dwell on the subject of the stability of the pontoon itself when afloat: the author would only observe, as the result of calculation, that the effect of a gale of 20lbs. pressure per square foot on the broadside of a frigate, with every sail set perpendicular to the pressure, would be an extra immersion of only 5 inches on the lee side of a pontoon. In practice, no gale ever produces any appreciable motion whatever.

Although, however, the tilting effect is inappreciable, yet during a gale of wind the navigation of a vessel, on the deck of a pontoon, requires proper caution. This was illustrated by a singular accident, which occurred during the great gales of 1860. A vessel, which had been repaired, was being towed by an 8-inch hawser across the open dock during the height of the storm; the rope gave way, and the pontoon, with the vessel upon it, drifted, with rapidly increasing velocity, entirely across the dock, when it came in contact with two empty pontoons, lying alongside the jetty. The immediate effect was to stave in one of the compartments, which filled, and the pontoon rebounded back some distance into the dock; the wind, however, catching it a second time, it again struck the pontoons and unfortunately staved in a second compartment, and sank. The vessel, however, remained upright and uninjured on the blocks. The operation of floating it again was characteristic of some of the advantages of the system. A low dam was placed across the upper end of the dock, in the shallow water, and a few feet of water were run out of the dock, by means of the sluice. This was sufficient to expose the side of the pontoon above the water, the damaged plates were then made tight with clay, and on pumping out the remaining water in the pontoon, it was left afloat again, and placed on the lift till it was repaired.

As to the practicability of enlarging the system to meet the requirements of vessels of any size, it is evident that by simply placing an additional column between every existing column in the present lift, the lifting power would be doubled, or made 6,400 tons, without altering the strain of a single bolt. The same result might be obtained by placing two presses in each column, and this was the form adopted in the designs prepared, by order of the Lords of the Admiralty, for vessels like the "Minotaur." The lifting power may further be indefinitely increased by enlarging the area of the presses, and no mechanical difficulty would be experienced, with even ten times the weight alluded to.

Again, the weight that could be lifted may be doubled, without any alteration of the presses, by using a close-decked pontoon instead of an open one. An additional lifting power equal to the displacement of the pontoon would be thus obtained by pumping out the water: the presses would ensure the necessary stability and complete the operation. A dock in this form was also designed for the Admiralty on their official request; but it is evident, no advantage could result from the substitution of the pontoon as a partial lifting power: it is, in any form, a far more costly arrangement, and its combination with the presses removes none of its disadvantages.

Although no doubt can exist as to the capability of the lift to deal with any required weight, the Author feels bound to state, that some doubts have been expressed as to the expediency of docking vessels of the largest class on a pontoon without the ordinary horizontal shoring, which forms so prominent a feature in an ordinary dock, and which would be naturally abandoned with reluctance by an old shipwright. There are, moreover, some localities where the docking of the largest class of vessels is so rarely required, that the cost of a special pontoon is scarcely warranted: an arrangement has accordingly been perfected which will fully meet these requirements. Altars or steps might undoubtedly be placed on a pontoon; but to secure an efficient base, a considerable increase of width would be necessary, as well on the pontoon as in the main girders of the dock. The requisite base may, however, be obtained by projecting the lifting girders beyond the columns, on each side of the dock. It is further proposed to combine them by longitudinal girders, and then, by close plating the whole externally, to convert the platform or gridiron into a water-tight pontoon, with framed altars on each side, of sufficient height to remain above water when the pontoon is sunk. The presses would then lift an entire floating dock, of the ordinary form, which, when raised, would remain afloat, independent of the presses, but be capable of being moved from its fixed position.

Smaller pontoons might be used in the ordinary manner, by lifting them on the top of this fixed pontoon. This would afford efficient means of shoring in the ordinary way, and effect some economy as regards the construction of an independent large pontoon; inasmuch as the main girders of the dock would take the place of the transverse girders that would be required for the pontoon. This arrangement is specially applicable to places where only a single dock is required.

Numberless other modifications suggest themselves. The pontoon may be used in any ordinary dock, or in a tide-way where the rise and fall is sufficient, without a lift at all. The tide may also be made available in diminishing the stroke of the presses to the extent of its rise. The lift may be erected in any open channel where there is sufficient shelter, and whatever be the character of the soil—the only limit to its application is in places where the depth is too great for fixed columns; but even for these situations a modification has been devised by Mr. W. H. Walker, which possesses great merit. This gentleman proposes to float the presses themselves, on a series of pontoons, employing machinery very similar, in many respects, to that described. The dock thus becomes a moveable floating dock, capable of being moored anywhere, and of its position being changed when desirable. It is also very portable in its parts.

In conclusion, it must be admitted that however successful this system may have proved in a mechanical point of view, its early history was characterized by complete want of commercial success. The first misfortune, which befel the Company at starting, was the irreparable loss of its Chairman, the late Mr. R. Stephenson. The Company had commenced with insufficient capital, and before completing their works, they found themselves deprived of the master mind, on which they were so much accustomed to rely. They possessed no large pontoons; and it was originally intended to rely solely on the dues from docking as a means of revenue; they were surrounded by numerous competitors, on each side the Thames; and to such an extent was competition carried, that the docking of vessels was, for a long time, performed in the Port of London without any charge whatever being made for dues. As the officers of the Company were restrained, by strict instructions —issued by the direction of the leading proprietors—from undertaking repairs, or entering into any mercantile arrangement, they were helpless. And it was seldom that even half the amount of the intended charge for docking a vessel could be obtained, though that charge was only 6d. a ton for the lifting, and 2d. per ton per day for the use of the pontoon. It then became evident that the only alternative was for the Company to entirely change their system of business; to become themselves manufacturers, and to do all repairs, &c. The immediate result has been successful beyond expectation. The Company now possess one of the most perfect and extensive ship-repairing yards in the kingdom, with spacious workshops, and abundant machinery for every class of work. The weekly payments, for labour only, reach £1,000, and although they now possess seven pontoons, equivalent to seven distinct graving docks, yet, to meet the increasing requirements of their trade, others are being constructed. The number of vessels that resort to the establishment is increasing, and among them are included some of the largest vessels that frequent the Port of London.

The principal features of the system may be conveniently summed up, as follows :—

1st. Its economy, as well in its first construction, as in its subsequent maintenance.

2nd. Its adaptability to almost any situation, especially in harbours or tideless seas.

3rd. The capability of almost indefinite extension, by the construction of additional pontoons, or as regards the lift, by the addition of extra columns.

4th. The simple and durable character of all its parts, and their perfect accessibility.

5th. The short time required for its construction and erection.

6th. The rapidity of its manipulation, and the small staff required.

7th. The convenient access afforded to all parts of the ship, and, especially in painting iron ships, their free exposure to light and air.

8th. The freedom from strain with which vessels, even in cargo, may be docked.

9th. The means afforded of rendering any area of shallow water available as a dock for the largest vessels.

The above characteristics are the result of direct experience; but it may be useful to indicate others that may be anticipated.

In the first place, it is evident, that this system affords ready means, by the construction of a shallow canal, of transporting the largest vessels in cargo either across an isthmus, or over river shallows; and of removing vessels of war inland, either for their protection, or for their employment as a means of internal defence.

The pontoon affords a convenient and economical method of avoiding the risk and cost that attends the launching of new vessels. It is intended by the Company to build vessels on their pontoons, which may be grounded for this purpose on a level bottom, and an immoveable platform will be thus at once secured. The launching will then be reduced to simply lowering on the lift. In this manner vessels of any dimensions may be constructed in a shallow estuary.

Vessels may, when unemployed, be laid up and kept dry under shelter, and thus preserved from decay, while the launch of a whole fleet would only be the work of a few hours.

No naval establishment possesses sufficient dock accommodation to provide for the numerous casualties that occur during war. It will not be doubted, that a lift, with sufficient pontoons, would prove of the utmost value, in affording immediate means, after an action, of docking a whole fleet of gun-boats and other craft, thus leaving the existing stone docks for routine use.

Lastly, it is evident, that should this system become as universal in its application as the Author confidently believes it must eventually do, such a result would inevitably lead to important modifications in the general arrangements of all large naval establishments. If fleets can thus be laid up, and vessels be built and navigated in any shallow-water space, no necessity can exist for that large area of floating dock accommodation which is now required; and a considerable portion of the enormous expenditure which characterizes such works may be economised.

THE ARCHITECTURAL ASSOCIATION.

The last meeting of the Session of this Association was held on 29th June, Mr. R. W. Edis, the President, occupied the chair. Mr. C. H. Hargreave, Mr. Alexander Payne, and Mr. R. Bird, were elected members of the Association.

The President read a letter from Mr. Ashpital, expressing regret that the Royal Institute of British Architects had declined to award a medal to those who had passed the Voluntary Architectural Examination, as suggested by the Committee of Examiners. It was satisfactory, however, that other of the proposals which had emanated from the Architectural Association had been adopted.

The following paper was then read:—

ON ORNAMENTAL IRONWORK.

By Chas. H. F. Lewes.

Among the many arts that flourished in the times of our forefathers, some of which have been revived in recent times, the art of the blacksmith, the ever favourite theme of the painter and the poet, is one which has received from us the least amount of study and attention. This is denominated an iron age, but it is certain that in the early days of our country iron was used for an infinitely greater variety of purposes than at present, and that in every article, however unimportant may have been its use, some traces of a feeling for ornamental art were displayed.

Although the Exhibition of 1851 was regarded by many as the harbinger of universal peace and ironwork, neither of these predictions has been fulfilled. Much has been done of late towards improving the character of ornamental ironwork by some of our enterprising metal-workers, for which they deserve the highest praise, but unfortunately there is such a painfully machine-made look about even some of their best hand-made work that I think the true revival of working in iron has yet to come. Of course I do not refer to such *chefs-d'œuvre* as the Hereford screen, and works of a similarly special and costly character, but to the ordinary every-day productions for ecclesiastical and domestic use.

Our railway engineers, the iconoclasts of the nineteenth century, have much to answer for in their wholesale abuse of this noble and national material, and I may safely say that in no other country in Europe would such monstrosities have been allowed to be perpetrated as are continually being erected in our metropolis—monstrosities not only painfully visible to the educated eye, but condemned by even those who have not the slightest shadow of a pretension to art knowledge. There must be something woefully wrong in the education of our engineers to lead to such increasing depravity of taste and total disregard of appearances and public opinion. That a purely scientific piece of construction should necessarily offend our sight by its repulsive ugliness is disproved by the works of our early engineers, some of which are perfect gems for beauty of proportion and grace of outline; and again, if we look to the works of our mechanical engineers, we find that, however massive, as a rule, they have a certain harmony of parts, the effect of their perfect fitness for the work they are intended to perform, and present a strong contrast to the clumsy masses of material piled up by our civil engineers. This would lead us to infer that the science involved in modern engineering works is of a very doubtful character; and this conclusion is rather strengthened by the failures constantly taking place in such simple matters, for instance, as a row of brick arches to a railway viaduct, even before a rail is laid or the parapet is on, which accidents are generally very complacently attributed to an extra shower of rain, or something equally absurd, and never to want of care on the part of the engineer. To my mind there does not appear to be much more science in suspending one of those Leviathan iron tanks called railway bridges, between two dead walls than in throwing a log across a mountain stream. Our engineers may have been spoilt in some measure by the twaddle that is occasionally written in our leading journals in praise of their large public works; for what can be worse than to be told that the hideous iron pipes of the Charing Cross Bridge remind you of the rock-cut temples of Egypt, or that the crude works of military engineers are equal, if not superior, to the works of Michael Angelo. It is to be regretted that in so few words Mr. Fowler, in his opening address before the Institution of Civil Engineers, should have dismissed the subject of architectural art in engineering works, and had not a word to say in condemnation of the abortions in iron designed by some of his contemporaries.

It is scarcely necessary to refer to the necessity of designing ironwork with a character peculiarly its own, and not in imitation of the features of wood or stonework, and that it should be in keeping with the architecture of the building of which it is an adjunct. Not any one would now be guilty of the anachronisms committed a few years since, or who would perpetrate such things as were done by a church architect of some thirty years ago, one of whose favourite arrangements was to make his apparently massive oak doors of a mixture of deal and cast-iron, the framing being of deal, and the cusping and mouldings to the panels being of cast-iron screwed on, the whole being afterwards grained in the most artistic manner to represent oak. One of the latest and most important examples of what to avoid in this direction (and in which we have to regret that a good opportunity was lost for shewing what might be done in the consistent treatment of ironwork), is afforded by Westminster Bridge, every single external detail of which is a cast-iron copy of stonework. Whatever difference of opinion may exist as to the merits of other portions of mediæval architecture, there can be no question as to the superlative excellence of its metal work, and of the true principles worked out in the best periods of it; it is only in the latest specimens that we find imitations of the treatment of other materials.

Ironwork is often made to appear too heavy in execution, from the designer judging of the effect from geometrical elevation only, and forgetting that when seen in perspective, the interstices become smaller, and the bars become larger, from seeing two faces of them, if square in section, instead of only one, as in the elevation, and consequently the proportions of the whole thing are entirely altered. This mistake is more easily perceptible in wrought ironwork where the iron is generally used of an oblong section for strength, shewing the narrow edge on the face. Many cases have come under my notice where designs, otherwise good, have been spoilt from this failing, when carried into execution. Allowance ought therefore always to be made for this peculiarity, and ironwork ought also to be designed with special reference to the position it is intended to occupy. For instance, when seen against the sky, surface treatment is of course unnecessary, and a much lighter and more delicate character ought to be adopted for internal purposes.

It is as well to remember that the heaviest ironwork is not always the strongest, and that the requisite amount of strength may be obtained by a proper distribution of the constructional parts of the design. The numerous examples of good ironwork to be found in London alone are such as to make our present deficiencies in its art treatment still more inexcusable, and we have only to cross the Channel to see what a revolution has been effected there during the last ten years in metal work generally, for one cannot walk a dozen yards in the new quarters of Paris, or the large towns of France, without meeting with something worthy of notice in the way of ironwork, in the shape of the railing to a square enclosure, balconies, balconets, window grilles, &c., for the most part of wrought iron, where the lines of the design bear the impress of careful study on the part of the designer, and do not look as if they came out of an ironmonger's pattern book. The ultra-refinement and delicacy which characterize the stone carving, and details generally of the architecture of Napoleon III, which would in some respects be improved by greater boldness of character, are the attributes particularly suitable to good ironwork.

It is curious to see with what pertinacity we adhere to the old stereotyped form of railing for our parks and squares, consisting of upright bars, top rail, and the everlasting spike-heads of the approved warlike pattern, and the same sort of thing, on a smaller scale, for the areas of our private houses, which makes the basements look more like the dens of wild beasts than the abodes of human beings.

Before proceeding further, I will refer to the distinctive features of some existing specimens of good ornamental ironwork. The elaborate wrought ironwork executed in the reign of William and Mary, for Hampton Court Palace, by Huntington Shaw, of Nottingham, is, or ought to be, well known to every architect. Some of the best portions of it were taken away from the railing which separates the river Terrace from the Home Park, and deposited in the South Kensington Museum. This ironwork is believed by some to have been designed by Sir Christopher Wren, but I think there may be doubts upon this point, as the smiths of Nottingham have always been celebrated for their work, and the execution of these gates is of such a superior character that it is very possible that they were designed by the workman himself. The design of these gates is noteworthy for the clever way in which heraldry is made to play its part in the general effect. In the centre panels of those preserved at South Kensington we have the rose of England, the thistle of Scotland, the harp of Ireland, and the royal monogram arranged in the most charming manner. The bold and graceful lines of the scrolls and foliage which make up the rest of the design afford good evidence of the perfection which the blacksmith's art had attained at that time. It is in the wrought ironwork of this period, both in England and on the Continent, that we find such elaborate imitations of natural flowers and foliage combined most artistically with the conventional forms.

The introduction into ironwork of armorial bearings, monograms, and dates of erection, should be encouraged at the present day, as it would add a material amount of interest to the work.

The English wrought ironwork of the first half of the last century, of which there is a great deal existing in London and its suburbs at the present time, deserves our attention for the very simple and honest methods by which a really good effect is obtained in most instances. The designs generally consisted of very light and elegant scrolls, with foliage of a purely conventional character, introduced in the most sparing manner, so as not to interfere with the lines of the scrolls. Our domestic buildings of this date had very little architectural art externally, except in the shape of ironwork, and what there was of it internally, was confined to the wrought iron staircase railings, the chimney-pieces, and the ceilings. The fine gates to be found in our Inns of Court, and attached to some of our country mansions, belong to this period, but the best example I know of is to be seen in the Armoury House of the Honourable Artillery Company at Finsbury.

The excellent museum of antiquities at Rouen is particularly rich in specimens of good French mediæval ironwork, the most perfect of which consists of a pair of gates formerly in the cathedral, and is a first-rate piece of workmanship. Although of the very lightest character, the diagonal arrangement of the filling-in bars, which is seen very often in mediæval work, gives a wonderful amount of stiffness. These gates belong, I believe, to the beginning of the fourteenth century. A slight sketch of them appeared in the *Builder* some years ago, but on too small a scale to give any idea of the originals, and in the paragraph attached to the sketch they were assigned to the twelfth century, which I think was a mistake, as they bear the character of a much later date. Another good example to be seen in the same museum is the frame of a doorgrille of the fifteenth century, which came from a convent near Rouen, and exhibits a very effective mode of treatment prevalent at that time, viz:—the piercing of thin plates of iron, and placing behind them red leather, or sometimes red cloth. This treatment is often seen in the lock-plates of old chests. No student who visits Rouen ought to fail to see its museum, as nearly everything contained therein will be found to bear some relation to architectural study.

I could have included among my references a few more examples of the ironwork of mediæval times, but those periods have been so well and thoroughly illustrated in the works of Digby Wyatt, Waring, Pugin, Parker, King (of Bruges), Raymond Bordeaux, and many others, that I cannot do better than refer any one wishing to study the subject to those books; of course personal study of the objects themselves is better still, but the advantage of their works is that they furnish the key to the mine of wealth in artistic wrought ironwork open for our exploration in England, France, Italy and Germany. I may, however, refer to the beautiful screen of Queen Eleanor's tomb in Westminster Abbey, which will repay any amount of study, both of its workmanship and design, as it belongs to the best period of the art. Had it not been happily rescued from oblivion by the hands of Mr. Scott, and restored to its original position, it is very probable that it would have shared the fate to which numberless other such ecclesiastical antiquities appear to be doomed by the ignorance or culpable negligence of their appointed guardians. An instance has only very recently come under my notice of the way in which good old art relics are destroyed. In Parker's Glossary will be found an illustration of a fine old chest, at Guestling Church, Sussex. A friend of mine, in making a tour through the country recently, was curious to see this chest, but after a long search, the only part he found remaining was one of the panels; all the rest has most probably been broken up for firewood.

With reference to the constructive treatment of wrought ironwork, the greatest evil of modern gothic work is the alarming extent to which the practice of screwing and rivetting together of the parts is carried, instead of adopting, where possible, the more lasting and workmanlike process of welding. Screwing is a process which ought never to be adopted, for not only does it give a brummagem and toyshop character to the work, but offers a great temptation to the mischievously inclined to attempt the dislocation of the parts. Of course there are methods by which the drawing out of the screws can be prevented, but it is a bungling affair after all, and it is lucky for us that such a fallacious process was not practised by the old smiths, or their works would not have been handed down to us in so complete a condition as we now see them. It is this screwing on *ad infinitum* of leaves and rosettes, all having the appearance of having been punched out of a thin sheet of metal, which gives the machine-made look before referred to.

Rivetting ought only to be resorted to when welding is not possible, but even then, in many cases, bands or collars welded round the parts to be attached, as in old work, would be the strongest method, and the most preferable with regard to appearance. An example of an injudicious arrangement of rivets may be seen in the wrought iron area railing to the houses in the Broad Sanctuary, Westminster, where all the small scrolls have been twisted out of their places, from being fixed so that they could turn upon the rivets. To ensure excellence as well as durability in wrought iron work, the hammer ought to be the master-tool, and the shears and file used as little as possible. As a general rule, old methods of construction are not always to be followed as the best, as they often are faulty in many respects, as may be seen occasionally in the framing of timber or the bonding of stonework. Although the indiscriminate use of cast iron has been one of the curses of modern architecture, and there is more interest attaching to the smallest scrap of wrought iron than to tons of the most celebrated cast work, still, there are many positions in which it may be used with advantage, but above all things, it ought to have a character entirely distinct from that of wrought iron, whereas the latter ought to revel in waving lines, cast iron ought to be stiff and geometrical in its forms, and should either be used in positions where it is not likely to meet with rough usage, or where the dimensions of the objects are such as to preclude the possibility of their being fractured, accidentally or otherwise, such as the columns for supporting warehouse floors or roofs, or street lamp-posts of appropriate design. We all know the effect of one of our street lamp-posts of the present period being struck by the wheel of a passing carriage, which always fractures it at the weakest point, which is most ingeniously placed in the best possible position for effecting that object. The lamp-posts on our bridges ought to afford an excellent opportunity for effective designs in iron-work, from their being generally seen against the sky. When cast iron is employed at all, the metal ought to be of the best description, and the castings ought to be as perfect as possible, and not require any filing up or tinkering afterwards, and to ensure the design being faithfully rendered by the pattern maker, it ought to be drawn out to the full size of the pattern and not to that of the finished casting, as, if made to the size of the latter, the pattern maker will have to make the enlarged drawing to allow of the proper amount of shrinkage of the casting in cooling. Regard must also be had to the equalisation as much as possible of the sectional area of the various parts of the design, so as to guard against the possibility of fracture from unequal cooling. More than ordinary care, instead of less, as is the almost universal rule, ought to be bestowed upon the designs for cast work of any description which has to bear a number of repetitions. Our Geological Museum contains some very wonderful examples of fine sand casting in iron from Magdeburg, in Prussia, in the shape of ladies' fans and jewellery. In England, the Coalbrookdale Company have always been celebrated for their fine castings, but the art treatment of their works, as well as those of the other large founders, would admit of a vast amount of improvement. The beautiful and extensive variety of geometrical and arabesque designs, to be met with in the metal work of the Indians and the Arabs, would furnish quite a new field for study in the improvement of cast iron work, and ideas might be obtained for light cast iron grilles for windows from the elaborate carved stone screens of Northern India, many of which were exhibited in London in 1851, and some of which are now to be seen in the India Museum.

A matter of minor importance in relation to ironwork, but which affects to a certain extent its durability, is its insertion into stonework. The disadvantages of lead for this purpose are well known. Sulphur and Portland cement have been used with success, but there is still the danger of the bursting of the stonework from the oxidisation of the metal caused by damp. As cast iron is known not to be so susceptible to this influence as wrought iron, it might be used for the standards for wrought iron work, by placing them at convenient distances, and making them of a sufficiently massive character. Cast iron is being used for this purpose in France, and with a very good effect.

The question of colouring ironwork is an important one, and deserves notice. I cannot say that I sympathize with the barber's-pole style of colouring so fashionable for ecclesiastical metal work, which probably is found to be attractive to the clerical eye. A better effect might certainly be obtained in most cases by the use of fewer colours, or even of one colour alone, properly selected, and heightened if you like by the use of gilding in prominent parts. Ironwork ought to depend for its effect mainly on the beauty of its forms and curves, and should not have the outlines distorted by colour applied without any meaning, as if the colourist had attempted to crowd the greatest number of colours into the smallest possible space. In colouring ironwork, the back ground ought to be the guide for the predominant colour, which ought to contrast favourably with it, and as a rule, to ensure a good effect, the ironwork ought to be darker than the background, never lighter, unless it be wholly gilt, which has a good effect, if the design is of a very light and open character, as in the gallery railing to the reading room of the British Museum. The beautiful wrought ironwork to the choir of Notre Dame at Paris, designed by Viollet-le-Duc, has been entirely gilt, but being of a very elaborate character, the effect is not good.

I am not aware that electrotyping with copper and bronze has yet been introduced into England for the purpose of protecting ironwork from rust, although this process is much used in France. An excellent mode of preserving iron from rust is to galvanise it previous to painting, but it is found that iron of the best kind and closest texture does not oxidise to anything like the extent of inferior iron, and the reason that old ironwork is in such a comparatively perfect state is, that greater care was taken in the preparation of what we may call the raw material, which was worked up by hand, and not sent wholesale through rolling mills. It will generally be found that where machinery is allowed to intrude into the domain of art, an increase of quantity may be the result, but never of quality. It is instructive to notice by what simple and trifling means a truly artistic effect was obtained in early ironwork, and we are thus taught the lesson that in introducing art into common things we are not compelled to adopt the most elaborate forms of it.

The subject of this paper is one which admits of so wide a range of investigation, that it would require abler hands than mine to do justice to it, and I have therefore only ventured upon some remarks as to the lack of art treatment in the ironwork of the present day, and have offered a few suggestions towards its improvement, with the hope that they may conduce to the furtherance of this desirable object, so that every scrap of ironwork may have some interest attaching to it, as of yore, and there will then be some chance of our rivalling, if not excelling, the genuine work of the mighty men of old.

Mr. Ridge remarked that Mr. Lewes had shown that the manufacture of good ironwork was not confined to the mediæval period, and he believed that students would see a great deal of good ironwork in some parts of London at the present time, and though the designs differed at different periods, the principles of all good work remained the same. The museum at Rouen referred to by Mr. Lewes, was most valuable as a place for the study of art work of all kinds. With regard to cast iron it had nearly always been its misfortune to be designed as an imitation of some other material, it was therefore most important that architects should be able to give it a character proper to itself. Cast iron capitals for instance deserved study, as both they and wrought iron capitals presented considerable difficulty to the designer. The last specimens of wrought iron capitals he had seen were at the Brighton Railway Station, at London Bridge, and nothing could be more hideous than the metal leaves which were attached to the capitals as decoration. Engineers' work, artistically considered, was generally simply horrible, so that a wide field would open to architects if they would make ironwork artistic. It was not of course difficult to imitate what had been accomplished by artists of preceding times, such as metal screens and works of that class, but the present age required that iron girders and similar works should be treated in an artistic style. Lattice girders had not a bad effect, but they were generally spoilt in our bridges by the kind of sentry box put over the piers, to cover the junctions of the girders. He concluded by proposing a vote of thanks to Mr. Lewes for his paper.

Mr. Dunphy said he quite agreed with Mr. Lewes in deprecating the abominable manner in which the London and South-Eastern Railway Company had contrived to carry their railway across the Thames at Charing Cross. The iron bridge put up there, with its pillars like inverted pipe-stoppers stuck into the bed of a river, was a perfect disgrace to the metropolis, and he considered that some representations ought to be made to the company on the subject. It was, of course, too late to get rid of the piers in question, but it was not too late to ask the company to direct their engineer to do something towards mitigating their hideous appearance. Surely something might be done by resorting to the screwing and riveting process, which Mr. Lewes deplored so much, to give the cylinders the appearance of pillars. Something ornamental might be designed and affixed to the tubes which would relieve them from their present hideous appearance. With regard to area railings, he was glad to see that in Portland-place an attempt had been made to substitute some artistic iron work for the dreary succession of menagerie railings now generally in use.

Mr. Tarver thought the study of iron work executed in the last century, referred to by Mr. Lewes, would go far towards modifying the "sensational" character of the prevailing designs of the present day, for which mediæval work was taken as a type. This had led, he thought, even in the hands of a leading architect, and his followers, to results which, for want of a better simile, he could only compare with fireworks. He believed that repose in metal work designs could be best obtained either by enclosing floriated patterns within definite bounding lines, or by the frequent use of spiral curves.

Mr. Dunphy inquired if Mr. Lewes could account for the excessive prices charged for any ironwork of superior design.

Mr. Lewes replied that it was the case in everything, if an architect wanted work according to his own design, he must pay extra for having it executed. Common articles which were kept in stock were of moderate price, while original designs were rendered more expensive by the extra labour.

Mr. Ash observed that architects of the present day were too fond of copying continental ironwork, in which the screw and rivet were used because if the work were welded at the joints it caused additional labour and expense. With reference to the difficulty of finding good examples of ironwork in England he stated that much good old ironwork had been destroyed during the last twelve years. During the repairs and restorations of churches the old ironwork, however beautiful in design, was too often destroyed, which was much to be deplored.

The President, in putting the vote of thanks to the meeting, said the

Association was much indebted to Mr. Lewes for the manner in which he had brought a very able paper before the meeting. Referring to what had been said as to the difficulty of obtaining good examples of ironwork, he instanced the screen at Westminster, and the gates at Merton College, Oxford, as being specimens worthy of study. A vast amount of the ironwork of which Mr. Lewes had spoken still remained, though much had been destroyed. He advised that all architects should take care that no ironwork of any kind, having any merit as to design, should be destroyed. In rebuilding or altering any building, the architect should preserve it as religiously as he did all old work in a church restoration. He could not imagine any architect of the present day designing the patterns which appeared in the manufacturers' books; but if architects were told they would find the work would be seventy-five per cent. cheaper if they took some of the manufactured designs, it was no wonder if they submitted to the force of circumstances. The fault was with the manufacturers, and he was sure they might manufacture good designs as cheaply as the present very inferior patterns. On one occasion he had asked a manufacturer in Thames-street why he allowed such designs to appear in his pattern books? And that gentleman's reply was, "the fact is this, if one architect designs a good thing, somebody else comes in and tells me it is horrible, and between the conflicting tastes of professional men, I am quite at a loss to know whose opinions to follow." He thought that architects should treat ironwork as they treated any other part of their building, and if it cost more to have it in good taste, then it should be in the estimate. He objected to students studying the works of any modern designers in ironwork, he thought they should look altogether to the teaching of ancient examples; they should not follow one architect more than another, but work to the best of their ability and knowledge.

The vote of thanks to Mr. Lewes was carried unanimously. The following are the names of the office bearers elected for Session 1866-67: *President*, Mr. Robert W. dis; *Vice-Presidents*, Messrs. R. Phené Spiers and Edward J. Tarver; *Committee*, Messrs. G. H. Birch, J. S. Edmeston, E. B. Ferrey, H. L. Florence, Ernest Lee, C. H. F. Lewes, W. Lonsdale, J. S. Quilter, L. C. Riddett, L. W. Ridge; *Hon. Treasurer*, Mr. J. Douglass Mathews; *Hon. Solicitor*, Mr. Francis Truefitt; *Auditors*, Messrs. C. B. Arding and J. A Bunker; *Curators and Librarians*, Messrs. L. C. Riddett and W. Frewer; *Hon. Secretaries*, Messrs. J. Douglass Mathews and Rowland Plumbe; *Registrar and Collector*, Mr. William Farthing.

Review.

Fires, Fire Engines, and Fire Brigades. By CHARLES F. T. YOUNG, C.E., Mem. Soc. Engineers, Author of "The Economy of Steam Power on Common Roads," &c. &c. London: Lockwood and Co.

CONCLUDING NOTICE.*

WE regret that in several of the views given of steam fire engines, so little is shown in the way of detail or even of the actual external working parts of the engines as constructed. We may instance especially the view of Messrs. Shand, Mason & Co's. horizontal engine of 1865, and that of the patent vertical engine of the same makers, also dated 1865, both of which strike us as being deficient in many particulars which we have been accustomed to associate with the engines purporting to be represented. It is easy to understand that these parts may have been omitted for the purpose of avoiding complexity in the figures, but we hold that by this omission, much of the value of the figures is lost, as they fail to give the thorough idea of the machine, which it should evidently be their object to produce. As regards the boilers of these engines, of which we should have liked to have seen sections, we presume that the accompanying figure and description taken, as we are informed, from the specification of Mr. James Shand's patent of 1863, will sufficiently give the type. "The accompanying engraving Fig. 7) is a longitudinal section, showing the construction of the boiler, steam engine, and pump. The fire box A is of conical form, so as to give space for a large fire grate or furnace. The fire box communicates with the smoke box B and the chimney by the vertical tubes C. In order to diminish the water space and increase the steam space, two semi-circular metal cases or pockets D are fitted with the boiler round the space occupied by the tubes C. The casing D communicates with the steam space by two or more open pipes E, which ascend above the water level, and small cocks (not shown in the drawing) are fitted in the bottoms of the cases D through the sides of the boiler, to draw off any water that may be formed by condensation. The upper shell of the boiler can be taken off by means of the bolted joints F and G; and the top of the smoke box can be taken off to repair the tubes, &c., by unscrewing the joint at H. The engine is composed of an inverted steam cylinder I, placed above and concentric with a pump K, which parts are framed together by the four bars L, which connect the enlarged head of the pump with the cylinder bottom, and which frame L also carries the bearings for the crank shaft M. The pump is fitted with india-rubber discs, which form the foot valve. In action, the suction is drawn in the up stroke by the bucket O, and in the down stroke about half the water is discharged by the displacement of the plunger N, and at the next up stroke the remainder of the water is discharged by the ascent of the bucket. The enlarged head of the pump K is fitted with a large air vessel Q, and nozzles to take the hose at R. Over the openings to these nozzles at S is fitted a valve, shown in plan in the engraving, which is so constructed as to admit of both outlet passages being open or to close either at pleasure, but not to close both outlet passages at the same time. The connecting rod T is jointed to the bottom of the pump plunger N, which is itself attached to the steam piston by two piston rods, between which the crank works. Upon one end of the crank shaft M is keyed a fly-wheel, and upon the other end an eccentric, which works the slide valve and the feed pump V. The governor is constructed with a piston fitted into a cylinder, with a trunk and stuffing box; the connecting link from the piston is attached to the lever of the regulator, a pipe is connected with the steam jacket of the cylinder, and another pipe with the enlarged head of the main pump, so that any change in the pressure of the water in the pump will cause the piston of the governor to be moved by the pressure of the steam, and thus regulate the admission of steam to the steam cylinder of the engine."

Boilers of the kind represented possess, while new and clean, most excellent steaming properties, and at first sight seem admirably adapted for steam fire engine purposes, but when

* See ante, pp. 182 and 211.

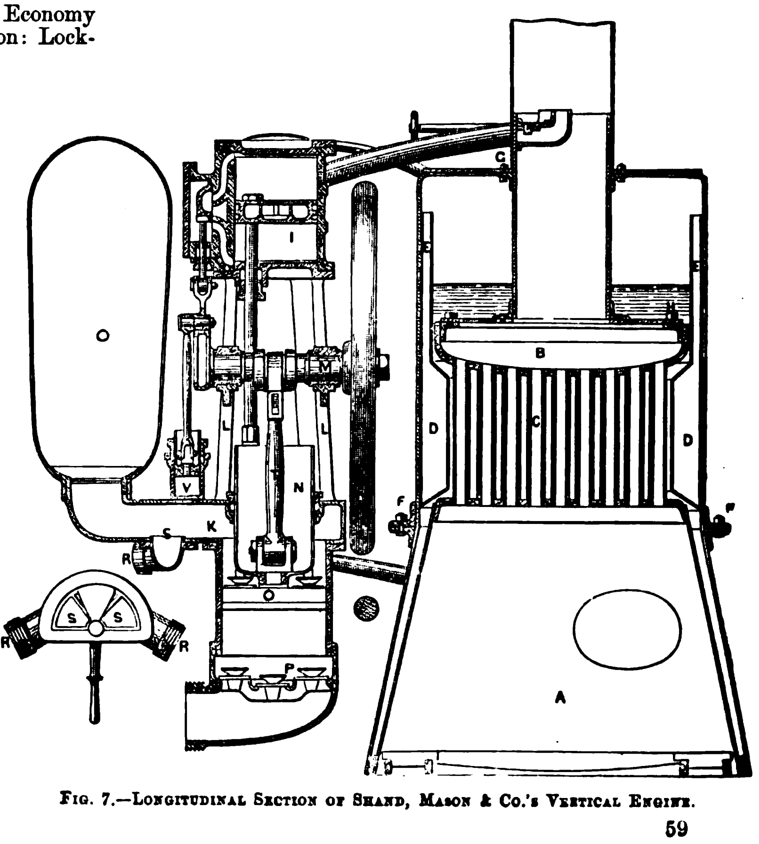


FIG. 7.—LONGITUDINAL SECTION OF SHAND, MASON & CO.'S VERTICAL ENGINE.

further examined we think it will be clear that the objections to them, as compared with some of different construction, considerably outweigh the advantages. Thus it would appear to us, that in the first place, they must of necessity be expensive to construct, and from their formation not entirely free from danger of explosion, while at the same time the unequal expansion of the parts will be likely to cause continual annoyance by leakage. The tubes, too, we should imagine must quickly become coated with deposit so as to greatly lessen their power of conducting heat to the water. Such at least is found to be the case with locomotive and marine boilers fitted with similar flue tubes passing through the water space. These are points which we think are well worthy the consideration of the makers.

The form of engine shown being of the quick running short stroke class, must, we fear, be somewhat unsteady in its action and liable to frequent derangement. It has always been our opinion that long steady strokes, with direct action between steam cylinders and pumps, are much to be preferred to those in which not only is the stroke short and rapid, but the motion, after having been converted from rectilinear into rotary, has again to be converted from the rotary of the fly wheel shaft into rectilinear in the pumps. The more direct the action of the parts and the fewer their number, consistent with the proper action of the machine, the better, and we think that this principle properly understood and carried out would go far to prevent the recurrence of circumstances, such as that alluded to by Lord Naas, who, according to a report in the *Standard* of the 13th of June, speaking of the late fire at Dublin, said it was stated "*that the steam fire engine, which arrived a considerable time after the outbreak of the fire, fell completely to pieces.*" It is no doubt an exaggeration to say that the engine referred to "fell completely to pieces," but that it became completely disabled is far from improbable, and would be a circumstance certainly not of very unusual occurrence.

That mishaps can at all times be avoided, even with the best constructed and most simple engines, we do not for a moment assume, but that many breaks-down are clearly traceable to the engines being decidedly wanting in these particulars is certain;

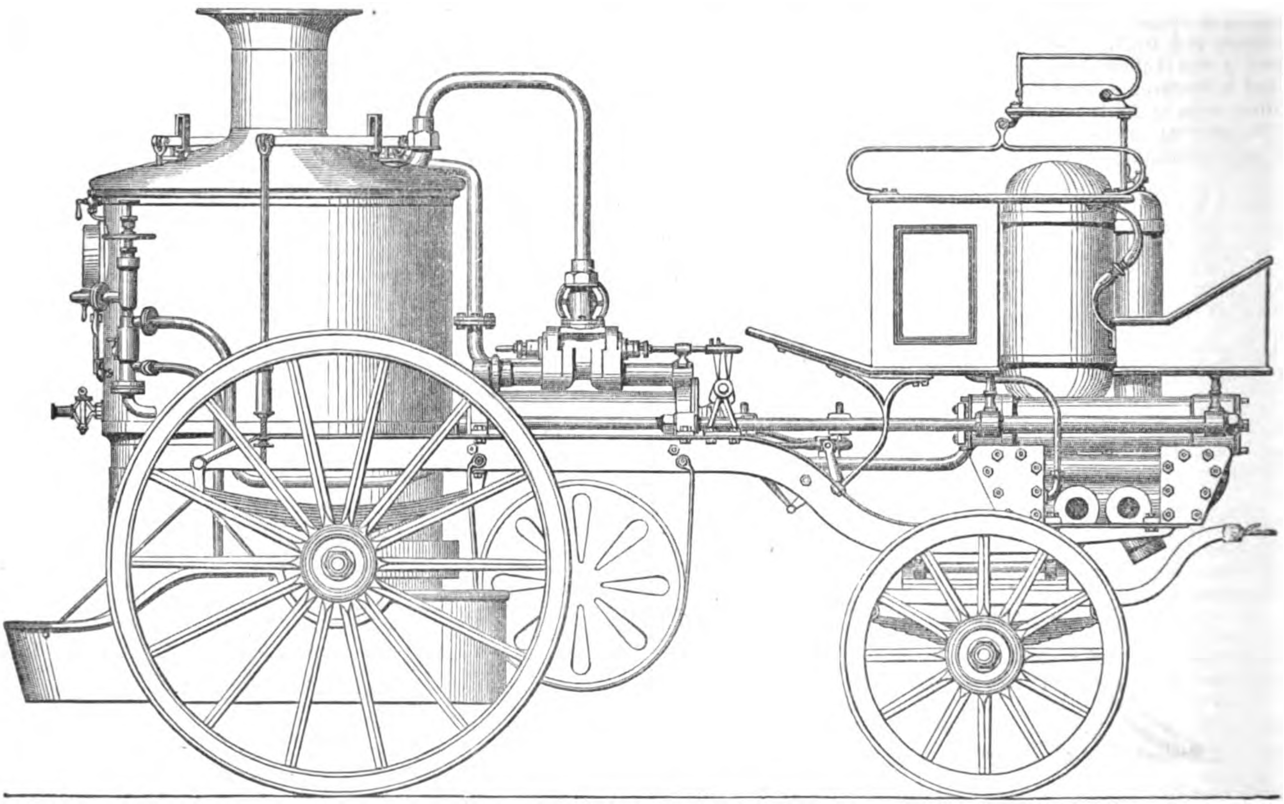


FIG. 8.—MERRYWEATHER'S CHAMPION ENGINE, "SUTHERLAND," 1863.

and we, in common we think with engineers in general, should have been glad if Mr. Young had entered at greater length into the subject of constructive detail and the principles upon which it should be carried out. In this way and by analytical comparison of the several engines whereby known results have been achieved, and which have steadily maintained their efficiency during lengthened periods of service, we think that much good might have been done, although at the same time it must be admitted that to do this in a thoroughly efficient and reliable manner, giving not only the aggregate of work done by, but the cost of maintenance of each engine and the fuel it consumed, would be a matter of great difficulty, if indeed it could be achieved at all. Further than this, we must not lose sight of the fact that Mr. Young's work is evidently rather a popular history and resumé of the whole subject of fires and their prevention, than one intended for the use of engineers, or of any other class of the public exclusively. In this point of view and as calling attention to past facts, past, and we may add, still existing, prejudices and exclusiveness, it may be of great service, and lead to the avoidance in respect of fire engines of an error comparatively as grievous as that of the Austrians in respect of improved firearms. The fact is that in these times progress is a necessity which will assert itself, and happy will it be for us as a nation, if we thoroughly realize this truth before being reminded of it, by loss either of commercial or political position. The Americans seem to be peculiarly alive to this, and to understand that it is better to run the risk of sometimes making a blunder, than to continue bound in the trammels of red tape or prejudice. It is unfortunate that not even facts themselves are at all times sufficient to ensure a just sentence, and hence we find that many inferior things are patronized, where others which are far superior are comparatively unknown. Still it is evident that tables of results, such as those so carefully given in this work, must lead to reflection, and we should hope, in the end, to a general adoption of the most correct principle, which, it will be observed, is in the direction we have already more than once indicated, and which is evidently the one which Mr. Young's observations lead him to prefer. Of the Sutherland, which is an admirable example of the class of direct acting engine to which we have referred, Mr. Young quotes the following from the last report of the late Lambeth Fire Brigade, which, referring to the Crystal Palace trials, says, "The Sutherland (Merryweather and Sons).—This engine worked most satisfactorily throughout the whole of the trials it was subjected to; its jets were quite free from pulsation, and its water and steam pressures were very equal; the water in the boiler was also very regular in quantity. The water cylinder, through a defective casting, leaked slightly during the first day's trial, which prevented the engine from accomplishing greater results, but it was repaired in the course of a few hours. The pumps were not charged for any trial, and the boiler did not prime in the least."

As regards the construction of the first steam fire engine in America, Mr. Young says, "The honour of having constructed the first steam fire engine in the United States has long been given to Mr. John Ericsson, and it has generally been believed, at least in this country, that to him the credit of this was due. Great pains and a considerable amount of research have satisfactorily proved, however, that this is not the case; but the grounds on which the idea became established were, that in the year 1840 he obtained the gold medal which was offered by the Mechanics' Institute of New York for the best plan of a steam fire engine.

"A design for a steam fire engine was sent in by him in answer to the offer, and this engine being almost identical, except in the boiler, with those which had been so successfully manufactured and employed by Mr. John Braithwaite in London some ten or twelve years before, and consequently, had been pretty well proved in working, naturally carried off the prize, as there could be little room to doubt its being successful if carried into practice.

"No account has been found of its ever having been made, nor has any information been received in answer to the inquiries made respecting it. The following remarks, and the sources whence they were obtained, seem evidently to show that they added in no small degree to the propagation of this idea:—In Le Cras' work, 'The United States and the Canadas,' written in 1841, it is stated that one of Ericsson's engines was then being built. It was to be a little over two tons in weight, and to throw 3,000 lbs. of water per minute, equal to about 300 gallons per minute, to a height of 100 feet, and so arranged as to throw four streams at once if required.

"The *Mechanics' Magazine*, for 1840, contains the following extract from the *Times* respecting this engine:—'A steam fire engine has been invented at New York by Capt. Ericsson. It weighs only 2¼ tons, and will throw 3,000 lbs. of water per minute to a height of 105 feet through a nozzle of 1½ inches in diameter.'

"The first steam fire engine constructed in the United States was designed and built by Mr. Paul Rapsey Hodge, C.E., a well known English engineer, at his own works in New York, in the year 1840-1. It was a self propelled engine, the first of the kind ever constructed, with horizontal cylinders and pumps; a locomotive boiler, in some respects like the style introduced by E. Bury for locomotives; the slab or plate framing to which the cylinders and pumps were attatched, as is now used in locomotives; and wrought iron wheels, which were manufactured by the Matteawan Company for Mr. Hodge. It was arranged to be drawn by horses if required, as well as by hand and its own steam power: and this, about twelve years after steam fire engines had been in use in England, was the first made and used in America."

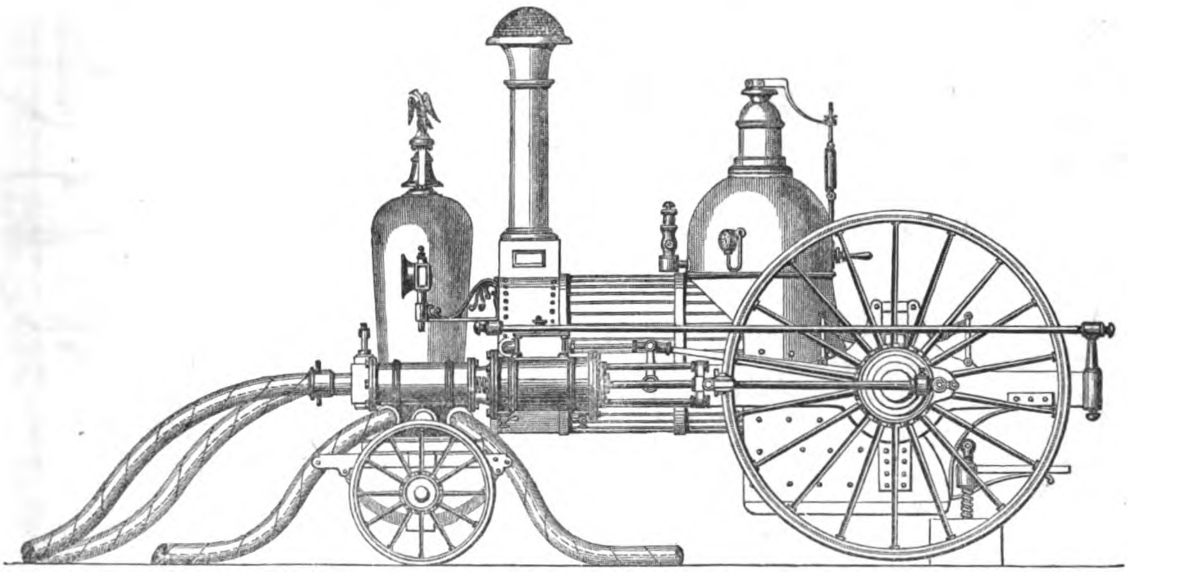


Fig. 9.—The First American Steam Fire Engine, P. R. Hodge, 1840-1.

We give the figure of Mr. Hodge's engine, which appears to have worked in a most satisfactory manner, giving results, which will compare very favourably with others of much later date; we also give an engine as constructed by Messrs. Poole and Hunt, of Baltimore, in 1865, of which we are told "the pumps employed by Messrs. Poole and Hunt are of a peculiar character, consisting of two barrels placed one over the other, in each of which are two pistons, attached to each piston rod, and fitted with india-rubber valves. The two piston rods are attached to a cross head, which is again attached to the piston rod, so that one cylinder and steam piston works the two pumps, and the four pistons connected with them, a small fly-wheel being used. They are constructed of three sizes or classes, each of the following weight:— No. 1 = 6,500 lbs, or 2 tons 18 cwt. 4 lbs. English; No. 2 = 5,600 lbs., or 2 tons 10 cwt. English; No. 3 = 4,500 lbs. or 2 tons 20 lbs. English. It is found that the second class is of sufficient capacity for use in the largest cities, whilst for towns or cities of moderate size, the third class is ample.

The trials at Rotterdam between an engine made by Messrs. Shand, Mason and Co., and the engine, "De Maas," by Messrs. Merryweather and Sons, are given from the official report of M. Von der Tak, Director of the Board of Works there. This report is accompanied by a diagram, showing the forms, heights, and horizontal distances of the jets thrown by each engine, of which a copy is given, and which is remarkable as showing the superior steadiness and continuity of the jets thrown by the longer and slower stroke of engine. There is, however, another class of engine of which we have as yet but little practical knowledge in this country, namely, that of which the unfortunate "Manhattan" is the type. Of the arrival of this engine to take part in the Crystal Palace trials, our Author says:—"The Manhattan, and the delegation, in the hands of the London Fire Engine Establishment, arrived at the Crystal Palace on the 30th June, and the engine having been weighed and the boiler tested, was declared all right, and was then to be removed to the portion of the grounds set apart for the trial. Instead of the engine being taken by the easiest and nearest way to this point, it was taken round by the north tower, where there was a steep incline; but when it reached the top of the incline, and began to descend, the weight overpowered the men in charge of it, and the man of the London Fire Engine Establishment, who had hold of the pole, was unable to guide it, and it ran away down the incline, and, at a point where the road curved, ran into a tree and capsized, smashing the engine and severely injuring the fireman before alluded to.

"The force of the blow knocked off the fore-carriage, broke one of the flywheels, and cracked the other, turning the engine completely upside down, thus leaving the engine, the night before the trials, in a most crippled condition. The delegation who brought the engine over, however, would not be beaten; and, procuring the assistance of some labourers, set to, to try and get the engine into condition for the next day's trial. By dint of great exertions they succeeded in doing so, so far as to have it on the ground in time, and thus prevent loosing the entrance fee. At this stage of the proceedings it was objected that the accident might have caused the engine to have become dangerous and unsafe to work, and therefore it ought not to be tried at all;

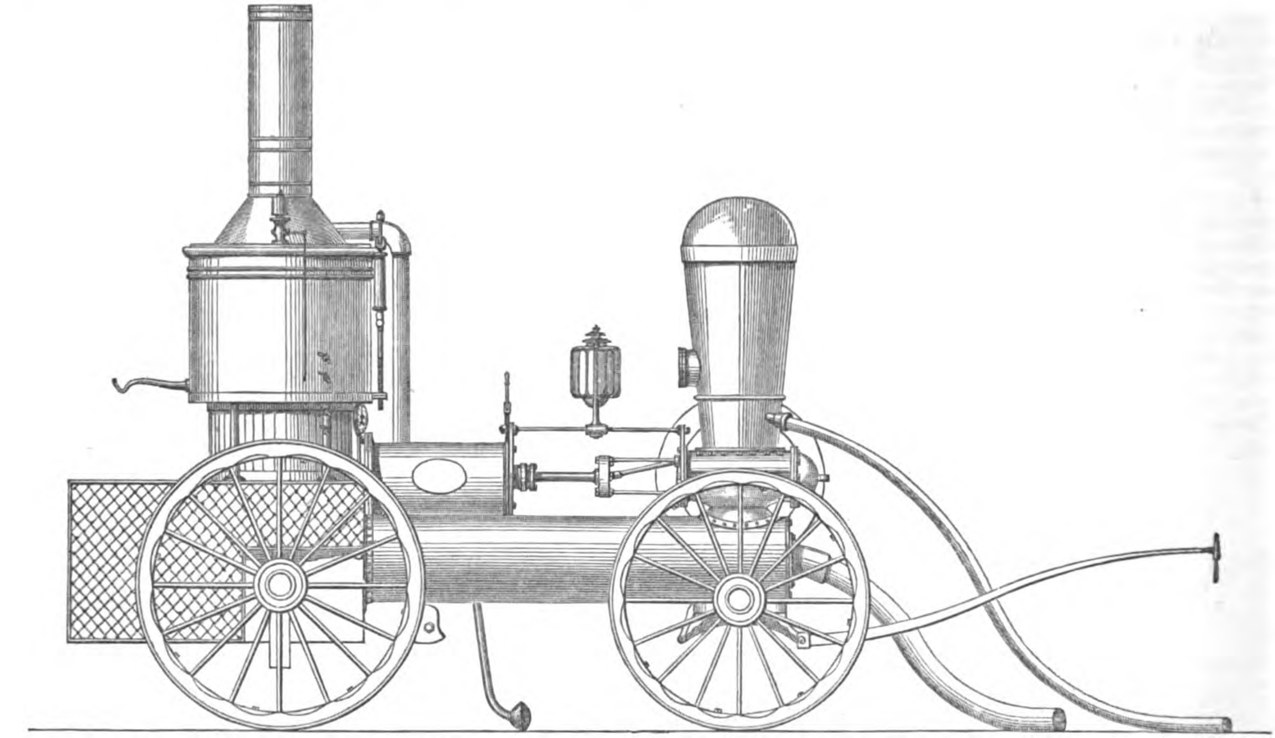


FIG. 10.—ENGINE OF POOLE & HUNT, BALTIMORE, 1865.

however, after much discussion, it was resolved to prove the boiler, and accordingly, with a laudable desire to prevent injury to the public, and which has been shown on numerous other occasions, the superintendent of the London Fire Engine Establishment proceeded to test the boiler with a water pressure of 250 lbs. on the inch, and double the pressure required; but the engine injured as it was stood the test well."

This mishap, and the culpable mismanagement, which led to it, are greatly to be regretted, not only because of the loss of the opportunity for testing that particular construction of engine, but on account of the feeling it induced on the part of our American brethren, that a desire existed to do them less than justice in this country. We trust, however, that this feeling will subside when it is seen that all among us whose opinion is of value are prepared and anxious to give American inventions as full and fair a trial as is accorded to those of our own countrymen, and whether the competitor be a Manhattan or a Miantonomah, we are prepared to accord to it the fullest meed of praise or acknowledgement of superiority its performance may deserve. Upon this subject, we regret to find the Authors' experience leads him to speak as follows:—"So far as the Author can gather from Americans resident in London, the disgust and annoyance felt by them from the treatment they received on the visit of the American firemen and engines in 1863, and the results of the so called 'trials' have raised such a feeling amongst them as cannot fail to lead them to refuse any information, or to render any assistance on such a subject, when sought to be obtained from this side of the Atlantic."

We cannot enter at length into a discussion of all the features of Mr. Young's work, which touches upon almost every detail of fires and their prevention, showing not only what has been done in our own country but in the other parts of the world, and giving numerous suggestions which can only have arisen from a careful consideration of the subject and a sincere desire to advance the ends of truth. To all those who may feel an interest in a subject of such importance to us all, we cannot do better than recommend an attentive persual of this laborious work, which we feel assured will direct attention to many points of importance not hitherto either properly understood or fairly appreciated.

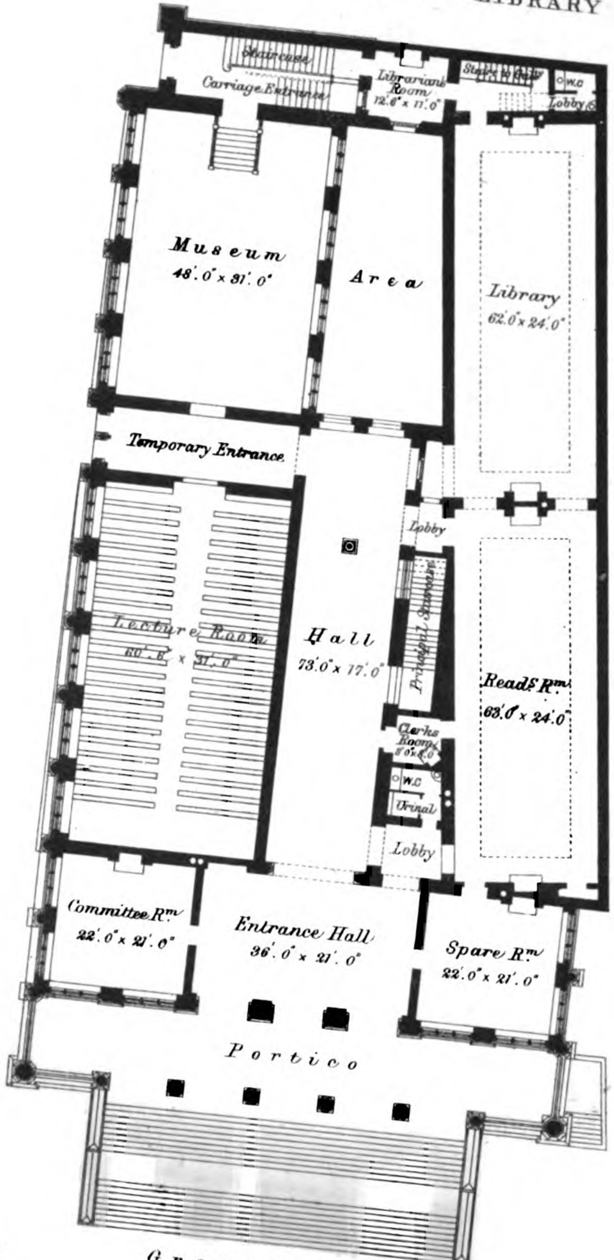
BUDDONNESS LIGHTHOUSES, RIVER TAY.

THE apparatus employed in the towers of the two new leading lights at Buddonness, consists entirely of glass, and is somewhat curious and intricate in its details. It was constructed from the designs of Messrs. Stevenson by Messrs. Chance, of Birmingham, and is remarkable and unique from its combining *every kind* of dioptric lighthouse apparatus. The whole of the light which comes from the burner is condensed by the best optical agents (no metallic reflection being used) into a horizontal arc of forty-five degs., and spread over that arc equally by means of the following instruments, viz.:—Fresnel's fixed light apparatus and annular lens; also the following instruments of Mr. Thomas Stevenson—the azimuthal condensing prisms, holophote, right-angled conoidal prisms, and dioptric spherical mirror, with Mr. J. T. Chance's setting. The conoidal prisms have never been employed before. The azimuthal condensing prisms were first used at Isle Oronsay Lighthouse, Argyleshire, in 1857, and the dioptric spherical mirror was first introduced by Messrs. Stevenson into a lighthouse in the colony of Otago, but it has not been applied till now in any light in Britain. It is composed of glass prisms, and possesses the property of returning all the light that falls on it back again to the flame, so as to increase its effect without allowing any rays to pass through, but causing all to go seawards. Hence an observer standing *behind* the apparatus sees no light, although the screen between his eye and the flame consists only of transparent glass prisms.

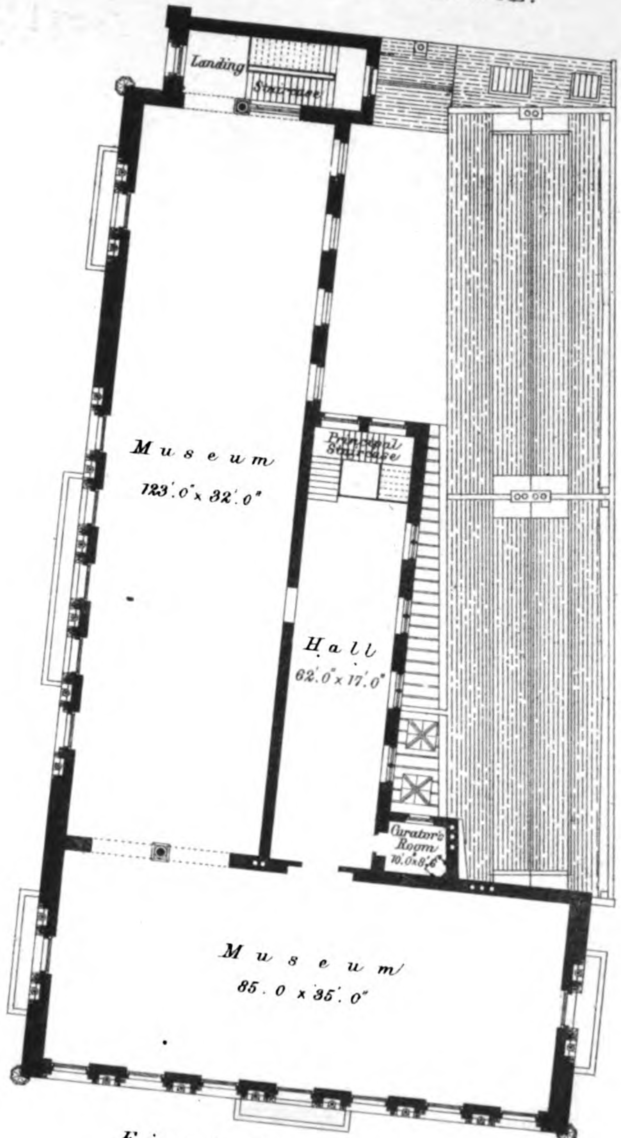
The Board of Trade have lately given authority to the Commissioners of Northern Lighthouses to get a facsimile of the Buddonness apparatus constructed for being shown at the Paris Exhibition. The lights were permanently exhibited on the 14th July, 1866.

DESIGN FOR MUSEUM AND LI

MUSEUM & LIBRARY TO BE ERECTED IN THE QUEEN'S ROAD, BRISTOL.



Ground Plan



First Floor Plan

ON THE ARCHITECTURAL HISTORY OF THE COLLEGE AT ETON.*

By Professor Willis.

The Professor prefaced his account with some introductory remarks on the general history of colleges and their growth. The universities were at first corporations of educated men, the teachers or doctors in which instructed by lectures in the public schools, the students being obliged to find lodgings for themselves. Soon, however, generous persons gave funds to assist poor students. After a time a more definite shape was assumed by these institutions; and lodgings were also provided, that the morals and manners of these students might be brought under superintendence and control. The next step was to purchase houses, endow them and provide them with statutes. Thus arose the communities termed colleges, residing in buildings called the *Domus* or *Aula*, which at first contained little else than chambers to lodge in, with a dining-hall, kitchens, &c., like the ordinary dwelling-house of the period. The first of these colleges was that at Oxford, by Walter de Merton, in 1264; one was founded at Cambridge soon after; and others followed at intervals up to 1379, when in the so-called New College at Oxford William de Wykeham erected the first architectural building, complete in all its details, and so well organized in its statutes, as well as in its structures, as to serve as a basis for all subsequent erections. His plans also included the then new feature of a preparatory school, at Winchester, for young boys, from whom the members of his Oxford College were to be selected. The Professor next proceeded to the consideration of King's College, Cambridge, and its appendage Eton.. He gave a touching account of the effect of the misfortunes of Henry the Sixth in retarding and finally suspending these works, followed by a just parallel between the continual devising of plans for the education and elevation of his people by that monarch and the constant efforts in the same directions by the late Prince Consort. Prof. Willis then detailed the original plans for Eton College as set forth in that monarch's "will"—this will being, however, not a "last will and testament," but in reality a building specification for his colleges, in which so clearly has he laid down his plans that the lecturer was able to transfer them to paper, and to exhibit diagrams of the ground-plans to his audience as a basis for comparison with a plan prepared by himself of the actual buildings subsequently erected, and showing the condition of Eton in 1866. Henry, however, did not mature his plans at once, but modified them very considerably at a shortly subsequent period. He first founded a collegiate grammer-school at Eton and a small college at Cambridge, dedicated to St. Nicholas, that saint's day having been his birthday. A site was purchased at Eton, north of the cemetry of the old parish church (now no more), and the King came down and laid the first stone, over which was to be the high altar of the new collegiate church. The King soon enlarged his plans, increasing the number of his beneficiaries and connecting, by statutes copied from Wykeham's, Eton School with King's College at Cambridge.

The contemporary building accounts and documents, containing the King's projects snd instructions, long mislaid, and believed to have been stolen, were by a fortunate accident discovered in a forgotten recess of the Library at Eton, about two months since, and liberally submitted to the Professor's inspection. They contain abundant proofs of the personal interest which the King took in the details of the college buildings, and of changes and improvements introduced by him as time went on. They show that the works at Eton were of two kinds, carried on simultaneously. First, the enlarging, refitting, and altering of buildings that already stood on the site purchased by the King, including the parish church, of which he obtained the advowson, and its conversion into a collegiate church. These buildings were so treated as to make them serve as temporary dwellings for the accommodation of the provost, fellows, and students of his new College, which enabled the school to be brought into active existence from the beginning, without waiting for the erection of the magnificent architectural pile described in his will and other documents, and which was commenced simultaneously with these temporary operations; but which, even if carried on in prosperous times, would necessarily have occupied many years in completion. The chancel of the old parish church was rebuilt on a larger scale, and fitted with stalls and other appurtenances for the daily choral service. A hall in one of the old houses was enlarged; a school-room and other buildings constructed of wood. The almshouse for poor men, described in the will, was also built.

The permanent College was also begun; the first buildings attacked being the great chapel, which now exists, and the hall and kitchens. This chapel was placed in the old parish churchyard, to the north of the old parish church, and was planned as the chancel of a large collegiate church, to be provided with a nave or body for the parishioners, as described in the well-known will of Henry the Sixth, dated 1448. But, after the signature of this will, the King enlarged and altered his plans. He sent persons to Sarum and Winton, and other parts, to measure the choirs and naves of churches there, and had improved designs made for the college buildings.

The Professor found among the documents two specifications relating to the chapel, the one exactly corresponding to that of the will, but in which every dimension is struck through with a pen, and an increased dimension written above it. The other specification describes the chapel or church, as it is called, in different phraseology from that of the will, and more completely. The dimensions in this latter paper are still greater than those of the corrected document, and, what is more curious still, they correspond exactly with the chapel as it exists. The paper concludes with minute directions that the foundations of the chapel, which had already been laid (of course in accordance with the will, for the works had been in progress for seven years before that will was signed), should not be disturbed, but the new foundations (*i.e.* for the enlarged dimensions), be laid round the outside of them, and be constructed with the greatest care, and with "mighty mortar." The first stone under the high altar to remain undisturbed. This stone was protected by a small chapel built over it in the first years of the works.

The deposition of the King, in 1461, put an abrupt stop to the buildings, which had languished during his increasing misfortunes. That they were resumed, after a long interval of time, by his confidential friend and executor Bishop Waynflete, is stated by Leland, and also shown by an indenture, in 1475, between him and a carver, who engaged to make a roodloft and stalls for the new chapel, and to take down the roodloft and stalls in the choir of the old parish church. This proves that the great chapel was only then brought into a condition to receive its fittings. It must have been just roofed in. The Professor pointed out to his audience evidences of the haste in which the upper part of the chapel had been completed. The arch heads of the windows are abruptly depressed, in a way which shows that the walls of the chapel were intended to have been carried much higher by the masons who built the jambs and springing of the window-arches. It is probable that the work had been carried up exactly to this level when the defeat of the King stopped the operations. When resumed by Waynflete, with insufficient funds, expedients were adopted to enable the buildings to be rapidly finished and roofed-in for use. The hall exhibits similar evidences to show that its walls and windows were designed to have been carried up to a much greater elevation than they now present; and that after a sudden interruption it had been hastily put into a condition to receive the roof, which is of a very plain construction. The magnificent body of the collegiate church designed by the founder was never even commenced. The choir, or present chapel, is now terminated westward by a low traverse ante-chapel of slight construction, probably the work of Waynflete.

The old parish church appears to have been pulled down after the present chapel was prepared for service, as above stated. The parishioners retained the right of employing this chapel as their parish church. But the increase in the numbers of the students and of the population, and other causes, creating great inconvenience, both to the college and the parish, a new church or chapel-of-ease was erected in the town of Eton for the use of the parishioners, in the last century.

The arrangement of the college buildings differs entirely from that described in the will of the founder in 1448. The Professor concluded from this, and from the mention of a plan or "Portratura" exhibited to the King, in the following year, "for the finishing of the buildings of the college," that he, when adopting an enlarged design for the chapel, had also determined upon a new disposition for the other buildings.

* Abstract of Address before the London Congress of the Archæological Institute.

The college in the will is imitated from Wykeham's colleges, consisting of a quadrangle, containing hall, library, and chambers, and of a cloister. But in the existing college the quadrangle of chambers contains not only the hall and library, but is also cloistered. The site of the cloister first proposed, but never commenced, is that now occupied by the school-yard. The cloister quadrangle is arranged upon a plan unusual in colleges. It was built in two stories, having chambers on the north and east sides, and the hall on the south, the dimensions of which agree exactly with the founder's will. The upper chambers are not reached in the usual manner, by assigning one staircase to each contiguous pair; but a gallery is carried round the upper floor, exactly over the cloister of the ground floor, to give access to the doors of the chambers. At each internal angle of the quadrangle, or *quadrant*, as the will terms it, is a square turret containing a spiral stone stair, or *vice*, with a door below and above, by which the upper gallery is conveniently reached.

The chamber buildings were carried round the east and north sides in one style, and probably in the founder's time; but the west side, which contains the great gateway called Lupton Tower, was built, after a considerable pause in the works, in a totally different manner during the provostship of Lupton, and probably in the reign of Henry the Eighth.

The cloister-arcade and chamber-doors on the ground floor on this side appear, however, to belong to the earlier building, and to have been suddenly stopped in an unfinished state. This western side of the quadrant is wholly devoted to the provost, and contains a large dining-hall, termed "Election Hall," with a withdrawing-room behind it, over Lupton's entrance-arch, and large bedchambers beyond, joining the hall. In the will of the founder a much smaller provost's lodging is placed in this position in two stories. The present extension is accounted for by the bountiful hospitality which, at and after the period of Henry the Eighth, was exercised by the masters of colleges in favour of the nobility and gentry. This compelled the building of chambers and reception rooms. After the Reformation the marriage of masters of colleges created a new demand for space, and made it necessary to supply these officers with a family residence.

The subsequent works carried out in this college were enumerated as follows: The lower school, or north side of the entrance quadrangle or "school-yard," was built before 1581, and has the long dormitory above it. The library in the cloister quadrangle was built by Sir Christopher Wren. The new The new upper school, which is the western boundary of the school-yard, was rebuilt in 1689. In 1758 an attic was raised upon the east and north sides of the cloister court, and the entire group of chambers altered so as to convert them into a row of private houses of three stories each for the fellows of the college. Lastly, the interior of the chapel, which had been refitted and "beautified" in the Italian style in 1699, by Mr. Banks, was well restored to its ancient aspect, with rich stalls and canopies, in 1850, from the designs of Mr. Deason.

THE ARCHITECTURE OF ASIA.

Since the revival of Mediæval architecture, the studies and researches of archæologists and professors have been usually limited to Europe. We began—and very naturally—with that phase of our own English Pointed which approached nearest to our own day in point of date, and which is connected with the Italian work of our best Renaissance period by the transitional Elizabethan style.

From Perpendicular we fell back successively on Florid Decorated, Early Decorated, Early Pointed, and Norman; and then we began to have recourse to French examples, taking them also in the same retrograde order, till French Romanesque being now pretty well exhausted by the archæologists—though not by the architects—the former are betaking themselves to the early Christian architecture of Syria and Asia Minor; and before long we shall no doubt hear of Early Syrian as an admitted style in which to erect a nineteenth century church.

Some portions of the field of art available in Europe have been more popular than others, but magnificent examples of architectural research exist, from which the Moorish architecture of Spain, the Norman of Sicily, the still earlier art of Ravenna, and the more oriental types of Venice, have respectively furnished the subjects, although notwithstanding that there is not one of these phases of art which can ever be said to have been popular enough here or in France for its revival to have been seriously attempted.

It will soon then be time for the antiquarians, whose cry like that of the ancient Anthenians, is ever for some new thing, which, however, must be old as well as novel in order to please them, to turn their attention to a new field; but it is also not improbable that among the students of architecture, as distinct from archæology, there are few who will not welcome an introduction to a fresh field where a development of architectural art hitherto little known or valued awaits their study.

To such the field of Western India may be well recommended as containing a fund of wealth, little known, and less cared for, embodied in piles of masonry crumbling to decay, and fast becoming desecrated and destroyed, but displaying a noble, a consistent, and a highly developed phase of art.

We have before us at this moment a volume of photographs from some of the most remarkable Mohammedan buildings of Ahmedabad, of which we shall in a future number give a careful notice, in the form of a review. This, by far the most accessible illustration of the art to which we are now endeavouring to bespeak attention, shows a mere fragment of the whole, and gives but an inadequate idea of the beauty and completeness of the work. Such as it is, however, we are delighted that it should be published, for the periods of high art have not lasted so long and their influence has not extended so wide as to make us willing to forego the knowledge of any truly noble work; and however well such works as these of Mr. Ferguson may have unfolded some of the peculiarities of the various Indian styles, the beauties of this, by far the most artistic of them all, are not familiar to many. The distance and climate of India render a visit to these works themselves formidable, yet we cannot forbear expressing the opinion, that before long they are likely to become a favourite field of research.

COTTAGES FOR AGRICULTURAL LABOURERS AND WORKMEN.

(*With an Engraving.*)

So much has been said and written upon this subject during the last few years, that it might appear little more relating to it remains to be stated or suggested. A variety of designs for cottages have been illustrated and described from time to time in this Journal, and in other publications; and many of these have possessed considerable merit, as to design and arrangement of plan. In many counties of England examples of such cottages have been erected, and are proofs of the great desire on the part of some landed proprietors to benefit the agriculturalists living upon their estates. In other cases, large manufacturers have manifested a great interest in the welfare of their workmen by the erection of whole villages of improved dwellings, the rental from which would not return even a moderate interest upon their cost. Those landlords who have in this way studied the comfort and well-being of their labourers appear to have adopted the late Lord Palmerston's idea who considered it was the duty of the landlord to provide decent homes for the agricultural labourers working upon his estates. He felt justly, that the wages received by the labourer is such that it is out of his power to pay in weekly rent sufficient to render cottage building a profitable investment; but he considered that a farmstead is imperfect unless the landlord provide cottages for the labourer as a necessary appendage to a farm, in the same manner as a dairy is to a farm house. As such he placed the investment on the acreage of the land.

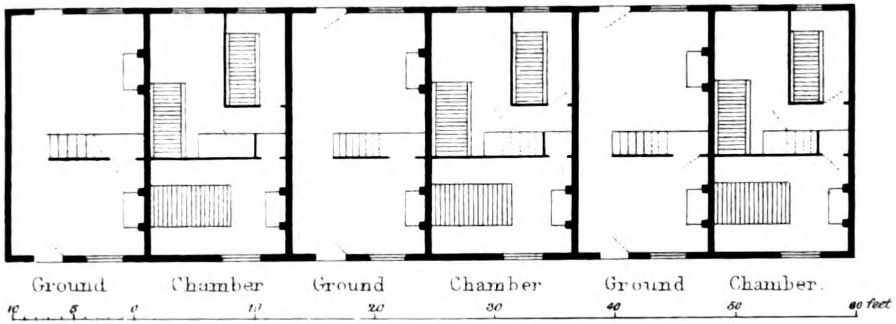
The model cottages built by the late Lord Palmerston at Broadlands, and by other landlords, do them much credit, but a mistake has in most instances been the unnecessary increase of cost, by making the rooms larger, with walls finished inside more expensively, than is at all desired by an agricultural labourer, thus causing these improved cottages to be comparatively rare in England.

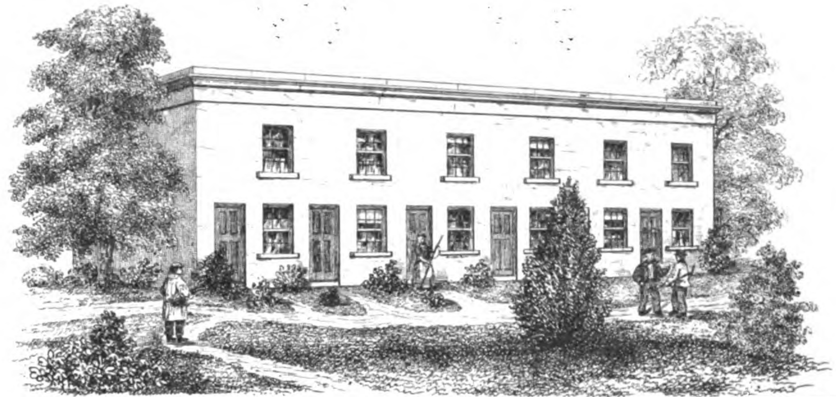
Landlords desiring to erect labourers' dwellings would find some useful suggestions in a little book;* entitled "Healthy

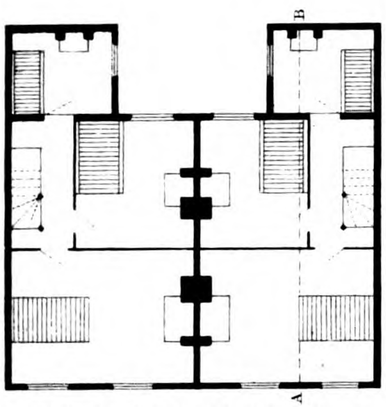
* "Healthy Moral Homes for Agricultural Labourers." 8vo., 24 plates. Published by the Author, P. Thompson, 24, High Street, Marylebone.

BLOCK OF SIX COTTAGES. - EACH WITH FIVE ROOMS, CONCRETE WALLS FLOORS AND ROOF, COST £ 70 EACH COTTAGE

PLANS

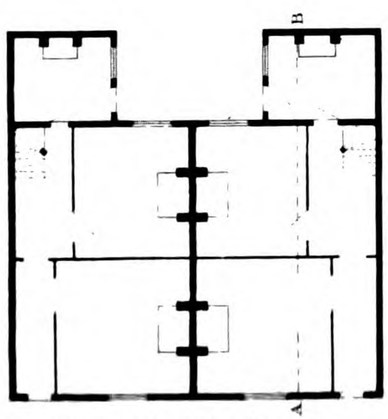






PLAN CHAMBER FLOOR

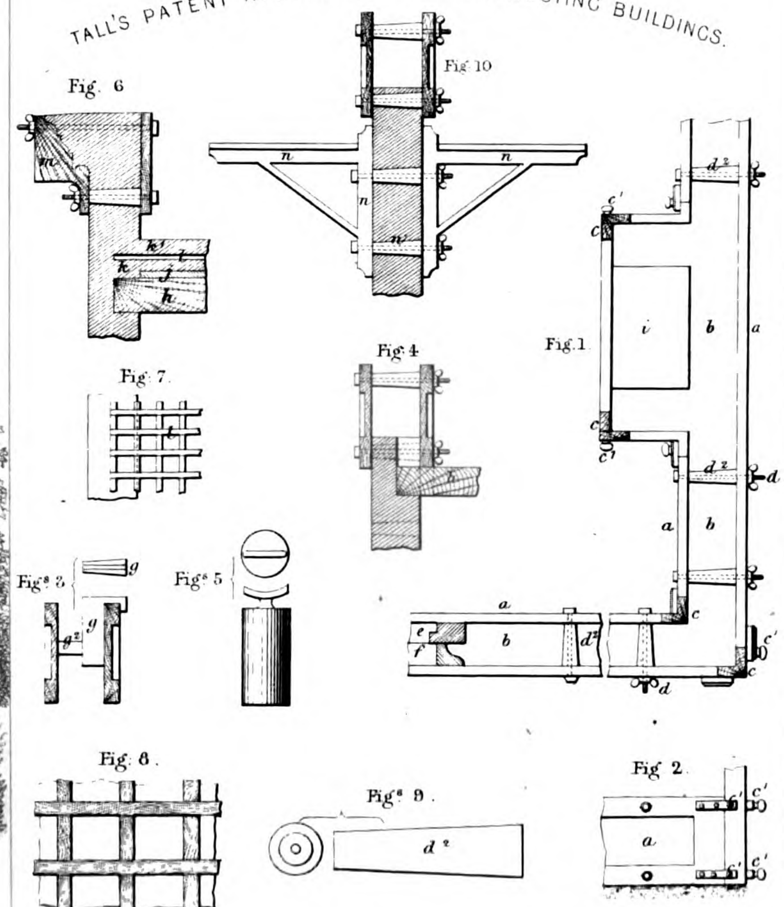
Transverse Section on line A B.



PLAN GROUND FLOOR

TWO SIX ROOM SEMI DETACHED HOUSES
Concrete Walls, Floors, and Roofs,
Cost £ [illegible] each house.

TALL'S PATENT APPARATUS FOR CONSTRUCTING BUILDINGS.



Moral Homes," the object of which is to prove that this class of cottages can be built at such a cost as to meet the low wages received by the agricultural labourer, and that the owner would receive a fair interest upon his outlay.

The suitability of concrete as a material for the cheap construction of walls of houses and other buildings has recently been tested, by the erection of two semi-detached cottages in the Woolwich Road, Bexley Heath, Kent, all the walls as well as the ground floor and roof of which are of concrete. These two cottages are illustrated on the accompanying Plate, (No. 34) by a perspective view, ground and chamber plan, and transverse section. They each contain six rooms and the cost of each, including carpenters' and joiners' work and all fixtures, was £100. The concrete walls of these dwellings were constructed by means of an apparatus invented and patented by Mr. Tall of the Old Kent Road, London. Part of this apparatus forms a scaffold as the work progresses. It is illustrated by the diagrams, figs. 1 to 10, (Plate 34), and will be best understood in the words of the specification of the patent, which we quote.

The object of this invention is to effect an economy in building dwelling-houses, cottages, garden walls, &c., by forming such structures in concrete combined with brick rubbish or other hard durable substance in place of employing costly brickwork or masonry, as is now the case. In carrying out this invention, an ordinary concrete foundation is laid, and upon the foundation horizontal frames, constructed of boards lined with zinc or other metal, are set up on edge. These frames, as shown in plan at fig. 1, plate 34, and in side elevation at fig. 2, will form the outer and inner faces of the walls to be built, and the two sides *a*, *a*, of the frames will together constitute a kind of trough *b*, for receiving the concrete and other matters of which the wall is to be composed. The walls or boards of the frame are secured at the angles to angular pillars or supports *c*, *c*, by means of thumb screws c^1, c^1. Gauge couplings *d*, *d*, may also be used to connect the sides *a*, *a*, of the frames together, and keep them from bulging. As the concrete in the trough *b* sets, the frames are to be shifted higher up the pillars *c*, *c*, and again attached or secured by the thumb screws c^1, and a further supply concrete and other materials is laid in the raised trough *b*. When the wall has been raised to a level for the doorway, the door frame is set up as at *e*, figs. 1 and 2, in the trough at the part where the door is required to be fixed, and a second frame *f*, acting as a core, forms the required reveal in the wall. In like manner, the openings for the windows are to be formed.

To allow of the flooring joists being bedded or inserted into the walls, cores representing the ends of the joists are used, so as to form recesses for the ends of the joists. Fig. 3 represents the cores *g*, *g*, formed in three pieces, so that by withdrawing the centre piece, which is wedge-shaped, the other pieces may be easily removed. They are secured behind by a block piece g^2. When placed in the trough, they are concreted over. When the concrete is set, the cores *g*, *g*, may be withdrawn, and the recesses will be provided for receiving the ends of the joists *n*, as shown in the detatched sectional view, fig. 4.

For the fireplaces and chimney flues, where they occur, the construction of the inner frame is changed, and the frame is constructed with a suitable angular internal projecting part, as shown at fig. 1, a core or block *i*, being provided for the fireplace. The flues are made by inserting cores nine inches in diameter, consisting of solid blocks or hollow tubes. These cores, which are shown detahced in plan and elevation at fig. 5, are drawn up higher and higher as the wall rises, so that a circular flue of the proper diameter is then formed. A suitable core *i*, is also provided for forming the fireplaces and for connecting them with the flues. In order to form the roof, a rough flooring of joists *h*, is first laid, as shown at fig. 6, and boards *j*; then the joists and boards are covered over with a layer of concrete *k*. Over this a latice work of hoop iron *l*, *l*, is next laid, or woodwork may be used, as at fig. 7, which will overlie or be inserted into half the thickness of the walls. This lattice work is covered with another layer of concrete k^1, care being taken to give the upper surface a suitable inclination to throw off the rain. If preferred, an arched roof may be constructed by applying concrete over an ordinary centre or arched framework covered with zinc, by which a smooth surface is produced.

In order to form cornices for the windows and doorways, moulds, as shown at *m*, fig. 6, are employed, which whether applied at the time of building up the walls or afterwards, admit of the cornice being cast in position by running the concrete into the mould.

For forming the ground floors of cottages and warehouses, the ground is covered with a layer of concrete, and upon this concrete is laid a lattice work of wood of square or other pattern, as shown in plan at fig. 8, and the spaces between the laths of lattice work are filled with concrete, the wood work being exposed.

Instead of using the angular pillars *c*, above mentioned, and shown in figs. 1 and 2, the side frames *a*, *a*, may, at the commencement of the work, be connected together at the angles by angle pieces equal in depth to the width of the frames, or the side frames may be connected together at their ends by screws; but in whatever way the ends of the side frames are connected together, the frames *a*, *a*, forming the opposite sides of the trough *b*, must be connected together throughout their length by two lines of the cross tie bolts *d*, *d*, which pass through the hollow cores d^2, d^2, shown detached at figs. 9. As the wall is formed, the bolts *d*, are withdrawn, to allow of the side frames *a*, being raised, and the lower series of bolts *d*, are again to be applied to the frames, but this time they will be passed through the holes in the concrete formed by the upper series. In this way the work will serve to support the frames, and the angular pillars *c*, will nor be required. It will be obvious that chimney shafts may be erected in a similar manner to the wall building above described. In proceeding with such erections, the use of expensive scaffolding may be avoided by coring out openings for the putlogs or supporting timbers, which carry the stages for the workmen. This is shown at fig. 10, which represents a portion of a wall with a scaffolding or stage supported upon brackets *n*, *n*, which are secured to the wall by the tie bolts n^1, n^1, When the brackets and their platform are no longer required, the bolts n^1 are withdrawn and the cores knocked out; the holes thus left may then be filled up.

Among the advantages resulting from this employment of concrete, as stated by the inventor of the apparatus referred to, are a saving of one half the cost of the walls as compared with brickwork; greater strength; the walls being thoroughly impervious to wet or damp; the ease with which circular flues can be formed in the thickness of the walls for the passage of smoke and for entilating shafts; that concrete walls are bad conductors of sound as well as of cold and heat; the absence of necessity for bond timbers; and that the walls being nearly smooth require but one coat of plaster internally. Mr. Tall states that cottages each containing five rooms, built in blocks of four or six, with a frontage of 12 feet and a depth from front to back of 21 feet 8 inches, heigth from floor to ceiling 7 feet 6 inches, with wood barn 7 feet square, can be built for £50 each. A block of six cottages of this class is also illustrated in the accompanying plate. It must be understood that we do not illustrate these cottages on the score of any merit in their design, but merely to show what has been done to cheapen the cost of labourers' dwellings by the employment of concrete.

The proportions of materials for concrete employed in the construction of the cottages described were 30 cubic yards of gravel stone, through a five-eights inch sieve; 3 cubic yards of Portland cement, 3 cubic yards of drift or river sand. 30 cubic yards of this concrete will build 120 yards of 9 inch work at a fraction over 1s. 8d. per yard. The cost of labour is stated to be 9d. per superficial yard of 9 inch work.

It may be stated that the Emperor of the French has ordered the erection, in Paris, of several blocks of workmens' dwellings, five stories in height, the walls of which, entirely of concrete, are now being constructed with the aid of the apparatus above described.

TRIAL OF A STEAM FIRE ENGINE.

On the 27th ult., an interesting official trial took place at the Royal Dockyard, Deptford, with a large steam fire engine just constructed for this dockyard by Messrs. Merryweather & Sons, from the designs of Mr. Edward Field, C.E.; the engine being, in general arrangement and construction, like those already supplied by the same firm for Devonport and Portsmouth dockyards and the Metropolitan Fire Brigade. Similar engines are likewise in hand, we are informed, for the dockyards of Woolwich and Chatham, and for the Russian and Belgian Governments.

The engine under notice has double cylinders and is arranged on the long steady stroke principle, with direct action between steam cylinders and pumps; the boiler being on the "Field" principle, now extensively employed both for stationary and portable purposes. The chief points aimed at in the designing of these engines have been simplicity, durability, efficiency. accessibility of the various parts, and facilities for repairing in cases of damage arising through the carelessness of attendants; especially in allowing the boilers to become short of water; as an instance of which we may mention that in the case of one of these engines recently returned from a fire engine station, the boiler had been allowed to get short of water, and that although nearly the whole of the tubes were burned, the other parts of the boiler were not in any way injured; and the engine was returned in perfect working order within 14 hours; whereas had the boiler been of the usual vertical tubular construction, there can be no doubt that it would have been entirely destroyed. The "Field" boiler, as applied to these engines, has, in numerous competitive trials against English and American engines, shown itself capable of raising steam in most cases from 3 to 4 minutes, and even on some occasions 10 minutes earlier than the boilers of competing engines, which is a great advantage in enabling an early attack to be made upon a fire. Another feature of these engines is that they are entirely free from a defect which sorely troubles all engines on the vertical system, viz., the excessive friction produced when pumping sandy water; amounting in many cases to 50 per cent. of the power of the engines, which have been known to work well during their early trials, but to decline in duty after a short period. This difficulty is overcome in Merryweather's engines by the peculiar construction of the pumps which have self-lubricating pistons, and discharge all sand and gritty matter through the valves without its passing through the barrels of the pumps.

At the trial on the 27th ult. which was considered highly satisfactory, the boiler was supplied with cold water; various pressures of steam being obtained as follows, viz., 5 lbs. per square inch in 4 minutes from time of lighting the fire; 20 lbs. in 5 minutes 30 seconds; 30 lbs. in 5 minutes 20 seconds; 40 lbs. in 7 minutes; 60 lbs. in 7 minutes 30 seconds; 80 lbs. in 8 minutes; 90 lbs. in 8 minutes 15 seconds; 100 lbs. in 8 minutes 30 seconds. The engine was then started, and in 9 minutes from the time of lighting the fire, a strong jet of water $1\frac{1}{2}$ inches in diameter was issuing from the nozzle, jets of various sizes were used, up to 2 inches in diameter, and four streams of $\frac{7}{8}$ inches diameter were projected. All the jets were thrown to great heights and distances, and went with great force well over chimney shafts in its vicinity notwithstanding the strong wind. The hydraulic pressure was sometimes 140 lbs. per square inch.

The engine with its suction and delivery boxes, while working remained practically quite free from vibration or oscillation. The two steam cylinders of this engine are each $8\frac{5}{8}$ inch diameter, and 24 inch stroke; each pump barrel being $6\frac{1}{2}$ inch diameter, and having the same stroke as the steam cylinders.

These trials were witnessed by Captain Wilmott, dockyard superintendent; Mr. Saunders, master shipwright; Mr. Simmonds, assistant engineer; and several other scientific men.

THE RESTORATION OF ST. DAVID'S CATHEDRAL.

The lower part of the great tower of St. David's Cathedral was in danger of falling, and new piers have recently been put in. The tottering condition of the tower needed prompt attention, and Mr. Geo. Gilbert Scott was invited to examine and report in 1862, upon this magnificent monument of the early ecclesiastical architecture of this country.

Mr. Scott's report was to the effect that the present structure was commenced about the year 1180, by Bishop de Leia at the exact time when the Romanesque or round arched style was in a state of transition into the Pointed Gothic, and at the period when architecture was being freed from the barbarism of the dark ages. About this time also the church of St. Cross, near Winchester, was built, also the eastern portions of Canterbury Cathedral, and the present Abbey of Glastonbury, all of which somewhat resemble St. David's Cathedral in style. The latter exhibits much beauty and refinement in its details, especially in the carved foliage and ornamental masonry, but it was rather backward in the adoption of the pointed arch. The whole of the building commenced in 1180 was prepared to be vaulted with stone on the "sexpartite" principle, but it is not evident that the vaulting was carried out.

In 1220 the great central tower fell in, severely injuring the choir and transept. One side of the ruined tower was left standing, that of the western arch with its two piers, so three sides of the tower with three arches were built up anew. In 1248 the building was much shaken by an earthquake, rendering much reconstruction necessary; chapels were extensively added, and about 1300, the Lady Chapel was either erected or greatly enlarged by Bishop David Martin, who probably carried up the tower to within one stage of its present height. Bishop Gower, who held the see from 1328 to 1347, had an insatiable appetite for building, so he enlarged and altered much of the cathedral, and besides erected the stupendous bishop's palace alongside. During his time the rood-screen was constructed, and several beautiful monuments introduced. In the next century Bishop Lloyd made further improvements, added a storey to the great tower, and reconstructed the gorgeous roof of the nave. From the fifteenth century to the present time the cathedral has been falling into a disgraceful state of decay, inhabited principally by the owls and bats, and when Mr. Scott made his survey, the walls and pavements were streaming with water. As might be expected, the old and new sides of the tower had begun to separate in the course of years, so he found a great crack in the masonry caused by the sinking of the western side, which also crushed down portions of the nave, and threw most of the pillars of the arches out of the perpendicular; in fact the ruin was in a most melancholy state, and the tower in immediate danger of falling.

Mr. Scott estimated the necessary expense of the restoration at £30,000. He proposed to follow the ancient style of architecture in all respects, so as to retain the ancient features of the building in their perfection, to make the tower safe, and to bring the edifice into a state of seemliness as a parish church, all that would be necessary for the few Cambrians in St. David's likely to attend service therein. The work of restoration was then divided into four contracts, and the most urgent being that for the preservation of the great tower, it was let out first to Messrs. Wood & Sons, of Worcester. This contract amounts to £11,000, which sum includes the construction of a drain all round the cathedral to carry off the water already mentioned, taking out the two west piers of the tower and replacing them with new on the ancient model, restoring the tower and repairing and restoring the choir stalls and seats, repairing the organ, and repairing thoroughly the eastern chancel.

The work of reparation was commenced about a year and a-half ago, by the difficult task of repairing the tower, on the same plan as that adopted a few years since in the preservation of the tower of the cathedral of Bayeux, in France. The tower of St. David's Cathedral is 124 feet high, 40 feet square externally, and weighs more than 4,000 tons. Mr. Clear, the resident architect, began by fixing bracing inside and outside the tower, and bolting its walls together to make it as much in one piece as possible, after which he screwed the sides of the tower 3 in. closer to each other. The bracing which consisted of massive ties of iron, of course took none of the weight of the tower. He next constructed some incompressible foundations for shoring of the most massive description, the supports containing, in all, 17,000 cubic feet of timber under the north and west arches, and against the two western piers. The whole weight of the tower rested for a considerable length of time principally upon the shoreing upon oak needles passing through the spandrils of the arches, wrought-iron girders being placed across the angles. The needles were supported by fir logs erected nearly perpendicularly, each of the logs being composed of nine pieces of timber from 14in. square, bolted and framed together.

While the tower rested on the main shoring, the two western piers were gradually rebuilt beneath it, in good cement work and in small portions at a time, a movable system of shores being used to sustain the work in immediate contact with the parts operated upon. The north-west pier was commenced in January last, and finished in March, when the south-west pier was completed. In the course of the restorations relics have been found indicating that a Christian place of worship existed on the site of the cathedral before the time of Bishop de Leia, although a popular superstition in Pembrokeshire, that St. Paul once landed at St. David's, was in no way corroborated. Several graves have been necessarily disturbed during the building operation, and Mr. Clear says of them, that beneath the dais in front of the rood-screen a grave was discovered, well built with ashlar, in three courses, and covered about three parts over with the hard roughly hewn local stone. Only earth and a few pieces of leather were found in this grave.

Another grave close by was built of hewn stone in three courses, with a cavity at the east end to fit the head, very similar to those of the eleventh or twelfth centuries, composed of a single block of stone. In it were found a human skeleton undisturbed, the head of a pastoral staff, the recent part of the handle of the staff, a chalice of thin silver, also a gold ring with an amethyst set in it. The pastoral staff head and portion of handle were of copper gilded, delicately chased, and in good preservation. It is conjectured that this might perhaps be the grave of Bishop Richard de Carew, who died on the 1st of April, 1280, and was buried, according to Leland, "*prope altare crucifixi.*"

RECENT PROGRESS OF SCIENCE.*

By W. R. Grove, F.R.S.,

President, British Association for the Advancement of Science, 1866-67.

If our rude predecessors, who at one time inhabited the caverns which surrounded this town, could rise from their graves and see it in its present state, it may be doubtful whether they would have sufficient knowledge to be surprised.

The machinery, almost resembling organic beings in delicacy of structure, by which you fabricate products of world-wide reputation, the powers of matter applied to give motion to that machinery, are so far removed from what must have been the conceptions of the semibarbarians to whom I have alluded, that they could not look on them with intelligent wonder.

Yet this immense progress has all been effected step by step, now and then a little more sudden than at other times; but, viewing the whole course of improvement, it has been gradual, though moving in an accelerated ratio. But it is not merely in those branches of natural knowledge which tend to improvements in economical arts and manufactures, that science has made great progress. In the study of our own planet and the organic beings with which it is crowded, and in so much of the universe, as vision, aided by the telescope, has brought within the scope of observation, the present century has surpassed any antecedent period of equal duration.

It would be difficult to trace out all the causes which have led to the increase of observational and experimental knowledge.

Among the more thinking portion of mankind the gratification felt by the discovery of new truths, the expansion of faculties, and extension of the boundaries of knowledge have been doubtless a sufficient inducement to the study of nature; while, to the more practical minds, the reality, the certainty, and the progressive character of the acquisitions of natural science, and the enormously increased means which its applications give, have impressed its importance as a minister to daily wants and a contributor to ever-increasing material comforts, luxury, and power.

Though by no means the only one, yet an important cause of the rapid advance of science is the growth of associations for promoting the progress either of physical knowledge generally, or of special branches of it. Since the foundation of the Royal Society, now more than two centuries ago, a vast number of kindred societies have sprung up in this country and in Europe. The advantages conferred by these societies are manifold; they enable those who are devoted to scientific research, to combine, compare, and check their observations, to assist, by the thoughts of several minds, the promotion of the inquiry undertaken; they contribute from a joint purse to such efforts as their members deem most worthy; they afford a means of submitting to a competent tribunal notices and memoirs, and of obtaining for their authors and others, by means of the discussions which ensue, information given by those best informed on the particular subject; they enable the author to judge whether it is worth his while to pursue the subjects he has brought forward, and they defray the expense of printing and publishing such researches as are thought deserving of it.

These advantages, and others might be named, pertain to the Association, the 36th Meeting of which we are assembled to inaugurate; but it has, from its intermittent and peripatetic character, advantages which belong to none of the societies which are fixed as to their locality.

Among these are the novelty and freshness of an annual meeting, which, while it brings together old Members of the Association, many of whom only meet on this occasion, always adds a quota of new Members, infusing new blood, and varying the social character of our meetings.

The visits of distinguished foreigners, whom we have previously known by reputation, is one of the most delightful and improving of the results. The wide field of inquiry, and the character of communications made to the Association, including all branches of natural knowledge, and varying from simple notices of an interesting observation or experiment, to the most intricate and refined branches of scientific research, is another valuable characteristic.

Lastly, perhaps the greatest advantage resulting from the annual visits of this great parliament to new localities is that, while it imparts fresh local knowledge to the visitors, it leaves behind stimulating memories, which rouse into permanent activity dormant or timid minds—an effect which, so far from ceasing with the visit of the Association, frequently begins when that visit terminates.

Every votary of physical science must be anxious to see it recognized by those institutions of the country which can to the greatest degree promote its cultivation and reap from it the greatest benefit. You will probably agree with me that the principal educational establishments on the one hand, and on the other the Government, in many of its departments, are the institutions which may best fulfil these conditions. The more early the mind is trained to a pursuit of any kind, the deeper and more permanent are the impressions received, and the more service can be rendered by the students.

Little can be achieved in scientific research without an acquaintance with it in youth; you will rarely find an instance of a man who has attained any eminence in science who has not commenced its study at a very early period of life. Nothing, again, can tend more to the promotion of science than the exertions of those who have early acquired the *ethos* resulting from a scientific education. I desire to make no complaint of the tardiness with which science has been received at our public schools and, with some exceptions, at our Universities. These great establishments have their roots in historical periods, and long time and patient endeavour is requisite before a new branch of thought can be grafted with success on a stem to which it is exotic. Nor should I ever wish to see the study of languages, of history, of all those refined associations which the past has transmitted to us, neglected; but there is room for both. It is sad to see the number of so-called educated men who, travelling by railway, voyaging by steamboat, consulting the almanac for the time of sunrise or full-moon, have not the most elementary knowledge of a steam-engine, a barometer, or a quadrant; and who will listen with a half confessed faith to the most idle predictions as to weather or cometic influences, while they are in a state of crass ignorance as to the cause of the trade-winds or the form of a comet's path. May we hope that the slight infiltration of scientific studies, now happily commenced, will extend till it occupies its fair space in the education of the young, and that those who may be able learnedly to discourse on the Eolic digamma will not be ashamed of knowing the principles of an air-pump, an electrical machine, or a telescope, and will not, as Bacon complained of his contemporaries, despise such knowledge as something mean and mechanical.

To assert that the great departments of Government should encourage physical science may appear a truism, and yet it is but of late that it has been seriously done; now, the habit of consulting men of science on important questions of national interest is becoming a recognized practice, and in a time, which may seem long to individuals, but is short in the history of a nation, a more definite sphere of usefulness for national purposes will, I have no doubt, be provided for those duly qualified men who may be content to give up the more tempting study of abstract science for that of its practical applications. In this respect the Report of the Kew Committee for this year affords a subject of congratulation to those whom I have the honour to address. The Kew Observatory, the petted child of the British Association, may possibly become an important national establishment; and if so, while it will not, I trust, lose its character of a home for untrammelled physical research, it will have superadded the Meteorological Department of the Board-of Trade with a staff of skilful and experienced observers.

This is one of the results which the general growth of science, and the labours of this Association in particular, have produced; but I do not propose on this occasion to recapitulate the special objects attained by the Association, this has been amply done by several of my predecessors; nor shall I confine my address to the progress made in physical science since the time when my most able and esteemed friend and predecessor addressed you at Birmingham. In the various reports and communications which will be read at your Sections, details of every step which has been made in science since our last Meeting will be brought to your notice, and I have no doubt fully and freely discussed.

I purpose to submit to you certain views of what has within a comparatively recent period been accomplished by science, what have been the steps leading to the attained results, and

* Inaugural Address, delivered at the Annual Meeting of the British Association, Nottingham, August, 1866.

what, as far as we may fairly form an opinion, is the general character pervading modern discovery.

It seems to me that the object we have in view would be more nearly approached, by each President, chosen as they are in succession as representing different branches of science, giving on these occasions either an account of the progress of the particular branch of science he has cultivated, when that is not of a very limited and special character, or enouncing his own view of the general progress of science; and though this will necessarily involve much that belongs to recent years, the confining a President to a mere *résumé* of what has taken place since our last Meeting would, I venture with diffidence to think, limit his means of usefulness, and render his discourse rather an annual register than an instructive essay.

I need not dwell on the common-place but yet important topics of the material advantages resulting from the application of science; I will address myself to what, in my humble judgment, are the lessons we have learned and the probable prospects of improved natural knowledge.

One word will give you the key to what I am about to discourse on; that word is *continuity*, no new word, and used in no new sense, but perhaps applied more generally than it has hitherto been. We shall see, unless I am much mistaken, that the development of observational, experimental, and even deductive knowledge is either attained by steps so extremely small as to form really a continuous ascent: or, when distinct results apparently separate from any co-ordinate phenomena have been attained, that then, by the subsequent progress of science, intermediate links have been discovered uniting the apparently segregated instances with other more familiar phenomena.

Thus the more we investigate, the more we find that in existing phenomena graduation from the like to the seemingly unlike prevails, and in the changes which take place in time, gradual progress is, and apparently must be, the course of nature.

Let me now endeavour to apply this view to the recent progress of some of the more prominent branches of science.

In Astronomy, from the time when the earth was considered a flat plain bounded by a flat ocean,—when the sun, moon, and stars were regarded as lanterns to illuminate this plain,—each successive discovery has brought with it similitudes and analogies between this earth and many of the objects of the universe with which our senses, aided by instruments, have made us acquainted. I pass, of course, over those discoveries which have established the Copernican system as applied to our sun, its attendant planets, and their satellites. The proofs, however, that gravitation is not confined to our solar system, but pervades the universe, have received many confirmations by the labours of Members of this Association; I may name those who have held the office of President, Lord Rosse, Lord Wrottesley, and Sir J. Herschel, the two latter having devoted special attention to the orbits of double stars, the former to those probably more recent systems called nebulæ. Double stars seem to be orbs analogous to our own sun and revolving round their common centre of gravity in a conic section curve, as do the planets with which we are more intimately acquainted; but the nebulæ present more difficulty, and some doubt has been expressed whether gravitation, such as we consider it, acts with those bodies (at least those exhibiting a spiral form), as it does with us; possibly some other modifying influence may exist, our present ignorance of which gives rise to the apparent difficulty. There is, however, another class of observations quite recent in its importance, and which has formed a special subject of contribution to the Reports and Transactions of this Association; I allude to those on Meteorites, at which our lamented Member, and to many of us our valued friend, Prof. Baden Powell assiduously laboured, for investigations into which a Committee of this Association is formed, and a series of star-charts for enabling observers of shooting-stars to record their observations, was laid before the last Meeting of the Association by Mr. Glaisher.

It would occupy too much of your time to detail the efforts of Bessel, Schwinke, the late Sir J. Lubbock, and others, as applied to the formation of star-charts for aiding the observation of meteorites which Mr. Alexander Herschel, Mr. Brayley, Mr. Sorby, and others are now studying.

Dr. Olmstead explained the appearance of a point from which the lines of flight of meteors seem to radiate, as being the perspective vanishing point of their parallel or nearly parallel courses appearing to an observer on the earth as it approaches them. The uniformity of position of these radiant points, the many corroborative observations on the direction, the distances, and the velocities of these bodies, the circumstance that their paths intersect the earth's orbit at certain definite periods, and the total failure of all other theories which have been advanced, while there is no substantial objection to this, afford evidence almost amounting to proof that these are cosmical bodies moving in the interplanetary space by gravitation round the sun, and some perhaps round planets. This view gives us a new element of continuity. The universe would thus appear not to have the extent of empty space formerly attributed to it, but to be studded between the larger and more visible masses with smaller planets, if the term be permitted to be applied to meteorites.

Observations are now made at the periods at which meteors appear in greatest numbers—at Greenwich by Mr. Glaisher, at Cambridge by Prof. Adams, and at Hawkhurst by Mr. Alexander Herschel—and every preparation is made to secure as much accuracy as can, in the present state of knowledge, be secured for such observations.

The number of known asteroids, or bodies of a smaller size than what are termed the ancient planets, has been so increased by numerous discoveries, that instead of seven we now count eighty-eight as the number of recognized planets—a field of discovery with which the name of Hind will be ever associated.

If we add these, the smallest of which is only three or four miles in diameter, indeed cannot be accurately measured, and if we were to apply the same scrutiny to other parts of the heavens as has been applied to the zone between Mars and Jupiter, it is no far-fetched speculation to suppose that between these asteroids and the meteorites, bodies of intermediate size exist until the space occupied by our solar system becomes filled up with planetary bodies varying in size from that of Jupiter (1240 times larger in volume than the earth), to that of a cannon-ball or even a pistol-bullet.

The researches of Leverrier on the intra-mercurial planets come in aid of these views; and another half century may, and not improbably will, enable us to ascertain that the now seemingly vacant interplanetary spaces are occupied by smaller bodies which have hitherto escaped observation, just as the asteroids had until the time of Olbers and Piazzi. But the evidence of continuity as pervading the universe does not stop at telescopic observation; chemistry and physical optics bring us new proofs. Those meteoric bodies which have from time to time come so far within reach of the earth's attraction as to fall upon its surface, give on analysis metals and oxides similar to those which belong to the structure of the earth—they come as travellers bringing specimens of minerals from extra-terrestrial regions.

In a series of papers recently communicated to the French Academy, M. Daubrée has discussed the chemical and mineralogical character of meteorites as compared with the rocks of the earth. He finds that the similarity of terrestrial rocks to meteorites increases as we penetrate deeper into the earth's crust, and that some of the deep-seated minerals have a composition and characteristics almost identical with meteorites [olivine, herzolite and serpentine, for instance, closely resemble them]; that as we approach the surface, rocks having similar components with meteorites are found, but in a state of oxidation, which necessarily much modifies their mineral character, and which, by involving secondary oxygenized compounds, must also change their chemical constitution. By experiments he has succeeded in forming from terrestrial rocks substances very much resembling meteorites. Thus close relationship, though by no means identity, is established between this earth and those wanderers from remote regions, some evidence, though at present incomplete, of a common origin.

Surprise has often been expressed that, while the mean specific gravity of this globe is from five to six times that of water, the mean specific gravity of its crust is barely half as great. It has long seemed to me that there is no ground for wonder here. The exterior of our planet is to a considerable depth oxidated; the interior is in all probability free from oxygen, and whatever bodies exist there are in a reduced or deoxidated state, if so, their specific gravity must necessarily be higher than that of their oxides or chlorides, &c.: we find, moreover, that some of the deep seated minerals have a higher specific gravity than the average of those on the surface; olivine, for instance, has a specific gravity of 3·3. There is therefore no *à priori* improbability that the mean specific gravity of the earth should notably exceed that of its surface; and if we go further and suppose the interior of the earth to be formed of the same ingredients as the exterior, minus oxygen, chlorine, bromine, &c., a specific gravity of 5 to 6 would not be an unlikely one. Many of the elementary bodies entering largely into the formation of the earth's crust are as light or lighter than water,—for instance, potassium, sodium, &c.; others, such as sulphur, silicon, aluminium, have from two to three times its specific gravity; others, again, as iron, copper, zinc, tin, seven to nine times; while others, lead, gold, platinum, &c., are much more dense,—but, speaking generally, the more dense are the least numerous. There seems no improbability in a mixture of such substances producing a mean specific gravity of from 5 to 6, although it by no means follows, indeed the probability is rather the other way, that the proportions of the substances in the interior of the earth are the same as on the exterior. It might be worth the labour to ascertain the mean specific gravity of all the known minerals on the earth's surface, averaging them in the ratios in which, as far as our knowledge goes, they quantitatively exist, and assuming them to exist without the oxygen, chlorine, &c., with which they are, with some rare exceptions, invariably combined on the surface of the earth: great assistance to the knowledge of the probable constitution of the earth might be derived from such an investigation.

While chemistry, analytic and synthetic, thus aids us in ascertaining the relationship of our planet to meteorites, its relation in composition to other planets, to the sun, and to more distant suns and systems is aided by another science, viz. optics.

That light passing from one transparent medium to another should carry with it evidence of the source from which it emanates, would, until lately, have seemed an extravagant supposition; but probably (could we read it), everything contains in itself a large portion of its own history.

I need not detail to you the discoveries of Kirchhoff, Bunsen, Miller, Huggins, and others, they have been dilated on by my predecessor. Assuming that spectrum analysis is a reliable indication of the presence of given substances by the position of transverse bright lines exhibited when they are burnt and of transverse dark lines when light is transmitted through their vapours, though Plücker has shown that with some substances these lines vary with temperature, the point of importance in the view I am presenting to you is, that while what may be called comparatively neighbouring cosmical bodies exhibit lines identical with many of those shown by the components of this planet, as we proceed to the more distant appearances of the nebulæ we get but one or two of such lines, and we get but one or two new bands not yet identified with any known to be produced by substances on this globe.

Within the last year Mr. Huggins has added to his former researches observations on the spectrum of a comet (comet 1 of 1866), the nucleus of which shows but one bright line, while the spectrum formed by the light of the coma is continuous, seeming to show that the nucleus is gaseous while the coma would consist of matter in a state of minute division shining by reflected light: whether this be solid, liquid, or gaseous is doubtful, but the author thinks it is in a condition analogous to that of fog or cloud. The position in the spectrum of the bright line furnished by the nucleus is the same as that of nitrogen, which also is shown in some of the nebulæ.

But the most remarkable achievement by spectrum analysis is the record of observations on a temporary star which has shone forth this year in the constellation of the northern crown about a degree S.E. of the star *ε*. When it was first seen, May 12th, it was nearly equal in brilliancy to a star of the second magnitude; when observed by Mr. Huggins and Dr. Miller, May 16th, it was reduced to the third or fourth magnitude. Examined by these observers with the spectroscope, it gave a spectrum which they state unlike that of any celestial body they had examined.

The light was compound and had emanated from two different sources. One sceptrum was analogous to that of the sun, viz., formed by the light of an incandescent solid or liquid photosphere which had suffered absorption by the vapours of an envelope cooler than itself. The second spectrum consisted of a few bright lines, which indicated that the light by which it was formed was emitted by matter in the state of luminous gas. They consider that, from the position of two of the bright lines, the gas must be probably hydrogen, and from their brilliancy compared with the light of the photosphere the gas must have been at a very high temperature. They imagine the phenomena to result from the burning of hydrogen with some other element, and that from the resulting temperature the photosphere is heated to incandescence.

There is strong reason to believe that this star is one previously seen by Argelander and Sir J. Herschel, and that it is a variable star of long or irregular period; it is also notable that some of its spectrum lines correspond with those of several variable stars. The time of its appearance was too short for any attempt to ascertain its parallax; it would have been important if it could even have been established that it is not a near neighbour, as the magnitude of such a phenomenon must depend upon its distance. I forbear to add any speculations as to the cause of this most singular phenomenon; however imperfect the knowledge given us by these observations, it is a great triumph to have caught this fleeting object, and obtained permanent records for the use of future observers.

It would seem as if the phenomenon of gradual change obtained towards the remotest objects with which we are at present acquainted, and that the further we penetrate into space the more unlike to those we are acquainted with become the objects of our examination,—sun, planets, meteorites, earth similarly though not indentically constituted, stars differing from each other and from our system, and nebulæ more remote in space and differing more in their characters and constitution.

While we thus can to some extent investigate the physical constitution of the most remote visible substances, may we not hope that some further insight as to the constitution of the nearest, viz., our own satellite, may be given us by the class of researches? The question whether the moon possesses any atmosphere may still be regarded as unsolved. If there be any, it must be exceedingly small in quantity and highly attenuated. Calculations, made from occultations of stars, on the apparent differences of the semidiameter of the bright and dark moon give an amount of difference which might indicate a minute atmosphere, but which Mr. Airy attributes to irradiation.

Supposing the moon to be constituted of similar materials to the earth, it must be, to say the least, doubtful whether there is oxygen enough to oxidate the metals of which she is composed; and if not, the surface which we see must be metallic, or nearly so. The appearance of her craters is not unlike that seen on the surface of some metals, such as bismuth, or, according to Professor Phillips, silver, when cooling from fusion and just previous to solidifying; and it might be a fair subject of inquiry whether, if there be any coating of oxide on the surface, it may not be so thin as not to disguise the form of the congealed metallic masses, as they may have set in cooling from ingeous fusion. M. Chacornac's recent observations lead him to suppose that many of the lunar craters were the result of a single explosion, which raised the surface as a bubble and deposited its débris around the orifice of eruption.

The eruptions on the surface of the moon clearly did not take place at one period only, for at many parts of the disk craters may be seen encroaching on and disfiguring more ancient craters, sometimes to the extent of three or four successive displacements: two important questions might, it seems to me, be solved by an attentive examination of such portions of the moon. By observing carefully with the most powerful telescope the character of the ridges thus successively formed, the successive states of the lunar surface at different epochs might be elucidated; and secondly, as on the earth we should look for actual volcanic action at those points where recent eruptions have taken place, so on the moon the more recently active points being ascertained by the successive displacement of anterior formations, it is these points which should be examined for existing disruptive disturbances. Metius and Fabricius might be cited as points of this character, having been found by M. Chacornac to present successive displacements and to be perforated by numerous channels or cavities. M. Chacornac considers that the seas, as they are called, or smoother portions of the lunar surface have at some time made inroads on anteriorly formed craters; if so, a large portion of the surface of the moon must have been in a fused, liquid, semiliquid, or alluvial state long after the solidifying of other portions of it. It would be difficult to suppose that this state was one of igneous fusion, for this could hardly exist over a large part of the surface without melting up the remaining parts; on the other hand, the total absence of any signs of water, and of any, if any, only the most attenuated, atmosphere, would make it equally difficult to account for a large diluvial formation.

Some substances, like mercury on this planet, might have remained liquid after others had solidified; but the problem is one which needs more examination and study before any positive opinion can be pronounced.

I cannot pass from the subject of lunar physics without recording the obligation we are under to our late President for his most valuable observations and for his exertion in organizing a band of observers devoted to the examination of this our nearest celestial neighbour, and to Mr. Nasmyth and Mr. De la Rue for their important graphical and photographical contributions to this subject. The granular character of the sun's surface observed by Mr. Nasmyth in 1860 is also a discovery which ought not to be passed over in silence.

Before quitting the subject of Astronomy I cannot avoid expressing a feeling of disappointment that the achromatic telescope, which has rendered such notable service to this science, still retains in practice the great defect which was known a century ago at the time of Hall and Dollond, namely, the inacuracy of definition arising from what was termed the irrationality of the spectrum, or the incommensurate divisions of the spectra formed by flint and crown glass.

The beautiful results obtained by Blair have remained inoperative from the circumstance that evaporable liquids being employed between the lenses, a want of permanent uniformity in the instrument was experienced; and notwithstanding the high degree of perfection to which the griding and polishing object-glasses has been brought by Clarke, Cooke, and Mertz, notwithstanding the greatly improved instrumental manufacture, the defect to which I have adverted remains unremedied and an eyesore to the observer with the refracting telescope.

We have now a large variety of different kinds of glass formed from different metallic oxides. A list of many such was given by M. Jacquelain a few years back; the last specimen which I have seen is a heavy highly refracting glass formed from the metal thallium by M. Lamy. Among all these could no two or three be selected which, having appropriate refracting and dispersing powers, would have the coloured spaces of their respective spectra if not absolutely in the same proportions, at all events much more nearly so than those of flint and crown glass? Could not, again, oily or resinous substances having much action on the green or middle colour of the spectrum, such as castor oil, canada balsam, &c., be made use of in combination with glass lenses to reduce if not annihilate this signal defect? This is not a problem to the solution of which there seems any insuperable difficulty; the reason why it has not been solved is, I incline to think, that the great practical opticians have no time at their disposal to devote to long tentative experiments and calculations, and on the other hand the theoretic opticians have not the machinery and the skill in manipulation requisite to give the appropriate degree of excellence to the materials with which they experiment; yet the result is worth labouring for, as, could the defect be remedied, the refracting telescope would make nearly as great an advance upon its present state as the achromatic did on the single lens refractor.

While gravitation, physical constitution, and chemical analysis by the spectrum show us that matter has similar characteristics in other worlds than our own, when we pass to the consideration of those other attributes of matter which were at one time supposed to be peculiar kinds of matter itself, or, as they were called, imponderables, but which are now generally, if not universally, recognized as forces or modes or motion, we find the evidence of continuity still stronger.

When all that was known of magnetism was that a piece of steel rubbed against a particular mineral had the power of attracting iron, and, if freely suspended, of arranging itself nearly in a line with the earth's meridian, it seemed an exceptional phenomenon. When it was observed that amber, if rubbed, had the temporary power of attracting light bodies, this also seemed something peculiar and anomalous. What are now magnetism and electricity? forces so universal, so apparently connected with matter as to become two of its invariable attributes, and that to speak of matter not being capable of being affected by these forces would seem almost as extravagant as to speak of matter not being affected by gravitation.

So with light, heat, and chemical affinity, not merely is every form of matter with which we are acquainted capable of manifesting all these modes of force, but so-called matter supposed incapable of such manifestations would to most minds cease to be matter.

Further than this it seems to me (though, as I have taken an active part for many years, now dating from a quarter of a century, in promoting this view, I may not be considered an impartial judge) that it is now proved that all these forces are so invariably connected *inter se* and with motion as to be regarded as modifications of each other, and as resolving themselves objectively into motion, and subjectively into that something which produce or resists motion, and which we call force.

(To be concluded in our next.)

THE INTERCOLONIAL EXHIBITION OF AUSTRALASIA.

The site fixed upon for the building in which the above exhibition will be held, is situated at the rear of the Public Library at Melbourne, and will no doubt be found a convenient position on account of its proximity to the more central parts of the city. The building like most of those in which exhibitions are held will be of a comparatively temporary nature, but some portions which are being constructed of greater solidity than the rest, are intended eventually to form part of proposed extensions of the present library.

The total amount of space to be provided is about 35,000 superficial feet, about one half of which is already applied for, and it is anticipated that the building will be completed and the exhibition opened by about the 11th October next. The building will consist of a central circular hall, a great hall, and two wings or annexes, beside one or two smaller apartments. The central or circular hall is 75 feet in diameter, and 50 feet high; it will form a vestibule or entrance hall to the rest of the building, and will be made available for the display of articles of an artistic nature. On each side of it there will be an open space about 75 feet square; one of these will be used for exhibiting such articles as are not liable to be damaged by exposure to weather; while in the other there will be held a series of flower shows. Immediately behind the central hall is the great hall, 220 feet by 84 feet, consisting of a central nave surmounted by a semicircular roof 50 feet high, and two side aisles each of which will be 15 feet high. It will be lighted by means of clestory windows. The two wings will be about 170 feet long by 28 feet wide; one will be used as a picture gallery, and in the other will be placed the machinery in motion. In this latter there will also be exhibited several manufacturing processes including pottery, iron founding, quartz crushing, gas making, &c. The whole cost of the building will be about £25,000, of which not more than about £3,000 will be expended on purely temporary work. The architects are Messrs. Reed and Barnes, of Melbourne, and the contractors Messrs. Cunningham and Hilton.

Ancient Mining.—Interesting discoveries have lately been made in the San Domingo mines of Spain, showing the methods of mining adopted by the ancients. In some of the mines the Romans dug draining galleries nearly three miles in length, but in others the water was raised by wheels to carry it over the rocks that crossed the drift. Eight of these wheels have recently been discovered by the miners who are now working in the same old mines. The wheels are made of wood, the arms and felloes of pine, and the axle and its support of oak, the fabric being remarkable for the lightness of its construction. It is supposed that these wheels cannot be less than fifteen hundred years old, and the wood is in a perfect state of preservation, owing to its immersion in water charged with the salts of copper and iron. From their position and construction the wheels are supposed to have been worked as tread-mills, by men standing with naked feet upon one side. The water was raised by one wheel into a basin, from which it was raised to another stage by the second wheel, and so on for eight stages.

THE HYDRAULIC LIFT GRAVING DOCK.*

By Edwin Clark, M. Inst. C.E.

(*Continued from page* 242.)

Mr. Edwin Clark remarked, that his object was to court the fullest discussion on the subject of these docks, and with that view, he had endeavoured to make the paper as comprehensive in its details as he could. He took this opportunity of expressing his obligations to those gentlemen who had assisted him in bringing these docks to their present state (more especially Mr. Bidder and the late Mr. Robert Stephenson), not only in the designs, but also in the financial part of the undertaking, by taking upon themselves personally a large share of the first outlay. He had also to thank Mr. John Heppel for the very ingenious suggestion, which had been described, of arranging the presses in three groups, instead of in the mode originally intended. Mr. Clark expressed his readiness to elucidate any point upon which further information was desired.

Mr. Abernethy inquired whether the statement of cost included all the necessary excavation in connection with the lift, in fact all the preparations for receiving the machinery. Some information on that point was necessary, to enable a comparison to be made of the cost of this dock, with that of graving docks of the ordinary description. It was stated, that the cost of the operation of lifting was about £3 per vessel. He presumed that was the average price.

Mr. Clark replied, that the cost of the excavations had not been given. Obviously the excavations for receiving the pontoons, if any were required, would form a considerable item in the cost of the work. In some places, however, the whole work consisted simply of sinking columns. But he would before the close of the discussion, give this information in detail. The cost of lifting named was an average for all the vessels lifted.

Mr. Charles Capper, having had opportunities of seeing a great deal of the operations of this dock, was satisfied that, as a mechanical contrivance, it was perfect. The commercial success of the undertaking was, however, the question which came more within his own province; for however successful it might be as a mechanical contrivance, if it were not commercially successful it would be of no use. The Author had described the circumstances under which this dock was a commercial failure, in the first instance. It was assumed, incorrectly, that the mere charge for lifting the ships, and the rental for the use of the pontoons would be sufficient to pay a renumerative return upon the outlay. There were about twenty-seven docks on both sides of the river, the proprietors of which docks were repairers of ships, as well as dock owners, and it was to their interest to sink the charge for the use of the docks in order to get the repairs of the vessels. This Company having at first no mechanical appliances for repairs, and being subject to the competition referred to, the commercial failure of the project would be readily conceived. It did not matter where dry docks were situated in this country, whether on the Tyne, or at Southampton; the system of charges for merely docking and undocking, and for the use of the docks, would not pay. The Tyne dry docks did not pay more than 2¾ per cent. if the profits were reckoned by these charges only; and the docks at Southampton only yielded a similar return, viz., 2¾ per cent. upon the £166,000 of outlay. It was obvious that, to make these docks, or any ordinary graving docks, successful speculations, the proprietors must, to a certain extent, go into the business of repairing the ships. If they did that, as was the case in this instance, they would turn a loss into a respectable profit. The last year before the Thames Graving Dock Company undertook repairs, the loss upon this dock was about £4,000, but since the repairing had been superadded, although it had only been as yet perfectly carried on for nine months, a profit had been realized of between £11,000 and £12,000 per annum, which of course made a very material difference in its commercial character. This dock experienced another drawback. Being the first of the kind on the Thames, many modifications were required to adapt it to the peculiar requirements of the port. These were all additional expenses, of course, as usual, charged to capital; and when revenue had to pay upon capital employed in making experiments, it affected the result. He was bound to say, that the undertaking was now approaching that state in which he wished to see it; and he believed before long it would be one of a highly renumerative character.

Mr. P. Hedger endorsed all that had been said as to the unremunerative character of the docks at Southampton, the return being not more than 2¾ per cent., or 3 per cent. upon the outlay. The repairing of ships formed no part of the business there. At Southampton there were three dry docks, one of which could accommodate any ship yet built, except the "Great Eastern."

Mr. A. Giles said, the paper contained much that was interesting, and the mechanical arrangements of this dock were no doubt of the most admirable and perfect character; but he thought the ordinary graving docks had been undeservedly condemned. Before the advantages of this dock could be compared with those of ordinary graving docks, it was necessary to be informed what had been the total cost of the existing works.

Mr. J. Scott Russell, V.P., thought additional information was required to enable a comparison to be made between this system and that of a floating dock to be filled with water by a steam engine, and emptied of water by the same means; and especially was information required in order to form an approximate estimate of the comparative cost of the system under discussion, and that of simply filling and emptying the tanks in the floating dock, which accomplished all that was done by the hydraulic apparatus. He yielded to no one in admiration of the ingenuity and ability displayed in the whole of this apparatus, but he thought there was a difficulty in comparing it fairly with stone docks. Information was also needed as to the advantages and disadvantages of having a vessel which has "hogged," or out of shape, placed upon an elastic pontoon which would yield to its distortion, or of placing it on a rigid pontoon which would not yield to its distortion, but which would compel it to come back to the straight line on which it was originally built, and which it was very desirable it should come back to, before it was repaired.

Mr. Edwin Clark stated, that the cost of the excavations for the lift pit proper was £2,000, the contract being let at 1s. per cubic yard. The cost of the whole of the excavation, including the lift pit and the deep channel leading from the lift pit to the Victoria Dock basin on the one hand, and to the shallow water used for the pontoons on the other hand, amounted to £3,593. The lining of the dock with concrete and masonry was executed at a cost of £4,473; and the timber platform all round the dock was provided at a cost of £4,618. The outlay upon the coffer-dram in the dock was £6,543. In addition to this the engine-house and valve-house were elected at a cost of £2,200, making the total cost in connection with the lifting apparatus, £21,427.

Sir Charles Fox thought the term "power," as applied in the paragraph of the paper which stated "That power, when required, is increased by cutting off one or more of the pumps," was an erroneous use of that word. The word "force" would more correctly convey the notion of the Author, inasmuch as no reduction in the number of the pumps could affect the power of the prime mover, in this case, a steam-engine of 50 H.P. The only result of cutting off pumps would be, to let the whole of the above power be expended upon a smaller number of pumps, and consequently to increase the pressure in the cylinders in work, and so to spread the operation of lifting over a longer period of time, but in no way could the power be interfered with by that operation. It was stated in the paper, that the rams were each 10 inches in diameter, having, of course, an area of 100 circular inches: that their lifting capacity being 2 tons per circular inch, was therefore (less the weight of the ram) 200 tons each. It was further stated that these rams had been proved, to the extent of 2½ tons only per circular inch. Now it seemed to him, that if some of these pumps were thrown out of work, and the pressure thereby increased in the cylinders still in operation, the limit of half a ton for proof was far too little. It was known, that the Board of Trade in dealing with a bar, which was considered to be capable of carrying, as a minimum, 20 tons, would not permit it to be loaded to more than 5 tons; but then that rule was applied to structures which where exposed to many trying circumstances and influences, such as corrosion, vibration, &c., and therefore, though he did not think the proof of hydraulic presses need be anything like that of double the actual pressure employed, still it should not be less than 50 per cent. more. He should not be satisfied with exerting a pressure of 2 tons per circular inch, unless he had proved the press to about 3 tons; and, if it were his intention to increase the pressure in any individual cylinder beyond the 2 tons, he would prove that cylinder to at least 8 tons and perhaps 4 tons. After a very long experience in the use of hydraulic presses, he had arrived at the conclusion, that a pressure of 2 tons per circular inch was the one practically the most desirable, and with that as a maximum, he would not feel comfortable with a press proved to less than 3 tons; and if any real advantage was to be obtained by cutting off any of the pumps, the presses ought to be proved to the extent of 4 tons; and, therefore, this operation of cutting off pumps could not be performed, with safety, with a proof of only half a ton beyond the ordinary working pressure of 2 tons in the cylinders. As to the commercial element of the Hydraulic Lift Graving Dock, compared with the old form of dry or graving docks, he thought the statements contained in the paper failed to carry conviction in its favour to the minds of those who would take the trouble of making a careful comparison between the two. It was admitted, that in consequence of the competition of dry docks in the Thames, it was not till about nine months ago, when the Company took upon themselves the additional business of repairing vessels, one open to but little competition, that the plan ceased to be attended with considerable loss. Up to that period the revenue account of the Company showed a debt of £4,000 against the working of the hydraulic lifting apparatus, and it was only by the Company having embarked in the new business of ship repairers that its pecuniary position was improved—not by the use of this lift, but by the profits of their new avocation; while the dry or graving docks at Southampton, where ships were not repaired, paid a return of 3 per cent. upon the capital embarked in them. The conclusion at which he had therefore arrived was, that this description of dock *per se* had hitherto failed to show satisfactory commercial results.

Mr. F. J. Bramwell would, in the first instance, add a few words on the history of floating-docks. This history had been touched on by the Author, but he had not carried it back to the earliest times. Mr. Bramwell found it recorded that, in 1785, one Watson, a shipwright on the Thames, constructed a wooden floating-dock in which a large vessel called

* Read before the Institution of Civil Engineers.

the "Mercury" was repaired. In this construction of floating-dock there was an end-gate, which was lowered to admit of the vessel entering, and the gate being afterwards raised, the water was pumped out of the dock. Mention was also made, in 1776, of one Aldersley having constructed "a large portable dock in which to float vessels."

As regarded the more modern history of floating-docks, the Author had alluded to the box dock and the sectional dock, both of which had been used in America; but he had omitted to mention a dock that was used in that country prior to either of the other two docks; and Mr. Bramwell was somewhat surprised at this, as, in its modified construction, it appeared to him to be one that ought to have found favour with those who advocated the raising of vessels by hydraulic presses. He alluded to the dock which, from its original construction, was known in the United States as the Screw Dock, but which was afterwards worked by hydraulic power. He had placed on the wall a rough drawing, showing this dock as thus constructed with hydraulic power. It would be seen that it consisted of two parallel rows of piling placed at right angles to the shore; these rows of piling being wide enough apart, sufficiently roomy, and in a sufficient depth of water to take in between them the largest ships the dock was competent to lift. The piles in each row were connected at the tops by timbers, on which was a gangway. From one row of piles to the other there were, at frequent intervals, transverse timbers. These timbers were lowered into the water, and the ships to be docked brought over them. At each end of each timber there was a chain, by which it was suspended. These chains went upwards, and passed over pulleys placed on the frames connecting the heads of the piles, and then all the chains on each side were connected to a horizontal traction-bar, which was a very strong wooden bar extending the whole length of the dock, and supported on rollers To each traction-bar, there was a powerful hydraulic cylinder, and on this being worked, the traction-bar was moved endways, and thereby the whole of the chains attached to it were uniformly drawn; and in this manner the presses on the two sides being worked at equal rates, the whole of the beams below the vessel were simultaneously and uniformly raised, lifting the vessel that was upon them out of the water. He had seen that dock when at New York in 1853, and he believed it had been in operation for many years previously, and with perfect success. It appeared to him to be interesting as regarded the present paper, to the lifting of vessels by means of hydraulic presses.

Having made these few remarks upon some points omitted from the history of floating docks and of docks worked by hydraulic power, he would now remark on the subjects mentioned in the paper. He understood the Author to lay considerable stress on an advantage possessed by the Hyraulic Lift Graving Dock, that the bilges of the vessels were supported almost immediately upon the keel taking the blocks, and a contrast was made between this mode and that practised in ordinary dry docks, where until the whole of the water was removed, so as to admit of the workmen fixing the shores, the bilges remained unsupported. He believed with the Author, that this ability to give support to the bilge of the vessel at once was an important matter. He thought that in all cases after the natural support of the water was removed, it should be compensated as speedily as possible by some other support. But although he entirely agreed with the Author in this view, he thought it ought to be clearly understood, that that ability to support the bilge at once was not a property peculiar to the dock under consideration. It would be found that it existed in the New York Screw Dock, to which he had just referred, and it existed also in the Sectional Dock. The Author, therefore, in availing himself of the system of blocks to support the bilges, had done no more than had been done in previous docks, nor than might be done in any other dry-dock; at the same time he was glad to find that the Author approved of that which he (Mr. Bramwell) believed to be a most useful precaution in the docking of ships

He would now go to another point which was raised by the Author which was this—that, in his judgment, not only was it unnecessary that the bed on which a vessel was received while being docked should be rigid, but that it was absolutely undesirable that it should be so. Now he must say he entirely dissented from this view. For although at the present day there were many iron ships which were so well built as to be efficient girders in themselves, and although even wooden ships were now much better trussed and braced than they used to be in days of yore, when they were little more an assemblage of timbers side by side without proper trussing and fastening, nevertheless he considered that a properly-constructed dock should be one in which any vessel might repose in the certainty of not being called on to rely upon its own strength as a girder to compensate for the want of strength in the dock, and where, therefore, a ship, however weak in its construction, or however old or damaged, might be taken with the assurance it would not get out of shape.

To explain himself still further, he might say that when he had been consulted on the subject of floating docks, he had laid it down as an axiom, that the dock, if properly made, ought to possess so much likeness to a stone dock in its rigidity, that if a ship placed in the dock were cut into slices, these various slices ought to retain their relative position to one another, although the weights of the various slices would, if of equal thickness, be very different. As bearing on this point of the difference of weight per foot run, he wished to call attention to the Author's mode of taking the weight of a ship, which he had done, as being, in extreme cases of armour-plated vessels, 20 tons per foot run, or 6,000 tons for a ship 300 feet in length. But Mr. Bramwell objected to the construction of a dock being based on the assumption, that a vessel had an uniform weight per foot run. Take the case of a ship 300 feet long, and weighing a not unusual weight for that length of 3,000 tons, it would be very wrong to assume that that ship weighed 10 tons per foot; the fact would probably be, that for each foot run amidships, she would weigh about 14 tons, and for each foot at the end only about 7 tons. The assumption, on the part of the Author, of uniformity of weight per foot run must, he thought, be admitted to be a mistake; and yet, upon this theory alone could the practice of a non-rigid bed be admitted, and certainly such an eminently non-rigid bed as the Author had put forward as his ideal of excellence, viz., a sheet of india rubber large enough to secure the vessel.

Having thus endeavoured to explain the reasons why non-rigid beds were bad, he thought he might be allowed to refer to the practice of ship-builders, to show that that practice coincided with the principles he had been advocating. It would be admitted that in building vessels, the greatest possible pains were taken to obtain a thoroughly solid bottom for the slip-way whereon they were built; and it was well known that considerable damage had arisen from the ground of a slip-way having occassionally yielded in parts. This showed the importance attached by ship-builders to having a rigid bed on which to build a ship. It seemed to him that that which required a rigid support while being built, required a rigid support while being repaired. He wished, on this point, to be allowed to refer to the very pertinent observation made by Mr. Scott Russell, that if a ship got out of shape while afloat, the thing wanted in repair was a dock that should bring her back into shape. Mr. Bramwell believed he was correct in saying, that about ten or twelve years ago, an impression existed in the mind of an inventor, that a rigid bottom to a dock was a bad thing; and he proposed to remedy this, by placing on the bottom of a stone dock a number of small hydraulic presses, on which the keel of a ship was to rest, in lieu of resting on the ordinary keel blocks. These presses were all to be connected by pipes, so that they might adjust themselves to the pressure of the keel. This arrangement was tried in one dock in London; but, as might, according to Mr. Bramwell's views, have been expected, was found to be injurious to the vessels, and had to be removed, and the rigid system of blocks restored.

It appeared to him that following upon this reference, to the effect of endeavouring to use for keel-block hydraulic presses, when coupled up into a system, came not improperly the consideration of the operations which took place in the Hydraulic Lift Dock, when raising vessels by the system of presses at each side of the dock. It was quite clear that so long as these were all united into one system, there was no remedy whatever against the vessel tilting either sideways or endways in the act of being lifted, and the Author had given well-merited praise to Mr. Heppel, for the suggestion of dividing the presses into three distinct groups. No doubt by this arrangement perfect command had been obtained over the raising, so far as related to keeping the lift horizontal; but this arrangement of grouping did not get over the fact, that the presses at the ends were exerting the same upward force as those in the middle; that was to say, a force representing the average load, and that therefore, as a vessel was undoubtedly lighter at the ends than in the middle, it was lifted by an excess of force at the ends, and a deficiency of force in the middle; and the difference between the forces employed at the respective parts, and those forces actually required there to balance the weight of the ship at those parts, had either to be taken off by the ship itself acting as a girder, or by the strength of the pontoon or saucers so acting; and he feared, looking at the want of depth in the saucer, that it was upon the ship itself the strain must come; and this he looked upon as an undesirable point in the construction of the dock.

Upon this question of preventing an undue lifting of one press as compared with another, he would allude to a plan he had prepared for the use of hydraulic presses in certain operations in the manufacture of iron, where he had introduced a system of wedges, the withdrawal of which could be regulated at pleasure, and thereby whatever might be the simple power of any press, its advance could only be at the rate allowed by the controlling wedges. He feared that such an apparatus could not be introduced to the presses in the dock without its being made somewhat complex; but, nevertheless, he called attention to it, as a means by which the want of uniformity of load on the presses might be overcome.

He would now say a few words on the subject of floating docks, which the Author indicated as proper objects of comparison with his system. The Author had referred to the failure of several floating docks, but he thought it would be found the failure had been confined to the American sectional dock. To Mr. Bramwell's mind, the failure of these docks was clearly to be traced to two defective points in their design, and to their having been built of wood. The error in design was, first, the making them in sections unconnected by any girder; secondly, the absence of proper water-tight bulkheads. The first error caused the ships to be strained, the second produced the liability to turn over while in the act of lifting the ships, but nothing was easier than to diminish to an insignificant amount this tendency. As by the introduction of a few water-tight bulkheads the tendency to turn over, caused by any accidental inclination of the dock having sent the water contained in it to one side, would be diminished, so as to have no practical importance; the decrease of the tendency would be in a very rapid ratio, that was to say, it would be in the ratio of the square of the number of chambers into which the dock was divided by bulkheads; so that a dock divided by three bulkheads into four chambers would only have $\frac{1}{16}$th the tendency to turn over, that a dock would have in which there were not any bulkheads.

He would, in conclusion, say a few words on a floating dock which was now being constructed from his designs for St. Thomas in the West Indies; and he begged leave to refer to it, because the Author had said in effect that all floating docks were bad and unsafe things. Mr. Bramwell could not concur in this opinion, and he thought it would be a matter of regret, if a class of docks, which could be used wherever there was water enough to float them, and which were wholly independent of the nature of the bottom, and might therefore possess peculiar advantages in certain weathers, were to be stigmatized as bad and unsafe unless they really deserved that character, which he hoped to convince the meeting they did not. The dock he now alluded to was made of wrought iron, and was 300 feet long by 100 feet wide, and the bottom part was 9 feet 6 inches deep; this bottom was for convenience of manufacture and repair, made in six separate pontoons; each pontoon extended from side to side of the dock, and was in breadth 50 feet, or one-sixth of the length of the dock. Inside the pontoons there were a proper number of water-tight bulkheads and a due system of trussing, to distribute the weight of the vessel. Upon the pontoons at the sides of the dock were two girders: these were lattice girders, of about 35 feet high, and sufficiently strong to transmit the surplus floating power of the end pontoons to the assistance of the more heavily loaded central pontoons, and in this way it was believed the fundamental points of keeping all strain off the vessel had been arrived at.

In order to prevent the dock from tilting out of level while lifting a vessel, there were smaller pontoons, or floats, which were contained within the open work of the side girders, and the position of which, in relation to the dock as it rose, was maintained by suitable machinery. He had preferred trussed girders to the ordinary close sides of a box dock for several reasons: one was, that greater strength was got for the same amount of metal; another was, that the open side afforded good ventilation, a most important point in a tropical climate; and another was, that the open girders, when immersed, displaced but little water, whereas the closed sides of a box dock displaced several thousand tons, which had to be overcome by the admission of that extra weight of water into the dock, all of which had afterwards to be pumped out. For these reasons he had preferred the open girders, and had employed the adjustable floats to play the same part in preserving the level of the dock, while being raised or lowered, that the closed sides effected in the box dock. The adjustable float, in fact, represented just that portion of the close side which, from time to time, was at the surface of the water. In using this dock the water would be admitted into the pontoons, which would cause the dock to rush past the floats which would remain on the surface; then the vessel would be drawn over the keel blocks, the water be pumped out, and the float apparatus worked, so that as the dock rose the floats would still remain at the surface, the bilge shores being brought to act on the vessel as soon as her weight was fairly on the keel floats. He thought that this dock and the box dock were, when properly constructed, absolutely safe, and that they would put far less strain on a ship when docked, than would be put on by the Hydraulic Lift Dock as now constructed.

Mr. Abernethy, while admitting the great ingenuity which had been displayed by the Author and the other engineers who had advised with him relative to the construction of the hydraulic dock at the Victoria Docks, was, nevertheless, somewhat at issue with him in the conclusion, that this description of dock was likely to become of universal application; on the contrary, he thought the Hydraulic Lift would be adopted only in exceptional cases. In the paper, the Hydraulic Lift had been compared with the graving dock system generally, and also with floating docks; and the subjects of comparison instituted were, first, the question of economy, and secondly, certain advantages which were claimed for the Hydraulic Lift. He was at a loss how to institute a fair comparison from the information contained in the paper, because the Author had selected, in respect of the economy of the question, one of the most recent docks constructed at Portsmouth in connection with the national dockyard at that place. The dimensions of that dock, and the quantity of stone and other material used in it were given, but not the cost. As far as economy was concerned, the Author could hardly have selected a more costly example; because the graving docks in connection with the Government naval establishments were generally built entirely of finely dressed granite ashlar, throughout the whole of their parts, the whole system of construction being of the most expensive character; and it was not therefore a fair subject of comparison with the Hydraulic Lift system; yet it would seem, from these examples, the Author had arrived at the conclusion, that the graving dock system must of necessity be more costly, and, in many cases, even impracticable. But the cost of the Hydraulic Lift had been £66,705 for the machinery, and £21,427 for the masonry and works connected with the lift, making a total cost of £88,132; the results of which, up to the present time, had been to provide seven pontoons of an aggregate length of 1,496 feet.

Mr. Abernethy had, during late years, constructed a number of graving docks at present in use, and proved to be very effective. Several of them possessed, it was true, advantages in respect of site, but there were numerous sites as favourable in all parts of the kingdom. He would, in the first place, allude to the graving docks on the river Mersey, in the red sandstone rock. The dimensions of five docks at Birkenhead, which he had constructed years ago, were as follows: No. 1, 300 feet long, 35 feet wide at the floor, and 18 feet 3 inches of water over the sill at ordinary spring tides; No. 2, 200 feet long, 40 feet wide, and 18 feet 3 inches of water over the sill; No. 3, 400 feet long, 64 feet 6 inches wide, and 22 feet 3 inches of water over the sill; No. 4, 440 feet long, 70 feet 9 inches wide, and 26 feet of water over the sill; No. 5, 350 feet long and 69 feet wide, and depth of water over the sill 22 feet 3 inches—making a total length of docks of 1,690 feet, which had been constructed at a cost of £86,000. Those were instances of graving docks in a favourable site, hewn out of the solid sandstone rock. He had also recently constructed two other docks at Falmouth, of the dimensions respectively of 350 feet by 51 feet, and 15 feet 6 inches of water over the sill, and 400 feet by 66 feet, and 17 feet 6 inches of water over the sill: making a total length of dock of 750 feet, at a cost of £29,000. In the construction of these latter docks, a considerable amount of pumping was necessary, in consequence of the open character of the rock. Then again on the question of economy, it was obviously impracticable to carry out the Hydraulic Lift system near the existing London Docks, on account of the large area occupied; it would be an expensive item to secure such an extent as 26 acres, the area occupied in connection with the Hydraulic Lift at the Victoria Docks.

The advantages claimed for Hydraulic Lifts over the existing graving docks, beyond the question of economy, were—first, freedom from strain to the vessels docked, arising from the elasticity of the pontoons. He was not a shipwright, but he apprehended that the element of elasticity would not be regarded by shipwrights as an advantage; and he thought the rigid floor of a graving dock was to be preferred. It would, he thought, be a dangerous experiment to place a crazy old ship on an elastic bearing. Another advantage claimed for the pontoon system was the peculiar mode in which the vessel was blocked. The same mode had for a long period been adopted in the ordinary patent slip, viz., by bildge and slide blocks. That was as much a matter of necessity in the case of patent slips, as it was on this system; but it was not a matter of necessity in ordinary graving docks. As a general rule, the vessel rested on the keel blocks, and was shored from the sides; but bilge blocks if necessary could as easily be provided on the floor of a graving dock as on a pontoon or patent slip. A great advantage claimed for this mode of blocking, was the replacing the pressure of the water on the outside of the vessel. Now, he thought, very extraordinary blocking was required accurately to represent the pressure of water on the outside of a vessel. It was also stated in the paper that the displacement of a vessel was equivalent to the weight of each particular section. That was to say, that if a vessel was divided into sections, the displacement was equivalent to the weight of each particular section. He apprehended the displacement was equivalent to the form, capacity, and weight of the vessel as a whole, and not to any particular section. It was further stated, that in the case of a vessel resting on keel blocks, the weight was nearly equally distributed over the whole keel; that, he thought, was erroneous, as the weight would be due to the particular section of the vessel resting on the blocks.

With regard to floating docks, he agreed that such docks could be constructed to dock vessels with perfect safety, and he felt certain, that floating docks would give a more profitable return, and could be worked with greater economy than hydraulic lifts occupying, as suggested, an entire pontoon for the accommodation of a single vessel at a time. One objection made to graving docks was, that on placing a vessel in dock, resting on the keel, a great length of shoring was required; and in the case of the Mersey docks he had adopted means to obviate that difficulty. At certain portions of the dock, he had upright piers in the place of the altar steps, so that a vessel could be brought in between those upright piers, and moored directly over the keel-blocks. Short shores only were required to keep her *in situ*, and those shores might be worked by machinery, so as to be adjusted immediately the vessel was on the keel-blocks. That system of piers had been adopted by him at all the docks at Birkenhead, eleven in number, and also at the two docks at Falmouth, to which he had referred. There could be no doubt, that in regard to vessels of the largest class, such as the "Warrior," which had a height of about 40 feet from keel to deck, it would be exceedingly dangerous to risk such vessels on pontoons merely blocked under the bilges, without horizontal shores at the sides. Therefore, he thought if pontoons were ever applied to that class of ships, it would be necessary to have side pontoons, or side frames upon the horizontal pontoons, and when that was the case, the cost of the whole would equal that of a floating dock of the same capacity. As a further use to which pontoons might be applied, the Author had pointed out the opportunities for transporting vessels on them for a considerable distance, as for instance, across the Isthmus of Suez, if the canal were ever cut; but it was quite obvious that it would be impossible to move a large ship any considerable distance on a pontoon with her masts and rigging standing and exposed to the action of the wind. In the instance given in the paper of such transport, the pontoon, with the ship on it, made so much leeway as to sink herself in a short time with the vessel upon her. It was fortunate this took place in shallow water, instead of in the Victoria Dock itself.

Another point, was the economical working of the existing graving docks as compared with the pontoons; as in the case of repairs to steamers, taking out the boilers, machinery, &c., and putting them in again. When vessels were placed on pontoons, it was a costly operation, either to erect staging to the level of the deck of the ship, or to lift the boilers, or other heavy weights from the ground, and then to lower them into the vessel; whereas, by means of a powerful crane, placed on such piers as he had provided in his graving docks, the boilers, or other heavy materials, could be removed from the ship, and replaced with the greatest facility. As regarded shoring in graving docks, it could be done in any position, but not so under the pontoon arrangement. While stating thus broadly his view, that this form of dock could be used only in exceptional cases, and not as a general rule, he was at the same time convinced in many positions it would prove successful, as in a tideless sea, or where the physical difficulties were so great as not to warrant the expenditure necessary for constructing the ordinary graving dock. In such a locality as the Victoria Docks, where peculiar facilities were at hand, he thought the hydraulic system was admirably adapted for its purpose; but he repeated, that he thought it must be considered altogether as exceptional.

Mr. Vignoles said, the history of docks having been touched upon in the paper, he would state—as the fact had not been mentioned—that he believed the first instance of the employment of a floating dock occurred about the time of Peter the Great, in the estuary or Bay of Cronstadt, where a north-country captain, wishing to repair his vessel, found an old hulk floating in the bay, upon which he had permission to operate; and he arranged means of letting in, and pumping out the water, so as to form a floating dock, on which to carry out the required repairs to his ship. The name of that old hulk was the "Camel," and to the present day a contrivance of that kind was understood by the term "Camel," which consisted of a rough wooden box from which the water could be discharged to raise it up, and into which water could be introduced to sink it again. With regard to the invention now under discussion, he thought it was one of the most ingenious contrivances that had appeared for many years. He thought it was applicable in more instances than had been generally admitted, and he thought the comparison of the expenses of the system with those of graving docks on other systems was quite fallacious. Every invention must be applied to its own particular case; and there were many cases in which this invention could be applied, both abroad and at home, with great advantage.

(To be continued.)

ON SOME OF THE ARTISTIC FEATURES OF THE ESSEX COTTAGES.*

By the Rev. E. S. Corrie.

This title is not only too ambitious, but not strictly accurate, as I shall embrace in my remarks not cottages only, but farm-houses, in fact, any dwelling-house, under the rank of the mansions of the squire or nobleman. *These* have been often well described and illustrated in works easily accessible to all; but the cottages and farm-houses left us by our forefathers in past ages have not received the attention which I think they deserve. I cannot but think that it would be well worth the while for some one really capable to undertake this subject and work it out; to illustrate the principle of design which these old houses exhibit; to endeavour to classify them as to date; and to publish careful illustrations of good examples. I have not the knowledge or skill for anything of the sort, and only venture to skim the surface of the subject, and direct the attention of some abler hand towards it.

I do not allude now in any way to the *ground* plan of these old homesteads—their arrangement of rooms—their appliances for the comfort and decency of their inhabitants at the time of their erection—or their capabilities for meeting the necessities of our modern life; I speak simply of their external form and design.

Nor is it impossible to deny that this is generally one full of beauty througout the whole of our country. Our poets have sung the beauty and quiet of our English Cottages. Travellers from other lands speak of them with unvarying admiration. Painters love to represent their picturesque gables, and shadowing eaves, and latticed windows, and broad chimneys. It is some few features of this beauty we would wish to point out.

And first, I would bid you remark how entirely they are designed to harmonise with their particular sites, and with the prevailing features of our quiet English landscape. This implies in their builders a perception of artistic propriety and fitness which is now little understood, and seldom attained, by our modern architects, even in great works. How often in these days do we see a building, placed in a city, crowded up in narrow streets, yet framed on a design requiring it to be seen from a distance, and fitted for some commanding position in the country. On the other hand we have buildings, like the facade of the new museum of Oxford, fitted for the continuous line of street, standing isolated and alone. Now, this fact of apportioning the character of a design not only to the object of the the building, but to the nature of its site; to make it thus appear to belong to the landscape around it; to grow out of it instead of being an extraneous thing, put down, as it were, hap-hazard, where it is; this, I say, is a mark of subtile and true artistic feeling. It was possessed in an eminent degree by the builders of old time; it is seen in their greatest works. The house of the noble in the city was a different type from that of his mansion in the country. Their churches varied according to the nature of the scenery around them and the materials to be used. Some had spires, some towers,—the towers themselves varying in form and size, and yet all so exactly suited to their several situations that, to a practised eye and cultivated taste, no small portion of effect could be lost when any two different types interchanged in site. A Pembrokeshire church, with its severe and simple pyramidal tower, would be out of place in the wooded or cultivated plains of Essex. An elaborate tower like that under whose shadow we are sitting, or one of beautiful brickwork like that we shall see at Hedingham, would lose half its beauty among the wild hills and rugged valleys of the west. Now just this very principle which the old architects adopted in these their great works, they successfully imparted even to their smallest. All that we have said of mansions and churches applies equally to their cottages and farms. To a mediæval builder nothing was to small for care. The same air of grace and fitness that marked the mansion of the squire or the noble was thrown round the humbler dwelling of the farmer or the peasant. If one looked grand and noble, with its wide sweep of lawn and far reaching avenues, the other equally became its knot of shadowing elms, and its little garden by the village green. The one as well as the other was fitted for its special site, and seemed equally a part and parcel of the general landscape around. In Herefordshire we have the homesteads formed with the black beams, showing oftentimes in beautiful and varied patterns through the white plaster between. In Gloucestershire the rich yellow stone, with stone mullions and quoins, and roof of slabs, give an air of solidity and comfort, fitting the rich gardens and orchards in which they stand. In Wales the grey cottages, low and nestling in some hollow of the hills, give an air of shelter from the wild winds of the mountain; all these, fit and beautiful in their several positions, we feel would be out of place in Essex, where the long stretch of roof, varied by projecting gables, and covered with thatch or tile, the white walls, with their quaint varieties of pargetting, seem at once the natural out-growth of our quiet, undulating county, and lend to it one of its greatest charms.

I know, indeed, it may be said that all this is purely accidental—that this grace and fitness result simply of themselves from the accident of material, or what not. But the objection is a shallow one. Things do not grow of themselves into forms of beauty. To make them do so requires knowledge, and thought, and skill. Nay, the objection itself only proves the more what we are stating, for it is the very height of art to conceal itself, and appear actually what it is not—the mere natural outgrowth of utility, of necessity, of material.

Take another view of these homesteads of our country, and observe the fitness with which their mere outward form expresses the kind of life for which they are constructed. There is thrown around them an air of quiet, calm repose—they seem to breathe an atmosphere of simplicity and content, harmonising completely with the quiet, unambitious tenor of a country life. Those, indeed, who know the country best, know that this appearance is but too fallacious—that amid those quiet scenes breathe the same wild human passions; there are yet the same troubles, miseries, the same wayward errors and sins, that beset life everywhere. Yet, as we look upon some country village, we feel the thought of all this runs counter to the outward show of things, and this very feeling of incongruity shows how deep a hold upon our mind have the ideas of peace and repose that the old builders have impressed upon their buildings.

* Read at Meeting of the Essex Archæological Society, at Earls Colne.

Yet a third matter to which I would call your attention in these old domestic buildings is their infinite *variety*. The type, indeed, is the same; there is always the high-pitched roof, the wooden-framed or mullioned windows, the genial stack of brick chimneys, suggesting the warm ingle within. But at the same time there is an almost endless variety. Sometimes the roof is unbroken from end to end, sometimes a central gable breaks its line, sometimes there is a gable at one end of the front, sometimes at both. When several houses are placed in a row, under one roof, the windows are sometimes dormers, sometimes carried up from the wall in small gables, grouping beautifully with the larger gables which in such cases usually flank on one end or the other; sometimes the upper story projects over the lower, throwing at once a dark mass of shadow, which adds greatly to beauty. The walls, as I have already said, though often simply rough cast, yet frequently present a greater number of patterns in pargetting, quaint and simple, and eminently constructive in design. All these and other matters we might mention, alone or in combination, produce infinite change and variety of form, and this alone is enough to claim for them a high artistic excellence. *Sameness of type* with *individual variety* is the law of nature's works; it regulates the growth of the trees of the forest, and the leaves of each individual tree; it marks no less these old cottages and homesteads of our native county.

This, then, is a high artistic feature—it is more, it is a great moral influence. It tends to gather the affections of the indwellers of these houses around them, to separate them from others, to intensify the idea expressed by our sweet English word *Home*.

Contrast these ancient houses with those which we erect today. Take an ordinary modern cottage, four square brick walls, a door at one side and a window at the other, and two windows above, a slate roof, low in pitch, with no eaves; it is a *dissight*—a blot upon the landscape around it. It is impossible to love a base mean thing like that. Or take a modern row of cottages—each one exactly like the others—each a repetition of the type I have distressed you by describing: without a single thing to distinguish it from its neighbours but the number of the door; how can any affectionate associations gather round such a dwelling as this? It seems almost a profanation to apply to it the sacred name of home. There is certainly nothing in it to attract, and everything to repel. But being constituted as we are, with body as well as spirit, susceptible as is our nature, and especially in its uneducated state, to external influences, it is, to say the least, *unwise* to render our homes outwardly unlovely and repelling. Our fathers acted *wisely* as well as tastefully when they sought to render a man's house itself attractive, to give it an individual peculiarity distinct from any other, and to make it outwardly a fitting type of those fair and gentle influences which should dwell within.

Such are a few of the artistic features of an old homestead—it is a poor and meagre outline; but it may serve, I think, at least to call attention to them, and gain for them an interest which they well merit, and which they but seldom excite. The more you really look at them the more you will be struck with their picturesque beauty. They are, moreover, very precious as memorials of the past of our people, still existing among us, and which if once lost could never be replaced.

And it is a fact that they are, slowly indeed, but surely, fading away from us. The mere process of inevitable decay must rob us of them in time, and of the oldest and of the best first; but besides this every year, in every village, one and another of them is falling often before the march of what is called improvement; either altogether pulled down to make room for some vulgar, tasteless erection, deficient in every point in which they excelled, or else mutilated or added to, and all their native beauty destroyed. Now, surely it is to be lamented that these buildings should pass away without some record and memorial. If the things themselves must cease from among us, surely at least, their *forms* may be preserved. Now this is the real object I have had in choosing the subject of this paper. I would venture to press upon you the importance and interest of securing some memorial of these old buildings. In every neighbourhood there is some one or other who has the power of making some sort of sketch, however rough. Will it not, then, be well to keep an eye upon these old buildings? whenever a house or cottage is to be pulled down, or *improved*, as the term is, let some one or other make it his business to take a sketch of it from one or two different points of view; a simple outline would be enough, just catching its leading features, the distribution of its shape, and the arrangements of its parts. Nay, more—there are many of you in these days who are *photographers*. I can conceive nothing more interesting than that some one who possesses this valuable art should go round his own particular neighbourhood and take photographs of the best and most picturesque of these ancient homesteads. A collection of such photographs would have an interest and value almost impossible to over-estimate. They would form at once interesting memorials of the past, and be precious guides to our architects for the buildings of the future. We are never likely to have a type of building so fitted for our climate and our scenery as these, and it is surely possible to combine with the increased comforts and greater requirements of modern life these time-honoured forms which add so much of beauty to the hills and plains of our native land.

THE FESTINIOG RAILWAY.

(*Concluded from page 224.*)

Mr. Pihl added that, last summer, Mr. Charles D. Fox inspected the narrow gauge lines in Norway. All the details, with the engines and rolling stock, were unreservedly placed at his disposal; and on leaving he wrote—"With reference to the interesting question of the 3 feet 6 inch gauge, I shall return convinced of the thorough efficiency of such a gauge for the purpose of a new country, and of the wisdom of adopting such a guage where the traffic is not very heavy."

Mr. Phipps inquired, whether the economy of these narrow gauge lines did not consist chiefly in the diminished cost of construction, rather than in working the traffic of the line? In his opinion, the cost of haulage per ton could not differ much, whatever the gauge might be; but as regarded the construction of the line, it would, of course, be less for the narrow way. These narrow ways were obviously suited for mountainous districts, where the curves being necessarily sharp and frequent, it became important to reduce, as much as possible, the friction arising from wheels keyed fast upon the axles, which was obviously done by dimishing the width of gauge. On tolerably level ground, with the ordinary alternations of cutting and embankment, where the slopes formed so large a proportion of the whole earthwork, the saving from narrowing the gauge would probably not be considerable.

Mr. Bruff replied that, though considerable economy in the earthworks arose by adopting sharp and reverse curves on the Norwegian lines, the bridges and viaducts were extremely heavy, so much so, as to have astonished him when he was informed of the prices at which the lines had been carried out. No doubt, the economy of construction was greater than if a heavier rolling stock and permanent way had been employed throughout.

Mr. Gregory, V.P., remarked that, with the narrow gauge, a shorter wheel base of the engines could be adopted, which gave greater ease in traversing sharp curves.

Mr. Robert Mallet said, as yet no mention had been made of another narrow gauge line, which had been a long time in successful operation, viz., that between Antwerp and Ghent, the gauge of which, he believed was only 2 feet 3 inches. He could not give the precise particulars of the rolling stock, but could state generally, that the carriages were wider than those on the Festiniog Railway, and they carried heavier loads.

The subject of narrow gauge lines was not new to him. About eleven years ago he recognised the advantages, in respect of cheap railways and traffic, which would arise from narrow gauge lines; and in 1855, he had proposed to Mr. Hemans a line along the north shore of the Bay of Dublin to have a gauge of only 2 feet 6 inches. That project, for reasons it was not necessary then to go into, was not carried out; a bill, however, was presented in the present session of Parliament for a similar line, and he hoped it might be made on the narrow gauge. In viewing the question of narrow gauge and ordinary gauge railways, it was necessary to consider, what he might call the prudential considerations, those that related to the circumstances of traffic, &c., separately from those which were of a purely physical character. He met in Sicily last year Colonel Yule, late of the Bengal Engineers, and he had had many opportunities of discussing with him what had passed relative to Indian tramways, or branch railways. Colonel Yule's opinion was decidedly in favour of narrow gauges, and he considered that in India it was simply a question between the bullock-cart, or these narrow-gauge lines, as feeders to the trunk lines. Reverting now to the purely physical considerations, it appeared to him, as a physical necessity that, not only the original cost of two similar lines differing in gauge, but also the cost of working them, would approach the ratio of the cube of the length of axle, or what was the same, of the breadth of gauge. A little consideration would show that, however startling, this proposition, without having any pretentions to be a mathematical truth, was nevertheless approximately true. As an illustration of this—if the axle of a carriage, as a cylindrical shaft, exposed to cross strains, were taken, it would not admit of dispute, that for equal strength, on different gauges, the diameter must vary as the cube of the length, or of the gauge; therefore the weight of the axles would be in that ratio, and so must be that of the wheels to carry them. Then as to the carriages, as it was equally undeniable that the weights of any similar structures whatever, varied as the cubes of their homologous dimensions, so the weight of the carriages would be as the cubes of the gauge, if the carriages were of equal lateral strength: and the axles and wheels must be proportionate to carry this load. In a word, all the rolling stock would be increased in something like the ratio of the cube of the gauge. If this were so, it followed, that the permanent way itself must be increased in a proportionate ratio to bear that load; and if it were true, that the cost of haulage was a function of the weight drawn, it equally followed, that the rolling expenses, or those for working the line of road, would be about in proportion to this increased weight of rolling stock also. He wished to guard against being mistaken as now speaking mathematically, or as using the cube as a precise expression of the relation; his intention was merely to illustrate the proposition which he deemed generally true —that not only the first cost of construction, but also the expense of working railways, increased with the width of the gauge, but in a greatly higher ratio, or in other words, that in proportion as the gauge was reduced, both the first cost and the working expenses would be diminished. There were some special physical advantages in narrowing the gauge; for example, engines, or carriages could go round a sharp curve more easily with a 2-feet gauge than with a 7-feet gauge: this fact had had some doubt thrown on it, but its truth was obvious, from the consideration that if the two rails could be brought close together, or into one, there would be no longer any resistance at all in going round, due to the outer and inner wheels having to go over different lengths of curve in equal times.

Mr. Savin said, he had not at first imagined that a line of so narrow a guage as the Festiniog Railway could be worked successfully with locomotives; but he had travelled on that line both with locomotives and in the boat carriage, and he thought it a great success, both in regard to its adaptation to the circumstances of the locality, and in its commercial results. He agreed that the gauge of railways in any one country should be uniform, as far as through systems of working were concerned; but, having had some experience in Wales, he thought it impracticable to carry out the broad gauge in that country. He had seen various gauges in operation, from 2 feet up to 3 feet 6 inches; his own feeling was in favour of 2 feet 3 inches or 2 feet 6 inches, where the valleys were crooked and steep sided. In this way many physical difficulties might be avoided, by the adoption of curves of shorter radius; a 2-feet gauge line might be fitted to the contours of the hill sides, in such a manner as to reduce the cost of railway communication to a minimum. A line 16 miles long, for which he had given £20,000, was laid on the gauge of 2 feet 3 inches, and that line had been extended into a district similar to that which the Festiniog Railway passed through. There would have been very little chance of carrying a bill for a railway on a gauge of 4 feet 8½ inches in that district, and the result would have been, that, but for this class of railway, the present development of the mineral resources of those valleys would not have been attained; and it was especially with reference to districts such as this, that the subject was worthy of the fullest consideration on the part of engineers.

Mr. G. P. Bidder—Past President—said he had listened to the paper with great interest. It was an evidence that the Author, as a government official, had a view to the commercial results of railways. This system was not propounded as a measure of economy, in other respects than that there were cases in which the economy of constructing the narrow gauge should be considered, where it could be introduced, for the sake of the curves and gradients, in districts where the broader gauge could not be introduced. That was the only ground on which this question could be fairly considered; but the Author did not pretend that a narrow gauge could be worked more cheaply than a broad gauge. The arguments adduced in favour of the economy of working the narrow gauge, if followed out, would lead to the conclusion—that if there were no gauge at all, a railway could be worked for nothing. The question was, not the cost of moving a carriage, but at what cost a ton of minerals, or coals, or a hundred passengers could be moved. As a matter of practice, a ton of minerals, or a hundred passengers, could not be moved on a narrow gauge more cheaply than on a broad gauge. That it was so in this case was shown in the figures given in the paper; for, although the substitution of steam traction in place of horses was undoubtedly a proper thing to do, yet he did not understand the Author as propounding the question of these narrow gauge railways to show that the cost of working, ton for ton, and passenger for passenger, was any cheaper than working on a broader gauge; the Author said distinctly, he did not propose this narrow gauge, except in isolated places—as in the instance given between Festiniog and Portmadoc, where the railway took the slates from the quarries to the ships, and had no connection with any other railway. But a break of gauge, whether in India, or elsewhere, was an avowed evil and could only be reconciled by the advantages of economy of construction, as compared with the cost and in convenience of trans-shipment. As to these railways, he had no doubt for short branches, or extensions, or even for village lines, it might be useful to introduce them. But in this country there were what were called 'the "Standing Orders of Parliament," which interfered very much with such lines. Engineers were allowed to deviate 5 feet vertically in open country, and were restricted to 2 feet in towns. Anything more absurd than that, it was impossible to conceive. In the neighbourhood of London, where the country was flat, a limit of 5 feet might be suitable; but in districts where the inclination of the surface of the ground was 1 in 5, or 1 in 6, the 100 yards of lateral deviation might change the work from cutting to embankment; and the 5 feet might require to be 20 feet, or 30 feet. Parliament said " A railway shall not cross a public highway in this country if it interfered with its level, excepting it be made with a gradient of 1 in 20 for a parish road, and 1 in 30 for a turnpike road; nor shall it cross a road on the level, without permission." Of course, these were questions of local circumstances: 1 in 20 might be a proper gradient for London; but there were districts where the normal gradients were 1 in 7, or 1 in 10, and where the traffic might amount to three vehicles, or four vehicles per day. No attention was, however, paid to that fact, nor were reasons listened to—but a gradient of 1 in 20 was insisted on. He had had to say, on one occasion, in committee, that if such conditions were to be abided by he could not prove the preamble, for the gradient of the valley 1 in 11, 1 in 20 would go quite across the valley. But what he proposed was, to spend £500 in improving the road on the other side of the railway, lading to the nearest village, and then the bill was passed.

With regard to level crossings, he feared he had been a great offender, for on one line he had as many as thirty-eight level crossings on as many miles of railway. But now the rule was, that there should be no level crossings. In consequence of this, where the Great Eastern Railway crossed a country road at its apex, at a most convenient place for a station, especially for minerals, the engineer was compelled to avoid making a level crossing, though it was near the highest point of the country, and to raise that road 15 feet or 16 feet, at a cost he believed of £7,000 or £8,000. The Company could not have a station there, the opening of the line was delayed for several months, and the thing was a nuisance to the neighbourhood.

He offered these remarks, because this paper showed, that the Author's mind was directed to commercial results. He said in effect " where the broad gauge is inappropriate have a narrow gauge." He agreed with him; but the question of commercial consideration entered as much into broad as into the narrow gauge railways, and regard must be had to the local circumstances where each gauge might be applied.

Mr. E. Woods thought it was evident, from the observations which had been made, that no one system could be laid down, nor any one gauge be fixed upon, as applicable to all conditions of locality, traffic, &c., but that each district must be treated according to its circumstances. With regard to the Indian gauge of 5 feet 6 inches, he could quite understand, it was most desirable to construct branch lines on the same gauge as the main lines, and in a flat country like India the difference of cost as between a gauge of 5 feet 6 inches and a narrower gauge would not be great, the principal item being in the additional length of the cross-sleepers. The rails might be lighter than those of the main line, and the engines for working the branches made light in proportion. Six years ago he had to construct a railway in Chili, 27 miles in length. The line was situated in the lower range of the Andes, where the gradients were necessarily severe and the curves sharp. Here curves of 500 feet radius in combination with gradients varying 1 in 20 to 1 in 30, constantly occurred. It was said, by the engineers of the country, that it would be impossible to work that line with locomotives, and accordingly it was laid out for mule traffic, and it was worked by mule power for eighteen months. But owing to the seasons, of drought and other causes the expenses of working were so high, that a decision was come to by the Directors, to work the line by locomotive power. He was called upon to design the engines, and in his design he limited the weight on the driving wheels to 7½ tons, but the difficulty was to get sufficient adhesion to take the loads up the severe inclines of 1 in 20 for 7 miles, and of 1 in 30 for 12 miles. That difficulty was overcome by putting 6 driving wheels to the engines, and placing the front end on a bogie truck. The rails, of 42lbs. to the yard, had stood exceedingly well, and up to this time were in good working order, for though the engines weighed 30 tons, the weight, being distributed over so many wheels, had produced no sensible injury to the rails. The ordinary working speed on the inclines was about 12 miles per hour.

From the experience of the working of that line, it was evident that railways of light and inexpensive construction might be advantageously worked, if due regard were paid to the adaptation of suitable rolling stock.

Mr. W. Bridges Adams said, in dealing with the question of light railways, there were two aspects from which to regard them—the commercial and mechanical. The latter might be a toy, but the former must have reference to utility. The object being to transport materials and men, there must be sufficient volume in the carriages to hold them conveniently. Now, it was not convenient to have the dimensions so reduced as to render it necessary to strap the passengers to the seats to prevent oversetting. It was quite true, that the narrower the gauge the shorter might be the distance between the axles, if rigidly parallel, so as to facilitate passing round sharp curves; but, on the other hand, the longer the vehicle the steadier would it run, and the rigid structures which formerly needed straight lines of way, or very flat curves might now cease to be rigid, by provision being made for the axles to radiate on curves, and point truly to the centres of those curves. By this arrangement, and by the use of spring tires, permitting the wheels to slip within the tires, it was now practicable for carriages, or engines, with extreme wheels 25 feet apart, to roll without rail friction round curves of 2 chains radius, and this fact rendered the width of gauge whether 2 feet or 7 feet, a matter of indifference as regarded curves. On the Norwegian line of 3 feet 6 inches gauge, engines of that class were now working.

In considering the cost of gauge, the saving could not be in the rails, but only in the length of the sleepers, and the quantity of balast, bridges, &c. The axles might be shorter, and material might be saved in length of cross framings, but it did not follow that this was economical. With a given load, there was a certain space required to stow it, and there was a certain proportion of length to breadth of train which gave the best results in traction. A long narrow train was disadvantageous and especially so on very sharp curves. The proportion of the width of rail gauge to the width of the carriages was another consideration. As a mechanical rule, the carriage bodies might be safely made double the width of the gauge. Beyond that width there would be a tendency to unsteadiness. A 2-feet gauge, by that rule, would only admit a carriage 4 feet wide, and that, even with passengers back to back, was very cramped. Again, with passengers so placed, 3 feet in length of the carriages would only carry four passengers. While seated fore and aft, eight passengers could be carried in a 4-feet length of carriage, with a 3 feet gauge of rails, *i.e.*, one-fourth increase in length of train would double the number of passengers, or volume of goods.

With a 2-feet gauge and wheels 2 feet in diameter the boiler and framings should be carried above the wheels altogether. With a gauge of 3 feet 6 inches, the boiler might be between the wheels; and engine-wheels of only 2 feet in diameter seriously damaged the rails if heavily loaded. If of larger diameter, better adhesion might be attained. The worst gradient on the Festiniog line appeared to be 1 to 60, but with heavier gradients heavier engines would be needed, and there was now no difficulty in constructing engines with eight drivers to roll round curves of 2 chains on any gauge. The very important feature in the engine described was the great pressure of steam—200 lbs. to the inch.

There was no doubt that narrow gauges might be made at less cost than wide ones, but it was doubtful if any material saving could be made by reducing a 3-feet gauge to a 2-feet gauge, when it was considered, that the upper structures of the train must be provided with sufficient space for convenience.

There was one reason why it was desirable to make branch lines of a narrower gauge than main lines when the traffic was light, viz., to prevent heavy engines and vehicles from running on and destroying them. But in the coal traffic it was desirable, and possible to employ wagons of the greatest capacity and length, capable of running round the sharpest possible curves and up to the pit's mouth, and in this case it was better to have no break of gauge. On a gauge of 4 feet 8½ inches, it was quite practicable to use 8 wheel wagons, 40 feet long, by 9 feet wide, with an internal capacity of 1,600 cubic feet.

Mr. Gregory, V.P., said, he was prepared to recognise the propriety of the measures adopted on the Festiniog railway, under circumstances which, he thought, were special and peculiar; but the Institution and the profession would be bold if they attempted, on the data now before them, to adopt, as had been suggested, the idea of a supplementary narrow gauge for all small branch lines. He believed that the advantage of such a gauge was limited to local conditions, such as those described in the paper. There was an old line having branches into several slate workings, and on account of the gauge already existing in those workings, and the character of the works and the curves of the Festiniog railway itself, it would have been exceedingly difficult to adopt the ordinary gauge, therefore the managers had endeavoured to make the most they could of an exceptionally narrow gauge, by converting the main line into a line for general goods and passengers. They also did well to introduce locomotive power on the line; but all who heard the paper must feel that this was done under difficulties. He must record his protest against the theory, that the cost of the working expenses of railways was in proportion to the cubes of their width of gauge. The quantity of goods, or the number of passengers to be carried, was an essential element in such a question, and he thought that it might with as much correctness be affirmed that Messrs. Pickford could carry on their business more cheaply in costermongers' carts than in their usual vans. This illustration would show that such a theory could not be practically supported. He was sure while Mr. England had got work out of an engine, under difficult circumstances, with an exceptionally narrow base, that gentleman would state that he could obtain greater power, and more economy for a large amount of work, if he had a wider base to work upon.

In considering the circumstances under which an exceptionally narrow gauge might be adopted, it became necessary to investigate its supposed advantages. Setting aside the idea of any saving in working, when there was anything beyond a very limited traffic, these advantages appeared to be classed principally under two heads, viz., firstly, a saving in cost of construction, and secondly, the easier use of sharp curves.

What had been done on the Festiniog Railway to make the most of its capabilities did not point to much saving in first cost; indeed it seemed, as had been remarked, that the saving would extend to little beyond sleepers and ballast. It was pointed out in the paper, that to make the most of the wagon and carriage room, the rolling stock overhung so far that a width of 4 feet 6 inches was required between the rail and any bridge piers, and a 7 feet space between any two lines of rail; the result would be the necessity for a minimum structure width for a single line, of 11 feet, as compared with 12 feet 8 inches on the ordinary gauge, and for a double line a width of 20 feet, as compared with 23 feet 5 inches in the ordinary gauge of 4 feet 8½ inches. Such a difference would produce so small a saving in the cost of the works, as not to compensate for the disadvantages of having a very narrow wheel base, which would limit the power of the engine, and in the event of the derangement of the permanent way, would cause such unsteadiness in running, that the speed common on ordinary railways would be dangerous.

With regard to curves, the friction arising from the different length of the arcs of the outer and inner rails was greater on a broad gauge than on a narrow gauge, and as rolling stock was at present generally constructed with rigidly parallel axles, the most obvious advantage of an exceptionally narrow gauge was the smaller radius of curves that might be adopted. But, he thought, modern improvements were going far to overcome the difficulties of sharpe curves, and he recognized the great value of such inventions as Mr. Adams' radial axles, by the application of which to the ordinary engines and rolling stock of the country, trains might run round sharp curves on the ordinary gauge as freely as on a narrower one.

As these two supposed advantages seemed likely to disappear, he therefore concluded, that seeing the loss which took place by the uneconomical application of the power of the engine, the fact that the ordinary gauge admitted of rolling stock, which would bear a smaller proportion of dead weight to the weight carried, and last but not least the evils of a break of gauge, it might be concluded, that if there was to be an exceptionally narrow gauge in this country, it could only be advantageously applied to exceptional cases.

Mr. T. E. Harrison said, he entirely agreed, that it would be absurd to say, because this narrow gauge had been succesful in its application in a particular state of things, therefore it was applicable generally. The particular case where it was applied was one in which the main traffic of the line was in slates, and the trucks were taken to where the slate was quarried, and where no large wagon could go. The slate was unavoidably brought down inclined planes in narrow wagons; and if the gauge of the main line had been broad, must have been reloaded into broad gauge wagons. At Portmadoc the slates would have to be again transferred from the wagons to the ships alongside the quays: this narrow gauge was therefore the best means of conveying them to the port of shipment. As to the mode adopted for the conveyance of passengers, no doubt it was ingenious, and people travelled on the line with a good deal of comfort; but the works were so narrow, that when the train was standing still in a cutting, a passenger could hardly make his way past the edges of the carriages. That was not a railway which could be taken as a sample of what was desirable. It was a clever adaptation of a state of things which previously existed, and which had been designed with a different object, and as far as it went, it was exceedingly good; but to suppose that the principle upon which it was constructed was to be applied to an unlimited extent where railways of the ordinary gauge existed, was a total fallacy. It was possible that there were exceptional parts of the country where such a system might be adopted; but at the present moment such an instance did not occur to his mind. He knew there was an intention to employ the narrow gauge in other slate-quarries; but those were particular cases, and he thought, if the Institution gave its sanction, in any shape or way, to the extension of the system to general traffic, it would be leading the public in a wrong direction.

Mr. Alfred Giles remarked, that it was some years since the battle of the gauges was fought, and he had scarcely expected a fresh campaign to be opened in this Institution in favour of a 2-feet gauge. The 7-feet gauge was known to be too wide. Mr. Hemans had observed that the Irish gauge of 5 feet 3 inches was wider than was necessary, and Sir Charles Fox had said, that if he had had his own way in India, he should have preferred to have laid the branch lines on the national gauge of this country instead of on the gauge of 3 feet 6 inches. This proved, that the old gauge was not far from the right thing. The advantages claimed for the narrow gauge were, first, great facility in traversing sharp curves; secondly, economy in construction; and thirdly, the use of lighter rolling stock. The first two points had already been disposed of. He remembered seeing in Paris, some years ago, a little railway with a gauge of 4 feet 8½ inches running in a circle, the radius of which, he believed, was only 25 mètres. He had seen trains run round that line with great facility; and if that were so, where was the necessity for making a 2-feet gauge to save a little in the radius of the curve? It was stated that the least curve on the Festiniog line had a radius of 2 chains, or about 40 mètres. As to first cost, it had been shown that the economy could result only in a little shortening of the sleepers, and a little saving of ballast. This could not be put down at more than £300 a mile. Then as to the weight of the rolling stock, credit was claimed for the engine being only 7½ tons weight; there was no reason why an engine of similar weight (plus a little extra for the longer axles) could not be applied to the ordinary gauge. But it had been asserted, that the weight of the rolling stock was increased as the cube of the gauge; if that were the case, the weight of the Great Western broad-gauge engines should be 343 tons. Looking at all these circumstances, it was clear that the national gauge was nearly the best that could have been chosen. On an ordinary road, where there was no limit as to gauge, carriages had a width of about 4 feet 6 inches, and even the smallest cart was wider than 2 feet; he hoped, therefore, that engineers would not adopt the idea that the 2-feet gauge was an example to be copied, when they knew, as had been remarked, that a break of gauge was a great public inconvenience.

Mr. J. J. Allport, having had many years' practical experience in the working of railways, would offer but one observation upon this very narrow gauge. For reasons which he would state, he was of opinion that it would be most objectionable to attempt to introduce it into the country generally. With respect to the existing broad and narrow gauges, it was well known to all practical men, that the weight of a train on the narrow gauge was as great as on the broad gauge, or rather, that engines could be constructed to take as great weights on the narrow gauge as on the broad gauge; and if engines were made much heavier than at present, various difficulties, such as of wear and tear, would arise. But there was one difficulty greater than all: the principal part of the work of a train was at the stations, in the loading, unloading, and moving of trucks and carriages from one part of a station to another, across turn-tables or traversers; and any one who had had experience at a station worked upon the mixed gauge, or solely upon one or other of the gauges, must have been struck with the great additional expense in working the broad-gauge plant at the stations. It was not difficult for a couple of men to move a narrow-gauge truck or carriage to any part of the station; but to shift the broad-gauge plant, horses must be employed. The capacity of the goods wagons and coal trucks upon the narrow gauge had been gradually increased from about the size of the Newcastle chaldron of 2 tons 12 cwt. up to 8 tons, 9 tons, and 10 tons, for the load; but, he thought, all narrow-gauge managers had come to the conclusion that, from 8 tons to 9 tons, for trucks was the maximum load that should be carried on the narrow gauge, with a due regard to economy and safety. If that weight for the load was exceeded, the wagon itself had to be made so much heavier, and then the friction was considerably increased, causing hot axles and other objectionable results, so that it was not uncommon to see these heavy wagons standing under their load, at various sidings and stations, and waiting to be repaired. On the Midland Railway there were between 17,000 and 18,000 coal trucks at work; for a long time the capacity of these trucks was limited to 6 tons: now the capacity had been increased to 8 tons; but the Company did not approve of greater capacity than that. He was of opinion, that for all practical purposes the gauge of 4 feet 8½ inches was the best, and superior to either the broad, or the narrower gauge. But there was another important consideration: if a very narrow gauge were adopted, it could only be on branches connected with main lines. That would involve, in all cases, trans-shipment of passengers, goods, and coals, at the junctions; and, in itself, would cause a greater annual expense than the interest upon the increased first cost of the line upon the uniform gauge of the parent lines, both in the purchase of land, and the construction of rolling stock. That was a fatal objection to the introduction of any gauge, other than that of the line with which these branches were connected. He had no doubt than in a very few years the gauge of 4 feet 8½ inches, as being the best adapted to the commercial wants of this country, would be the only one in use.

Mr. Zerah Colburn said this paper raised the question, how small could a locomotive be made to give practically useful work? In 1852 the contractor for a portion of the works on the Great Western Railway of Canada employed the steam excavator, which no doubt many present had seen in former days on the Eastern Counties line. For that purpose he proposed to lay the temporary line on the 3 feet 3 inches gauge, and wagons were built to hold each 15 cwt. as a load. Mr. Colburn designed and built a small 4-wheel tank engine for working these wagons, and six other similar engines were afterwards built. The tank was placed under the boiler between the frames, and as the gauge was so narrow, the fire-box was placed behind the driving wheels, and to correct the overhanging weight the tank was carried as far forward as possible. These engines weighed 6 tons only, with fuel and water, and could be easily taken apart, for carriage over common roads, into three principal portions, of which the heaviest weighed hardly more than 2 tons. The cylinders were 9 inches in diameter, with a length of stroke of 16 inches; and the wheels, of 3 feet diameter, were placed 4 feet 6 inches apart from the centres. The engines worked well, although of course only at moderate speeds.

Mr. James Brunlees knew the Festiniog railway well, and though he did not question the success of working locomotives on so narrow a gauge mechanically, he much doubted its success commercially. On the other hand, he believed that, beyond a certain limit, the wider the gauge, the less would be the dividends: he looked upon that as an established fact. Some years ago he constructed a narrow gauge line from Portmadoc to Gorsedda, the length of which was 8 miles, and the gauge 3 feet: the total rise in the 8 miles was 900 feet, and the cost per mile, including land, was £2,000: the sharpest curve had a radius of 400 feet and the down loads were worked entirely by gravitation; but passengers were not carried on the line; and although he had advised this line to be made on a narrow gauge, he was not prepared to recommend its further adoption, unless for exceptional purposes, or for purposes similar to the one in question. The want of uniformity of gauge was a great drawback to traffic in many parts of this country, and hence any departure from the ordinary gauge would perpetuate and augment that drawback.

Mr. Galbraith said, there was one principle involved in the paper which had been lost sight of in the question of the gauges; that was—was there no room in this country, particulary in the agricultural districts, for cheaply constructed railways on the gauge of 4 feet 8½ inches? He thought there was. There were many cases where, by adopting sharp curves and a light permanent way, with light engines and level crossings at public roads, a railway might be laid down for £4,000 or £5,000 per mile, which would pay a fair dividend upon the outlay; and he hoped it would be impressed upon the members of the Board of Trade, that in respect of branch lines, on which the traffic was light, they ought to relax the stringent requirements with respect to expensive permanent way, and costly works to avoid level crossings. He had been engaged in laying out a line in Devonshire, of the character he suggested. If heavy earthworks and bridges were to be encountered, it was impossible that the line could be constructed to pay a dividend at all. In parts of Devonshire there were small public roads the traffic on which did not exceed two vehicles or three vehicles per day. To maintain, at a heavy cost, the principle of avoiding level crossings in such cases was, he thought, unwise. In many cases, railway companies erected cottages along the line for the plate-layers to be near their work; and there could be no objection to the wives of the men attending to the gates at such level crossings, in consideration for living rent free. He thought curves of 10 or 12 chains radius, and level crossings where the public traffic was light, might be fairly admitted on branch lines, which, when constructed at £4,000 or 5,000 a mile, might be made to pay a dividend. In such cases, a light rail of 40lbs. or 50 lbs. to the yard might be laid down, which would carry the ordinary carriages, if not the ordinary engines; but for short branches of 10 miles or 12 miles, one engine or two engines might be specially provided by the company, to work the branch alone. Such a plan as that was far preferable to an exceptionally narrow gauge causing a break between the branch and the main line, and the consequent trans-shipment of the traffic, and the supply of fresh plant in the shape of carriages and wagons to work the traffic when so transferred. This question having been now fairly raised, he thought it was a point which ought not to be lost sight of, and which was well worthy of consideration.

Mr. Peter Barlow said, that though he was not of opinion that the gauge of 2 feet was expedient, or that any gauge at all approaching it was correct, yet he considered, that the same gauge could not be suited to every description of traffic. The gauge adapted to the costermonger's cart would not answer for Pickford's vans, and the gauge of ocean steamers would not suit the penny boats on the Thames. He thought the cost of constructing a line was very little influenced by the width of the gauge; but was rather influenced by the width of the carriages. It was desirable that a uniform gauge should prevail all over the country, and good reasons ought to be shown for deviating from the established gauge. At the same time he hardly conceived it was a gauge suited to all circumstances, and cases might arise in which the local traffic might be better provided for by a narrower gauge. What led him to think so was the result given by the Author, who had shown that an engine weighing only 7¼ tons could take a load of 50 tons up a gradient of 1 in 60. On the metropolitan lines, engines of 40 tons were often employed for less loads; but the exigencies of a metropolitan traffic required frequent and light trains, with power to get rapidly into speed, and thus resembled the case of the penny boats on the Thames. He agreed with Mr. Gregory that there was little economy in the construction of these exceptional gauges, and he thought what was done upon the 2 feet-gauge might possibly be done upon the gauge of 4 feet 8½ inches. Still the fact of what had been performed by the locomotives on the Festiniog line was worthy of attention, and he thought the Institution was much indebted to the Author for having brought the subject forward.

Sir Cusack Roney had seen the gauges of Canada and the United States andh adtravelled upon continental lines in various parts of Europe. He had also had the opportunity of seeing the working of many branch lines, and he was thoroughly convinced of the desirability of a uniformity of gauge in all cases, between the branches and the main lines. He considered that the gauge adopted in this country was the correct and really practicable one. In most parts of Europe he had met with nothing but the narrow gauge: with one exception—where the line was worked by horse-power.

Mr. Robert Mallet begged to offer one or two observations in explanation. He had not intended to say, that in choosing a gauge the choice depended upon the purely physical considerations he had brought forward, but, on the contrary, that the choice of gauge must depend upon prudential conditions, and, amongst other things, primarily upon the question of traffic. To put an obvious example: If the whole traffic were to be of cubes of granite, or other stone, each of 20 tons weight, a railway of even more than 7 feet gauge might not be sufficient. Thus at the harbour works at Holyhead the contractor's gauge was 9 feet or 10 feet, being employed for the transport of blocks of 15 tons. But for certain conditions and amounts of traffic, a narrower gauge than 4 feet 8½ inches would not only be sufficient, but would be found the most economical and advantageous. What he had stated with reference to gauge was, that it was a general physical fact, that both the first cost of the works, and of the rolling stock of any similar railways, and also the working expenses for the haulage of any total of traffic, must increase with the width of the gauge, and as a high function of it, and that this function would probably be very nearly in the ratio of the cube of the gauges. English railways with a gauge of 7 feet, and those with a gauge of 4 feet 8½ inches, could not be compared, in those respects, not being similar either in way, or in rolling stock; thus, as respected the wheels and axles, those of the Great Western were rather lighter; being obviously weaker than those used on the narrow gauge, and having only the same width of tread. In the case of the passenger carriages, as a whole, he found the bodies were nearly of the same breadth on the narrow gauge as on the broad, on the former the overhang was greater. It was thus impossible to establish any ratio whatever between the width of gauge and rolling stock, where there was no similarity of construction on the two different gauges.

With respect to the remark that if the width of the gauge were 'nil' the cost of working would be also 'nil,' it should be remembered, that on such an assumption the traffic also became 'nil' at the same moment; so that while the mathematical deduction might be true, it did not in the least touch the question of the relative economy of the narrow and the wide gauges.

Mr. George England said, he did not for a moment apprehend, that the narrow gauge of the Festiniog railway was regarded as having been brought forward as a pattern for universal adoption. That line had been made fifteen years, and it was not originally contemplated that it would ever be worked by locomotives. During the time that the traction was performed by horses, the owners were satisfied, both with the mode of traffic and the dividend the line yielded; and it was only when another Company wished to take a wider gauge into the district, that the working of so narrow a gauge by locomotive power was determined upon. It was done solely in self-dence: and he was applied to, to carry out the object of drawing a load of 25 tons up an incline of 1 in 60 at the rate of six miles per hour. The first engine that was started took a load of 50 tons up the line at the rate of 12 miles per hour. That was simply the statement that the Author had brought before the Institution. The line was 14 miles long in the incline: the wagons were taken into the slate quarries, and the locomotive was only adopted in order to suit local circumstances.

The valuable paper on the Festiniog Railway, which appeared in our last number, was read by its author, Captain Tyler, R.E., before the Institution of Civil Engineers, and the foregoing discussion thereon will be read with interest.

MANCHESTER ASSOCIATION FOR THE PREVENTION OF BOILER EXPLOSIONS.

The ordinary monthly meeting of the executive committee of this association was held at the offices, Corporation-street, Manchester, on the 31st of July, 1866, William Fairbairn, C.E., F.R.S., LL.D., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

"During the last month 182 engines have been examined, and 340 boilers, as well as two of the latter tested by hydraulic pressure. Of the boiler examinations, 201 have been external, 10 internal, and 129 entire. In the boilers examined, 87 defects have been discovered, 7 of those being dangerous.

"*Corrosion—Internal.*—Some corrosive waters not only waste and indent the surface of boilers internally, but also destroy the vitality of the metal, so that the edge of the overlap may be cut away with a few slight blows with the hammer, and the rivet heads knocked off with a hand chisel only, and easily pulverised. Such was the character of the defects found in one of the boilers examined during the past month, which was at once laid off by the owners, and condemned as soon as its condition was pointed out by the association. The above shows the importance of carefully testing corroded rivet heads with a hammer.

"*Corrosion—External.*—Both the dangerous cases referred to in the table arose from leakage at the joints of boiler mountings, in consequence of their being bolted to the shell instead of rivetted. The plates were so eaten away that in one case the inspector scraped a hole through with his chisel, while this could easily have been repeated in the other. One of the mountings was a cast iron man-hole mouth-piece of somewhat large size, and as the corrosion extended in a groove all round it the boiler was clearly unsafe to be worked, and was immediately laid off. This encircling groove was not very easy of detection, since, although nearly eating through the plate it was only three-eighths to half an inch wide, and almost buried under the edge of the casting, added to which it was filled up with tar with which the boiler had been coated. There may be others in a similar condition for which this may be a caution. All mountings, instead of being bolted to boilers, should be attached with suitable fitting blocks rivetted to the shell.

"*Deficiency of Water.*—This arose at night time when the fires were banked up, from the attendants omitting to close the feed stop valve, there being no self-acting back-pressure valve, and the feed inlet being below the furnace crowns. The importance of every boiler being fitted with a good self-acting feed back-pressure valve, as well as of the feed inlet being above the level of the furnace crowns, has been frequently pointed out in previous reports. The furnace crown was fitted with one of those fusible plugs in which the alloy is in the shape of a washer about the size of a penny-piece, having a copper button in the centre of it. This did not, however, prevent the plates becoming red-hot. The plug did not put out the fire, or, properly speaking, go off at all. A little piece of the alloy melted away on one side and allowed a slight escape of steam, which fortunately attracted the attention of a workman, who at once examined the boiler and found the furnace crown red-hot.

TABULAR STATEMENT OF EXPLOSIONS FROM JUNE 23, TO JULY 27, 1866, INCLUSIVE.

Progressive No. for 1866	Date.	General description of boiler.	Persons killed.	Persons injured.	Total.
33	July 2	Plain cylindrical egg-ended Externally fired	4	0	4
34	July 16	Particulars not yet fully ascertained	1	1	2
		Total	5	1	6

"No. 33 explosion occurred at a colliery at half-past three o'clock on the morning of Monday, July 2nd, and resulted in the loss of four lives.

"The boiler, which was not under the inspection of this association, was of the plain cylindrical externally-fired class, its length being 30 feet, its diameter 6 feet, and the thickness of the plates three-eighths of an inch, while the pressure at which the safety valves were loaded was 30 lb. per square inch. From the evidence given at the inquest it appeared that the boiler was nine years old, was set with a wheel flue, fed with hot water, and had been cleaned and repaired, when five new plates were put in, but a week before it burst. Also that at the time of the explosion the boiler had plenty of water in it, and that the pressure of the steam did not exceed 27 lb. on the square inch; while, on subsequent examination, the plates were found to be of good quality, and to present no evidence either of flaws or of having been over-heated. The engineer to the colliery, who stated that he had held the position for sixteen years, was 'very well accustomed to boilers,' and had the superintendence of all the enginemen, gave it in evidence that he could not in any way account for the explosion, and thought that there must have been something more powerful than steam to produce it. The jury brought in a verdict that 'the four lives were lost by the explosion of a boiler at the colliery, but what caused the explosion there was no evidence to show.'

"Such evidence and such verdicts, though but too common, are not only unsatisfactory but positively mischievous, and can only tend to perpetuate explosions, as is shown by the occurrence of the one under consideration. But five weeks before a very similar explosion occurred to another colliery boiler belonging to the same proprietor and under the superintendence of the same engineer; while at the inquest evidence to the same effect as that just described was given by the superintending engineer, the smith who had repaired the boiler, and the engineman, all of whom considered the bursting of the boiler to be unaccountable, so that the jury gave it in their verdict that 'what caused the explosion there was no evidence to show.' The tendency of such evidence and verdicts to reproduce rather than to prevent these disasters was pointed out in a previous report in the remarks on this explosion, which ranks as No. 24 for the present year, though it was hardly expected that they would be corroborated by a second explosion at the same works within the short space of five weeks.

"As long as explosions are considered to be altogether unaccountable by those who have charge of the boilers, and this view is indorsed at coroner's inquests, it will be seen that nothing is done for their prevention, and boilers similarly dangerous to those which have exploded will be worked on till other explosions occur and more lives are lost, when at the inquests the same stereotyped evidence will in all probability be repeated, viz.: That the boilers were very good, very strong, and perfectly sound; that the explosions were altogether unaccountable and could not be helped.

"There is nothing, however, either unaccountable or unavoidable in these explosions. The majority of those at collieries arise simply from the use of plain cylindrical externally-fired boilers, which, as has been repeatedly pointed out in previous reports, are so dangerous and treacherous as to be entirely untrustworthy. Every fresh explosion which occurs to this class of boiler is an additional illustration of this. The two explosions recorded in last month's report both took place very shortly after the boilers had been repaired and passed as sound, one of them having been cleaned and examined but the very day before it burst, while the boiler in the present case had worked but five days and nights since being repaired and cleaned, when it is stated that the boiler was found perfectly sound and considered safe. This treacherous class of boiler should be discarded altogether, and until this be done these so-called unaccountable and unavoidable explosions will continue to recur as at present, with their attendant loss of life month after month.

"Several explosions, the particulars of which have not yet been reported, have occurred during the last few months to internally-fired single-flued or Cornish boilers, all of which might have been prevented by strengthening the furnace tubes with encircling hoops or flanged seams. The particulars of five such explosions may now be given, while two others have been reported to me which, there is little doubt, arose from the same cause, but sufficiently full details have not yet been received to enable me to speak quite positively. Not one of the boilers in question was under the charge of this association. The five explosions referred to are Nos. 3A, 10A, 11, 17, and 26, while the details are as follows:—

"No. 3A explosion, which resulted in the loss of a life, occurred on the afternoon of January 9th, at a saw-mill, to a boiler 28 ft. long, 6 ft. 6 in. diameter in the shell, and 3 ft. 6 in. diameter in the furnace tube, which was made of four plates in its circumference, three of which were three-eighths of an inch in thickness, and the fourth seven-sixteenths of an inch, the ordinary working pressure being 45lb. per square inch. The boiler was in good condition and well equipped with mountings, while the plates of the furnace tube are reported not to have presented the slightest appearance of having been overheated. It seems that the engineman had noticed, on several occasions when getting up steam, certain vibrations in the tube, and imagining that these arose from its deflection consequent on its weight, hung it up to the top of the shell by a couple of stay rods. These, however, proved of no avail. The furnace tube collapsed in an inclined direction, midway between the vertical and horizontal. Had encircling hoops been added to the tube, instead of the stay rods, the explosion would have been prevented.

"No. 10A explosion happened at a quarter before twelve on the morning of Monday, February 26th, to a boiler employed at a currier's factory. Fortunately no one was killed, and only one person injured. The boiler, which was a second-hand one, had just been re-set, and been at work but a few hours before the furnace crown collapsed, on which the steam and water rushed out from the rent and did considerable damage to the surrounding property, reducing the boiler-house and adjoining sheds to a wreck, and scattering the *débris* to a considerable distance. The length of the boiler was 21 ft., the diameter of the shell 5 ft., and of the furnace tube 2 ft. 11 in., the thickness of the plates being three-eighths of an inch, while the pressure of the steam on the square inch shortly before the explosion was 64 lb. A furnace tube of such dimensions, especially when not perfectly circular, is quite unfit to be worked at as high a pressure as this one was, viz., 64 lb., and all similar boilers should at once be strengthened, or they will only be worked at the risk of failing in the same way as this one did.

"No. 11 explosion happened at a mine on Saturday, March 3rd, and resulted in the death of one man. The boiler was 31 ft. 9 in. in length, and had a diameter of 5 ft. 9 in. in the shell, and 3ft. 8 in. in the furnace tube, the thickness of the plates being three-eighths of an inch, and the load upon the safely-valve 40 lb. on the square inch. The tube collapsed laterally, from which it appears probable that it was not truly circular; but, even if it had been, such a flue could not be prudently worked at a pressure of 40 lb. on the square inch unless strengthened with encircling hoops, or other approved means.

"No. 17 explosion, which was of a much more disastrous character than either of the preceding, resulted in the death of five persons, as well as in injury to five others, occurred at ten minutes past six o'clock on the evening of Wednesday, April 4th, at a tin-plate works. In this instance not only did the tube collapse, but both ends of the boiler were completely torn away, the body of the shell being blown in one direction and a considerable portion of the furnace tube in another, while the buildings of the works were seriously damaged, the roofs dismantled, and the whole thrown into utter confusion. The length of the boiler was 30 ft., the diameter of the shell 7 ft., and of the furnace tube 4 ft., while the plates were seven-sixteenths of an inch in thickness, and the pressure of the steam 43 lb. per square inch.

"This pressure, in the absence of any strengthening rings, was excessive for such a tube, and more particularly so if at all out of the circular shape, which is generally the case in those of so large a diameter, unless of first-class workmanship, which could hardly be expected to be met with in a boiler made in the locality in which this one was.

"At the inquest some rather curious views were expressed. An application to the Board of Trade for a government inspector to assist in the investigation had met with a refusal, coupled with the suggestion that the coroner should, if he considered it necessary, obtain the assistance of some duly qualified engineer in the neighbourhood. This, however, the coroner stated to the jury he deemed unnecessary, since several of them were practically acquainted with the construction of boilers, and able, he considered, to get at the whole facts of the case themselves. One of the jurymen stated, for the information of his fellow jurors, that a furnace tube of a boiler would withstand the same pressure of steam as the shell, if only half its diameter and made of the same thickness of plate; and as in the boiler under consideration the tube a little exceeded half the diameter of the shell it was somewhat weaker, but that had nothing to do with the explosion. It need scarcely be said that this rule is as empirical as it is false and dangerous. Another juryman undertook to estimate the precise per-centage of strength that furnace tubes lost from being overheated from shortness of water; while in the opinion of a third juror, if the plates became overheated the steam would oxidise the iron and blow up the boiler. The coroner stated it was clear the explosion had arisen from neglect in one or two ways, either in generating too much steam or giving the boiler too little water, but no one pointed out that the explosion arose from the weakness of the furnace tube, or called attention to the fatal defect in its construction of omitting strengthening rings, &c. The jury returned a verdict of 'accidental death,' caused by the explosion of a steam boiler in consequence of the smallness of the safety valve, and thus closed the inquiry without having thrown any light on the true cause of the explosion, so that it is feared that in the neighbourhood in which this explosion occurred makers will still continue to turn out unsafe boilers, and firemen to attend to them in total ignorance of their danger.

"No. 26 explosion took place at a mine on Monday, May 28th, one person being killed and three others injured.

"The boiler was of the single flue internally-fired Cornish class, its length being 30 ft. 8 in., its diameter 6 ft. 8 in. in the shell, and 4 ft. in the furnace tube, some of the plates of which measured seven-sixteenths, and others from that to three-eighths of an inch in thickness. There were two safety valves on the boiler loaded to a pressure of 40 lb. on the square inch, one glass water gauge, and two gauge taps.

"The internal flue tube collapsed from one end to the other, with the exception of about 4ft. at the front end over the fire, where the tube retained its original shape almost uninjured, the collapse taking place in a vertical direction, the crown flattening down to the bottom of the flue, while about 8ft. of the tube at the back end of the boiler was severed from the remainder and thrown to a distance of about thirty yards, the shell, with the other part of the flue tube, weighing about nine tons, being thrown in an opposite direction for about seventy yards. At the moment of explosion the engine was standing, and had been doing so for twenty minutes, the dampers being shut, and the steam it is reported blowing off gently; while the attendant, who is stated to be a trustworthy and perfectly competent workman, says that when the engine stopped there were 9 in. of water in the glass; and, also, that he tried the top gauge tap.'

"A good deal of discussion has arisen as to the cause of this explosion, and it has been attributed, as usual, to shortness of water. Had this been the case the plates of the furnace crown immediately over the fire would have been the first to have given way, whereas, as already stated, the tube failed at the back end, and retained its original shape at the front, added to which the ,tube was of such dimensions that it could not be prudently worked at so high a pressure as it was, so that it is thought there is no reason to doubt that the explosion arose from weakness of the internal flue tube, and not from shortness of water. It must not be forgotten that when an engine is standing and the safety valves are blowing off, as was the case in the present instance, that the steam pressure will always exceed the load on the safety valves more or less, and it must again be repeated that it has a most important influence on the strength of internal flue tubes, whether they be truly circular or not; which is a consideration too much lost sight of, while it explains the apparent anomaly of one boiler exploding and another of similar dimensions working safely. Tubes made with plates overlapping can never be truly circular. Many of those now under inspection are made without any lap at all, the ends being welded or else butted with a joint strip, so as to accurately maintain the circular shape. Also a belt of T iron, welded up into a solid hoop, is introduced at each ring seam of rivets. With this arrangement plates three-eighths of an inch in thickness, instead of those seven-sixteenths or half an inch, are found to be ample, and to be perfectly safe at a pressure of 60 lb. per square inch or even higher. Had this arrangement been adopted in the present instance the explosion would not have happened.

"It is feared that in the district in which this explosion occurred many boilers of very similar proportions are at work, and under these circumstances it is no kindness to the steam user and especially to the poor fireman, to enunciate half truths. It must, therefore, plainly be stated that all such boilers are dangerous, that they should be immediately stopped and the furnace tubes strengthened. This, in some cases, may be done in place by the addition of angle iron hoops; while in others, where the furnace tubes are much out of the circular shape, it might be better to remove them altogether."

ON THE SCULPTURE IN WESTMINSTER ABBEY,

By Professor Westmacott, R.A.

(*Concluded from page* 220.)

I will now refer to some of those productions which claim attention for such art qualities as they exhibit when they are employed for a higher purpose than mere architectural ornament. This is in illustrating scenes in Scripture or other history, and it then comes under the class of "subject" sculpture. Though there are works in the Abbey of an earlier date than those now to be brought under notice, there are none of greater interest, in their way, than the series of stone *relievi* which decorate the screen on the west side of the chapel of Edward the Confessor. They comprise a variety of subjects, real and imaginary, in the life of that pious monarch, derived from a chronicle written by Alfred, an ecclesiastic of the time of Henry II. This record was presented by its author to that prince in the year 1163, when, after his canonization, the remains of the Confessor were removed into a new shrine. The subjects are fourteen in number, and they are separated from each other by trefoils, rudely formed by a running ribbon. The whole length of the sculpture is 38 ft. 6 in., by 3 ft. in height. The principal figures are about 1 ft. high. The relief is very bold, the irregular concave ground being much hollowed out behind.

There is no evidence to assist in settling the disputed question of the date of this curious work; and it is from circumstances only, connected with other erections in this part of the Abbey, that any probable conclusion can be arrived at. It is now generally attributed to some time in the reign of Henry VI. in the fifteenth century. It was not later than this, and reasons might be adduced for giving it a somewhat earlier date. This, however, is not a matter of any great importance; for the few years only, of less or greater antiquity, would not materially affect the interest that attaches to the work; and this consists rather in its being "subject," or illustrative, sculpture than in any merit it possesses as a work of art. The execution is extremely rude. The figures are short and thick, ill proportioned, and utterly deficient in anatomical correctness. Of course it is impossible to judge of the expression, as the surface is everywhere greatly injured, but the stories or incidents are told in the most primitive and clumsy manner. This frieze, which in its time, must have been considered a production of no slight pretension, both from the position it occupies, and the subject treated, shows the very low condition of art in England, at fourteen hundred years after Christ. So far from exhibiting anything like progress or development, it literally is suggestive of retrogression; for it is, in every respect, inferior in art-qualities to sculpture near it, of a much earlier date. It is curious to see how little care was paid to what may be called *keeping* in these designs. In two of the subjects a church is represented; one refers to a miracle operated on an occasion of the king receiving the sacrament, when, it is recorded, the wafer was converted into the figure of a boy, who gave his benediction to the Confessor and his attendant. The other is said to represent the dedication, by himself, of Edward the Confessor's church. In both instances the church is in a style of very advanced Gothic unknown till at least three centuries after the Confessor's death. Although these works can take no rank as good art they have an interest of another kind. They are valuable as illustrations of the condition of art; but they have a further claim to attention as exhibiting the tone of feeling of the time. The traditions of the holy life and experiences of the Confessor were thoroughly believed in; and here art is exercising its true mission in giving expression to ideas that were familiar and dear to popular feeling. Without entering into the measure of truth attaching to Abbot Ailred's chronicle, sculpture is here employed in one of its most legitimate functions, especially, as in this case, in association with a sacred edifice. Rude and incomplete as it is, this work may justly be referred to as a mode in which subjects of similar importance and character might be effectively and advantageously presented in the decoration of Christain churches.

In another part of the Abbey, between this (Henry VII.'s) chapel, and the chapel of the kings, as it is called, is another very interesting work of a somewhat similar character, though the subjects in it are fewer. This is the screen of the shrine of Henry V. The decoration consists chiefly of statues in niches, but there are groups of figures in two compartments, which come legitimately within the category of subjects. One is a coronation, comprising several figures, with the king seated in the centre. It is right that attention should be directed to their treatment. That on the north side is by far the best; but here again the sculpture is extremely rude, and exhibits no true feeling for art. In other parts of the church—for instance, in some spandrels of the chapel of St. John—there are also examples of what may be classed as subject-sculpture (as distinguished from mere architectural decoration), which fully bear out the above remarks as to the rudeness of the art of the time. The more important one may, probably, be a representation of our Lord giving judgment at the Resurrection. The centure figure of the Saviour, if this interpretation be allowed, is represented seated, and is of larger proportions than those near him. The left hand appears to be raised; the right is broken off. The figures behind him are variously employed. One seems to have a pastoral staff; another, as far as it can be distinguished, is supplicating: there are three on each side. Another spandrel exhibits a draped female standing on a dragon, the hands are placed together on the breast, as if in prayer. Behind her appears to be a cross. She is surrounded by foliage, and on one side is a second dragon. This design may be intended to represent the Virgin treading the dragon under her feet. The arches of the spandrels spring from human heads. From what remains of the figures, draperies, and composition of these designs, the art exhibited is of a very rude quality. The figures want proportion, and they are rather packed than arranged in the space they are made to occupy. Two of them in the larger composition are falling on their backs evidently to accommodate them, in the usual Gothic mode of treatment, to the curve of the arched moulding against which they are placed. Of the details it is impossible to give any opinion, owing to the injury to the surface of the work; but beyond their use in filling in and enriching the space occupied by them, they evidently have but little claim to attention.

There is a class of subject-sculpture especially associated with what may be called ecclesiastical decoration, which may not be entirely overlooked in this paper. Strange to say, it is only found in religious buildings; and yet it is usually of a character that renders it quite unfitted for such application. This is in the incidents chosen for the ornaments of stall-seats and brackets, and especially in gargoyles and drip-stones, where the jealousy that existed between the regular and the secular clergy was shown in the grotesque and often highly indelicate carvings in which one body satirized the other. It is difficult to understand how the representation of such coarse buffoonery, and even of the most scandalous subjects could be permitted by those who controlled church decoration; at a time, too, when some ardent admirers of mediævalism insist that the most exemplary religious and pious impulse directed all art. It is thus breifly referred to in this place as a part of our subject, and because Westminster Abbey is not without examples of this strange and lamentable offence against propriety and good taste. It may be added, however, that with very few exceptions, the instances found here are rather of the broadly humorous than of the indecent type.

Before closing this subject, the attention of the meeting may be directed to the very remarkable series of statues that are found in the chapel of Henry VII. Here, indeed, may be seen works that, in certain qualities, may challenge comparison with the production of any school. They are of unequal merit; but the best of them are fine examples of the success of the mediæval artists in treating drapery, and in the impressive simplicity of *pose*, in single figures. At the same time, they preserve all the distinctive characteristics of the Gothic school, so carefully and so curiously maintained during the whole period of its existence.

The works referred to constitute a portion of the decoration of this exquisite architectural triumph of the sixteenth century. The nave of the chapel is divided from the aisles by four arches on each side, and similar arches divide it from five small chapels at the east end. Immediately under the arches, and extending entirely round the chapel, is a range of demi-angels, crowned, in high relief. They are rather grotesquely treated; some are draped, some are represented with their bodies feathered; and, generally, they have rich, curly hair. Their function is to support, on shields, the royal devices of Henry VII.—the rose, portcullis, *fleur de lis*, &c. Over these angels are octangular pedestals and niches, enriched with tracery and foliage, containing statues about 3 ft. high of saints, martyrs, and other venerable persons. There is here great variety of action and a fine feeling for art. The draperies especially are largely and grandly arranged. In the heads, also, there will be observed a remarkable attention to the proper expression, as well as to character and form. The action of the hands is, generally, well studied. When the naked form is introduced, as in the St. Sebastian, it is conventional, and as usual shows no intimate acquaintance with the study of nature; but in all other respects these works possess merits of a very high class, and have justly been noticed by all the best judges of sculpture as examples, of their kind, thoroughly deserving careful study and imitation. It may be noticed that though the statues in the nave average about 3 ft. in height, those in the chapels are nearly life size. They are arranged in threes, over five demi-angels. It is to be lamented that some of these interesting works have been injured, while some have been removed, and the niches and panelling destroyed to make way for monuments; as, for instance, those of two ducal houses of Buckingham; of the respective families of Villiers, and Sheffield. The statues, of all sizes, employed in the enrichment of the chapel of Henry VII., are said to have amounted, originally, to nearly three thousand. Many of the smaller ones, especially those in gilt metal, have, no doubt, been stolen.

The Monuments.

The earliest examples of sculpture in the Abbey Church of Westminster—and they are believed to be the oldest monuments in England—are seen on some tomb or grave stones in the east cloister. They are of abbots of the church. One of these is said to be of Vitalis, who died about 1082. Two others are of Crispinus, about 1114, and Laurentius, who died towards the end of that century. The effigies of these dignitaries, carved on gravestones, are represented in their robes. That of Vitalis has a mitre on his head, and in one hand are the remains of a pastoral staff. The execution of these works is extremely rude, and the relief very flat. They possess considerable antiquarian interest, but they offer no peculiarities to arrest the attention of the lover of art.

It may be observed here, that all the earlier monuments in which effigies appear are of ecclesiastics. This may, at first, appear strange, when it would seem to be so much more natural and fitting that crowned heads, kings and queens, princes, or great nobles and knights, warriors and statesmen, should be so honoured, and not that such distinction should have been exclusively conferred on the clergy. But here is seen one of the great uses of monumental art, when it is exercised under a real and true impulse: it shows the character of its age. The earliest Christian art, resembling in this impulse all the early monumental sculpture that exists, was employed exclusively in illustrating subjects of religious interest; and when applied as decoration on the tombs of holy persons or martyrs—prior to the representation of the deceased in an effigy—the subjects of the designs, whether paintings or sculpture, were always taken from Scripture or from some sacred tradition. The character of the art was rude, and examples often occur of the pagan subjects of the debased Roman schools being adapted to Christian illustration,—a new meaning being given them to fit them for this appropriation; but, however expressed, the *motive* was undoubtedly religious, and such decoration was felt to be the only proper accessory on the tombs of departed Christians. At first no personal or secular element was prominently put forth in such works.

The cause of a change in this treatment as applied to monuments is not difficult of explanation.

In the eleventh century, the period when the effigy of the deceased was first introduced, the Church exercised very great power, not only spiritual, but political. Its dignitaries held many of the highest offices of State, and the clergy generally occupied the influential position to which their education and attainments—great indeed, compared with the universal ignorance of the laity of all ranks—justly entitled them. It is not, therefore, to be wondered at, that the most eminent of its members should, on their decease, receive marks of honour at the hands of their brethren, especially, too, when these could be conferred upon them in the very edifices in which they had held the highest offices. There was, also, a great *esprit de corps* in the members of each foundation. Such memorials testified, in the first place, to the importance of the religious house, while the tomb of its bishop or abbot attracted attention, invited the devotion of the pious, and procured for the church itself many substantial advantages in the way of privileges and offerings from all classes of persons who frequented them, according to their position and means. It must also be borne in mind that all religious edifices were entirely and exclusively under the guardianship of the clergy. Ecclesiastics alone controlled everything connected with the arrangements within the building. In some societies, it is well known, their own members were competent to act as architects, painters, and carvers, and often were the sole artists employed in the design and the decoration of the church, or monastery, or whatever it might be. It follows from this, that in erecting monuments of especial honour, the members or chapter of a religious house would, naturally, first pay this mark of distinction to one of their own body; and thus the bishop or abbot, or other high dignitary connected with the particular church would, when the practice of personal representation came into fashion, have his effigy placed over his grave. For a hundred years and more this character of tomb-monument seems to have prevailed. There is not an instance of even a royal effigy during this period, the first regal monument which is found in England so treated, being that of King John, in Worcester Cathedral. Its date is probably early in the thirteenth century, as John died in 1216.

Though the previous strictly religious character of monumental sculpture, admitting only Scripture or sacred subjects in the accessories, was, as has been shown, invaded when the effigy of the deceased was represented, there still was a solemnity and repose in the design of such works peculiarly appropriate to their place in a church, and to the intention of the memorial. The figure was represented recumbent, as though extended on his deathbed. Habited usually in the full costume of his rank, with his crozier or pastoral staff by his side, the chalice in his hand, or sometimes with the hands in the action of prayer, the bishop or abbot, or whatever his title, appeared simply as the dead or dying Christian priest. It was a record, a memorial of the individual—no more. There was no ostentatious display of worldly distinction and titles; no vain, boasting epitaph. The name only—and sometimes not even that—with a date, was inscribed round the margin of the stone, and this was followed, occasionally, by a simple petition for divine mercy, or asking the prayers of the passers-by.

The principle which is so conspicuously exhibited in these earlier works continued to influence monumental design when, subsequently, such memorials ceased to be confined to the clergy, and were erected to the noble and distinguished among the laity. The recumbent effigy of the deceased surmounted the tomb. The attitude was still extremely simple, and in perfect repose, excepting when the slight action of the hands, raised on the breast in prayer, showed how the departing spirit was occupied in its last earthly moments. Whether the figure was that of a prince, knight, or lady, it was dressed in the costume of the day; and it gives great antiquarian interest to these monuments to have the assurance that the effigies on them really represent the individuals whom they record in the dresses worn at their respective dates. In a number of instances in which tombs have been opened, the costume in which the deceased was buried has been found to correspond with that given to the sculptured figure. The monument before alluded to of King John, at Worcester, was examined late in the last century, and, allowing for the changes consequent upon its great age, the dress in which the body was entombed was clearly identical in its forms with that sculptured in the effigy.

The first regal monument in Westminster Abbey, in point of date, and having an effigy on it, is that of the founder of the present edifice, Henry III, who died in 1272-3. The tomb was erected a few years later by his son and successor, King Edward I. The king is represented recumbent, crowded, habited in royal costume, with a mantle reaching to the feet. The head, with its crown of *fleur de lis*, rests on two small pillows. The long curls of hair fall from under this coronet; and the face, which appears small and delicate, and is no doubt, a portrait, has a beard and moustaches. The action of the hands suggests that the figure may originally have held some object, probably sceptres, no longer remaining. The feet have shoes on them, enriched with a running pattern of diaper gilt. As late as 1681 there was a lion against which the feet rested. This has disappeared, as well as some architectural decoration over the tomb. The material of this extremely interesting statue is bronze; and it is said, by Walpole, who does not, however, mention his authority, that it was considered the first example of metal casting in England. Both the statue and the table beneath are richly gilt, but the hard coating of dirt that has been suffered to accumulate over it entirely conceals this decoration. The latter is diapered with lozenges, each enclosing a lion *passant guardant:* this design may be plainly distinguished near the pillows. There is great dignity in the simple *pose* of this statue, and the drapery is very gracefully composed. The workmanship and materials throughout are remarkable. The panels at the sides of the tomb are of polished porphyry, surrounded by a border or framework of mosaic, with gilding and coloured stones. At each corner there are twisted columns, similarly enriched with variously coloured marbles. The lower portion, or base of the monument, still exhibits the signs of its former lavish enrichment, in its lozenges of green jasper, and the remains of elaborate ornamental carving. It is said that Edward had the precious stones employed in its decoration brought from France in 1281.

There is a peculiarity in the base of this tomb, which is worthy of remark. On the south side—that within the chapel—there are three sunk compartments. The centre one has a pediment supported by pilasters, with an architrave. The side recesses have trefoil heads. It is supposed that these recesses were used as "ambries" or lockers, in which sacred vestments or other objects, and possibly relics, were kept. At the back of each is a cross in masoic. It will be observed that the style of architecture exhibited in this work is of a very mixed character, and is highly suggestive of a foreign origin. It is known that one Pietro Cavalini was employed in the execution of this tomb, as well as that of Queen Eleanor, and it is not improbable that this may fully account for the non-Gothic treatment of the architectural portions of the design.

The immediately adjoining tomb, also, in the Chapel of the Confessor, merits attention for the extraordinary elegance and beauty displayed in some of its details. It is that of Eleanor, the wife of Edward I. She died in 1291. The figure is recumbent, habited in the royal costume. The hands are designed with the utmost grace, and there is a calm, gentle expression in the face, which is extremely touching. There has been a question as to the authorship of this very beautiful work, as well as the monument and statue of Henry III., and a patriotic desire has been shown to attribute them to native artists, but others, and Flaxman among the number, think that foreign sculptors were employed here on many of the works, and that the name of Torell, goldsmith, which occurs in a document of the time, should be Torelli. It may be so, but the expression "goldsmith" may refer to the gilder of the bronze figure, and this may have been done by an Englishman. The best argument for believing that foreign artists were employed in the more important parts of these designs, especially in the figures, is in the general inferiority of those decorative portions which would necessarily be executed by such workmen as could commonly and easily be found in this country; and the mention of Pietro Cavalini in a contemporary work gives strength to this opinion. This is a subject of very great interest to Englishmen, but it is not possible at this time to give it the consideration due to it. The occurrence of unquestionably English names in the documents connected with public works proves the existence of native artists; and it is natural that art-historians should endeavour to show that some of the most interesting works of art were produced by native sculptors. In some of these, as at Wells, there certainly is no appearance of foreign interference. They are as original in style as they are rude in execution.

The next monuments especially worthy of remark for their sculpture, are in memory of King Edward III,, his Queen Philippa, and two of their children. This king died in 1377. The royal effigy, of bronze, lies on a table of the same metal, and the whole has been richly gilt. In this statue there is evidence of great care in the portraiture of the deceased monarch. The face is long, and there is a remarkable fall in the lower lip. The hair is also, doubtless, represented as worn by the king. It is long and slightly curly, and the beard is, ample and flowing. Altogether it is an interesting example of attention to nature, in transmitting the likeness to posterity of one of England's greatest sovereigns. There are at the same time those conventionalisms of treatment which, while they give its character to Gothic art, remove the works out of the category of really good sculpture. The long drapery in which the king is habited, though extending to the feet, shows a want of truthfulness in the disposition or fall of the folds. They are composed, in straight parallel lines, as if the figure were standing. Among the careful details the shoes are "rights and lefts," erroneously believed to be a very modern fashion of shoemaking. This tomb has suffered greatly from age, neglect, and no doubt intentional illusage. Much of its enrichment has disappeared, and many of the numerous small statues that decorated the tomb have been stolen. Some of these representing the sons and daughters of Edward were in solid brass gilt.

The tomb of Queen Philippa, the consort of Edward III., still shows proofs of its former magnificence, though it is one of the most injured of the monuments in the Abbey. The effigy of this princess happily remains in a condition to afford a good idea of her person, as well as of the art of the day. The portrait is evidently carefully studied, and the sculptor who was able to give so much natural character in the treatment of the details was no mean practitioner. Such a work proves that there were artists of widely different schools employed in these productions, though it will be seen they were still under the influence of a peculiar mode or style which makes all, even the best, of Gothic sculpture. The costume of this effigy gives great antiquarian value to this monument of Queen Philippa. There is a small tomb of Petworth marble in the chapel of St. Edmund which may here be noticed, on which repose two very small alabaster figures of children of the above king and queen. They represent William of Windsor and Blanche. This interesting memorial of these young persons stands near the fine monument of John of Eltham. It has been much damaged, and the feet cut off. The costume of both is characteristic. The prince had flowing air, with a fillet; the princess, who died in 1340, a raised or horn head-dress, now broken. In these personal monuments, if they may be so called, from having the figure of the deceased upon the tomb, the effigy constitutes the chief interest of the sculpture. But small accessorial figures were introduced, either as attendant angels or statues of the apostles, saints, or other persons, to enrich the sides of the tomb or the architecture connected with it. The angels appear ministering, sometimes at the head of the figure, on each side of the pillow, sometimes at the feet. They usually are represented kneeling, and holding the chalice, or, as *thuriferi*, throwing incense from censers. They are less frequently seen at the feet, where either a lion or a dog, sometimes both, *couchant*, are made to support the feet of the effigy. With respect to technical treatment, considerable improvement will here be observed in the graceful manner in which certain details are represented. The hands of the figures are frequently of great beauty, and the draperies are most carefully studied. They are large and broad in their masses, varied in design, yet remarkable for simplicity; and where action or movement is to be shown, as in flying or floating angels, the proper character is most admirably expressed. Of course there is no display of the nude figure; and where any indication of it appears, there is evidence of the usual absence of knowledge of the human form.

Amongst the older monuments to be especially noticed are three in the choir—namely, those of Edmund Crouchback, earl of Lancaster, son of Edward II.; of Aveline, his wife (died 1275); and that of Aymer de Valence, earl of Pembroke (died 1323). They are admirable illustrations of the elegant and yet rich style of monuments of their time. The precise date of their erection is not known, but from the general treatment, the costume, and the architectural details, they may probably all be placed at between the middle of the reign of Edward I. and the beginning of that of Edward III. There is also so much similarity in the general design, that it might be fairly imagined that the same artists were employed on all the three works.

Crouchback died in 1296. His effigy lies on an altar-tomb. He is clad in chain-mail, and wears a close round helmet. The figure is slightly turned to the right,—a movement that may have been intended to convey the idea of looking towards the altar. This monument exhibits the peculiar sculptured enrichment that began at this period to characterize these designs. The sides of the tomb are filled with small figures in niches, under canopies; and the different portions of the lofty canopy which surmounts the whole work abound with decorative details. In the large trefoils, in the apex or pediment, are figures of the earl on horseback, armed in mail. The whole was gorgeously coloured and gilt, and remains of this may still be discovered in some parts of the monument.

The monument of Aveline, his wife, the daughter and heiress of William de Fortibus, earl of Albemarle, consists of an altar-tomb, upon which, under an elevated canopy, reposes a recumbent figure of this lady. The head rests on two cushions, supported by angels. The dress and drapery of this monument are remarkable for the elegant taste displayed in their composition and execution. She is represented in a hood and coif, which fall over her arms, her hands being raised in the act of prayer. The other part of her costume consists of a loose robe and long flowing mantle, reaching to the feet; and in the graceful arrangement of these the sculptor has shown himself a consummate artist. With carefully studied form, there is a character of quiet repose quite in harmony with the subject.

The third monument referred to, of Aymer, or Andomar, of Valence, resembles in its general features that of the Countess Aveline, but its dimensions are greater; it is more lofty, and the enrichments appear to have been more elaborate. As in the other examples, the figure is recumbent on an altar-tomb. The earl is in chain armour, with a surcoat of his arms. The hands, which no longer exist, were evidently raised on the breast as if in prayer. There is an interesting passage in the introduction of two small half-kneeling angels at the head of the earl, supporting on their hands a third figure draped. This is too much injured and broken to afford any details, but it has been thought to represent the soul of the deceased being thus held up by angels on its ascent to heaven. No mere description would do entire justice to this very remarkable work. In its details it exhibits the peculiarities of the Gothic style, in its fanciful and elaborate accumulations of crockets, foliated cusps, varied trefoils, and similar enrichment; but if the purpose of the artist was to produce a striking effect, and to impress the spectator with a solemn yet pleasing train of thought while contemplating this noble and beautiful memorial of the great earl, there can be no question that this monument deserves to be considered, of its class, a most valuable work of art. The sides of the tomb are filled with statues, now, alas! much mutilated, and in a large trefoil panel in the pediment of the canopy appears a knight fully armed, on horseback. The whole of the monument has been richly gilt and painted, and, like the works previously described, was studded, in every part that would allow of it, with shields with heraldic bearings painted or emblazoned. These tombs are surmounted by lofty, enriched canopies, tapering upwards with every variety of accessorial decoration. Crockets run along the exterior lines, while foliage, diapered grounds, trefoils, quatrefoils, enriched cusps, gilding, enameling, and colour, now much dilapidated and defaced, formed the costly details of these memorials of rank and greatness. An altar-tomb monument, in the chapel of St. Edmund, having on it a recumbent effigy of William de Valence, earl of Pembroke, whose death occurred in France in 1296, deserves especial notice here. The body of the earl is believed, from an expression in the old inscription, now no longer existing, to be deposited in the stone tomb which forms the lower part of the monument, but the effigy is placed above this, on a long wooden chest. The figure is in chain armour, with a surcoat extending to the knees. An enamelled emblazoned shield suspended by a richly-decorated belt, is on the left side. The head, dressed in a close skull cap surrounded by a flowered fillet, in which are sockets which formerly held precious stones, rests on an enamelled pillow, and a lion, much mutilated, supports the feet. The hands are raised as in prayer, and the portions of the dress that can be examined closely are diapered. There is also much gilding and enamelling still perceptible in the enrichment of this interesting work. But the circumstance that calls more particularly for notice is, that that the statue itself is made of wood (oak) covered with plates of metal (copper) richly gilt, while the effect of the chain mail is given by engraving on the metal. It is said this monument was erected by Aymer de Valence to his father's memory.

The much-injured monument of John of Eltham, earl of Cornwall, (son of Edward II.), who died in 1334, merits attention as a good specimen of the treatment of such works. The effigy is made of alabaster; and the details, of plate-armour, surcoat, gorget, coronetted helmet, with the other proper accessories, give great antiquarian interest to this work. The coronet is of the ducal form, having alternately small and large trefoil leaves; and it is thought that this is the earliest authority for its being so represented. There is nothing unusual in the style of art exhibited in the sculpture; but with the small attendant angels at the head, and the figures in niches on the side of the tomb, it affords another of the numerous valuable examples of the monumental style of the fourteenth century. There was formerly a very beautiful canopy over this tomb, but there are now no remains of it. The accessorial statues are much broken, and many portions of the monument have doubtless been stolen.

The introduction of knights fully armed and mounted, representing no doubt the noble persons whose larger effigies are placed on the tombs, in the decoration of the canopies of the monuments of the two Earls of Pembroke, is the only instance in this church of a reference to the worldly deeds or occupation of the subjects of the memorial. There are examples in equally early works in other places of a deviation from this rule of confining the accessories to religious objects only, as angels and attendants, sometimes relations, but more frequently ecclesiastics, but none occur here except in the slight degree referred to. Nor is there any example of the double representation of the subject; first, in the figure on the tomb, habited in the usual costume; and, secondly, showing the corruption and decay of the body in death; either with the skin shrivelled on the bones, or the bare skeleton laid out.

These characteristic examples, selected from the large number of interesting monuments of the Gothic or Mediæval school of art, are sufficient to convey a notion of the best monumental sculpture prevailing in what has been thought by many the best period of Gothic architecture. Judged as productions of *fine art*, it need scarcely be said they fall far short of the excellence that the remains of sculpture of a much older date show the art was capable of attaining. They have, however, their own peculiar merit, arising out of the sentiment which pervades them, and the propriety of their design; as expressive of certain feelings, and for its appropriateness, both to place and object. There is a truly serious and religious character in the *motive* of these works, which subdues and tranquillizes the feelings of those who contemplate them, carrying the reflections of the thoughtful to objects beyond the present. In this respect, however deficient they may be in technical qualities, they fulfil a great purpose, and they stamp the monumental design of the fourteenth and fifteenth centuries with a principle which must be admitted to be one of high value, and worthy of praise and imitation. It will not be desirable here to multiply the specimens of the immediately following dates after those already particularised; but it may be observed, in support of remarks already made, that the subsequent monuments were not proofs of progress in sculpture. The technical deficiencies of the works of the two centuries just surveyed were not replaced by any valuable development of style or beauty of form, even where a wider practice may have induced some greater readiness and facility of mere execution. The monumental form, of recumbent dead or dying and praying figures was still preserved. Either by prescription, habit or feeling, this style of treating the subject was happily and properly maintained; but, it will be seen that a new and not an improved feature was admitted into these designs, which interfered disadvantageously with the spirit of the old types.

The tomb of the royal founder of the chapel, upon which are placed the effigies in bronze gilt of Henry VII. and his Queen Elizabeth, is so well known, that it would unnecessarily intrude upon our limited time to describe it in detail. The statues, as well as the accessories, were designed by a celebrated sculptor of Italy, Pietro Torreggiano, the contemporary and rival of Michelangelo. These figures, in royal costume, are placed on a tomb of black marble, at the corners of which, somewhat uneasily balanced or sitting, are four nude cherubs or angels. The monument is inclosed within an elaborately enriched screen or "closure," also of bronze gilt, but now, like the statues, blackened by the rust of ages.

This might properly conclude our necessarily brief notice of this marvellous chapel; but as the name of Torreggiano has been mentioned, it will be right to direct attention to one other work, said to be by him, in connection with this chapel. In the south aisle is the effigy, in bronze gilt, of Margaret, countess of Richmond, the mother of Henry VII. The aged and noble lady is represented in the dress of a nun, with a mantle over all. The details of this figure deserve careful examination. The hands, in the act of prayer, are very true in character and form, and give the idea of having been cast from moulds taken from nature.

It need scarcely be said that the accessories of Torreggiano's works exhibit much of the bastard Italian style of his school as opposed to true Gothic; and there can be little doubt that the fusion of styles, as the mixture of the classical orders with certain Gothic traditions, are to be traced to the employment of foreign artists on the more important monuments erected in the churches of this country. The recumbent effigy was still insisted on, but the accessories were not strictly required to harmonize with any particular style of architecture; and thus, especially in the designs of the period succeeding the Perpendicular phase of Gothic, are found the most capricious introductions of Corinthian and other architecture of the debased forms of the classical orders,—precisely as they occur in continental design of the time. As this corrupt style was introduced in this country about the time of the Reformation, it has been said, without any reason, that the Reformation was the cause of the change and fall of religious or ecclesiastical art; when the fact is, the same bad and even worse taste is found in Italy, from whence it reached England. The sixteenth century gives a date to this false style of design; but the corruption of taste is to be sought for, as numerous monuments show, in the productions of those countries which, at that time, were much more advanced in art than England.

The period of true Gothic sculpture may be considered to be completed at this date, the middle of the sixteenth century. Already sculptured monuments of a more mixed style were executed, and it will be seen that this, in a very short time, entirely superseded the old simple character of Mediæval and ecclesiastical art.

It has already been seen that lofty, highly enriched canopies formed a striking feature in the early monuments of the Gothic period. The same protecting roof or shrine is found in the monumental design of the post-Mediæval time, and equally exhibiting a great quantity and variety of decoration. Colour, gilding, inlaid marbles, armorial emblazonment, scrolls, were profusely employed, as in the same class of design in the fourteenth and fifteenth centuries; but though there is quite as much meaning in the lozenges, twisted columns, urns, and other ornaments in these monuments as in crockets, finials, cusps, trefoils, and the other fanciful devices of the Gothic canopies, the latter were part of, and in harmony with, the architecture with which they were associated, which the ponderous vagaries of the sixteenth and seventeenth centuries were not. This independently of other circumstances, constitutes the great difference between the two; and it must be admitted that, in an art point of view, the latter offer no compensating qualities. Two monuments in Westminster Abbey, of great historical interest, at once offer themselves in illustration of these remarks. They are the tombs of Mary Queen of Scots, and of Elizabeth Queen of England. The former stands in the centre of the south aisle of Henry VII.'s Chapel; that of the English queen in the north aisle. As in the monuments of the earlier style, the effigies of these princesses form the main subject of the design. The inferior character of the sculpture, generally, is at once evident. Mary is represented in full dress, with her hands raised and pressed together, as if in prayer. The dress is elaborately worked, but is wanting in true artistic treatment; the folds not falling gracefully, but composed in heavy and straight lines, as in a standing figure, and then gathered in unseemly confusion at the feet. The hands have suffered injury, some of the fingers being broken off; but they are small and elegant in form; and the face, young, and having a gentle expression is of a pleasing character. The architectural portions are cumbrous; and every species of decoration that could be crowded into the design is lavishly introduced.

The monument of Queen Elizabeth is not on quite so large a scale as that of Queen Mary, but it is composed on the same principle, exhibiting profuse and cumbrous ornamentation totally devoid of taste. The effigy surmounts an elevated table tomb. The Queen is in royal costume, with a small crown on her head. In her left hand she holds a globe, in the right a sceptre. The drapery is in large quantity, ill designed, and, like that of Queen Mary, stands up stiffly, instead of falling over to the ground. The order, if it can be so called, of the architecture of these two monuments is Corinthian; and therefore entirely out of harmony with this beautiful chapel of a most enriched character of Perpendicular Gothic.

This, however, must be a difficulty with regard to all works of later date that are to be placed in older erections. Unless the style of the architecture be imitated, the more modern works must always appear anomalous. Yet the mere copying, in part, of an older style deprives works of anything like a character consistent with their own date. They lose all contemporary distinction, while they are no trustworthy authority of the style they imitate.

A modern statue represented recumbent and in prayer is as fitting a type of a Christian in the present day as it was five centuries ago; but placing such a figure under a Gothic canopy, with all the accessories that mark the peculiar art of a particular and past age of architecture, though it may be very like the older work and very pretty, is, after all, incongruous. The statue expresses a sentiment, and a beautiful because a true one; but copying the architecture of another age is an anachronism. Every work of art should be truthful; and one of the most valuable recommendations of art is its power to illustrate its own age. If the age has no distinctive expression in its architecture, the difficulty is only increased; for then there can be no real or original design. It must be factitious, and borrowed.

Two of the most important and, to Englishmen, interesting monuments in the Abbey, have been selected to illustrate the unfortunate taste that was now introduced. So long as the recumbent figure of the deceased was made the first object, a principle was preserved which gave character and interest to the design; but, soon after the introduction of this style, allegory was resorted to, and the monuments not only exhibit the effigy of the principle subject of the monument, and occasionally the figures of descendants, as sons and daughters of all ages, but semi-classical figures of the virtues, as Temperance, Prudence, and the personification of warlike or learned attainments, in statues of Mars, Minerva, and other heathen images, overload the design, and deprive it of all character of repose.

Three very remarkable examples of this mixed character offer themselves to notice in this (Henry VII.'s) chapel. They are the monuments of Villiers, Duke of Buckingham, and his family; of Sheffield, Duke of Buckingham; and of the Duke and Duchess of Lenox, in three of the chapels at the east end of the nave. These fully illustrate all the peculiarities referred to, and they are, also, very good specimens of the state of art at the time. In the large composition of the Lenox monument there is much to arrest attention in the superior quality of the sculpture.

The Gothic monuments exhibit attendant angels at the head and foot of the effigies, ministering in various ways; and small figures of holy persons, and even of relations, introduced as mere accessories, are seen arranged in niches in the lower part of the tomb. In the later monuments these accompaniments assume a much more pronounced character. Big, naked, chubby boys, winged and fluttering about, or sitting or standing in different parts of the monument, take the place of the small, draped, kneeling figures that support the pillow of the deceased in the Gothic monuments; while lines of sons and daughters, sometimes life-size, are placed in the base, or in the background of the design, kneeling, or praying against a lectern. The males usually are arranged on one side, the females on the other. Another peculiarity is often seen in these family tombs; and that is the introduction of deceased children, wrapped in swaddling or grave clothes, lying horizontally, on the side of the sex to which they belong. The monuments of this style,—like the older works, again, in this respect,—are usually richly gilt and painted; and a variety of materials is used in their composition, as coloured marbles, alabaster, and brass, which, at least, produce a gorgeous effect, if they cannot be reconciled with good taste.

The Abbey possesses many examples of these designs, in which, notwithstanding the indifferent art exhibited in the sculpture, we still recognize a respect for the old religious traditions. The recumbent effigies, with uplifted hands and serious expression, arrest attention and are aids to reflection; but the time came when the more personal honour or glorification of the subject of the monument was to be illustrated, and the quiet tomb character of the design was superseded by the endeavour to give prominence to the worldly dignity of the deceased. The figures are now turned on their sides; some lean on their elbow, looking out from their resting-place, as if inviting the notice and admiration of the passers-by. The various chapels, to be visited after this lecture, offer many examples of this class of monument. It will be remarked that, almost universally, the sculpture is bad. The dresses seldom are designed to suit the recumbent attitude of the wearer, the folds usually running, as if stiffly starched, in parallel and horizontal lines, instead of falling with their own weight. In this respect they are curiously similar to the stiffness of Gothic art. There are some remarkable examples of designs of the kind in the chapel of St. Nicholas; they are, however, of various degrees of artistic merit. Many of these tombs are in memory of persons eminent in history, and have great interest apart from the illustration they afford of the monumental art of the period. The neighbouring chapel of St. Edmund also contains some examples worthy of notice.

Before noticing a few other works of the sixteenth and seventeenth centuries, it will be proper to make particular reference to two striking monuments in the united chapels of St. John Evangelist, St. Michael and St. Andrew. The first is that in memory of Lord and Lady Norris, early in 1600. The effigies of both, in alabaster, lie recumbent on a raised tomb. A canopy is above them; on each side of the composition, at the base, are three kneeling figures, life size, dressed in the armour of the day, representing the six sons of the above. This monument is very striking, not merely on account of its great size, but for the sentiment expressed in it. Although the sculpture is not fine, *quoad* style and technical value, the motive of the design is good and appropriate. The effigies of the heads of the family reposing in death, with their sons kneeling and praying around them, is a touching and beautiful subject, well fitted for a mortuary chapel.

The next monument in this chapel to which attention may be called in a few words, is that of Sir Francis Vere, one of the eminent worthies and warriors of the Elizabethan era. Sir Francis, habited in a loose gown, is recumbent on a low bed or table tomb. At each corner is a knight, in full armour, kneeling. They support on their shoulders a large table, which forms a canopy over the principal figure. On this are placed various pieces of armour, supposed to be that of the great soldier lying beneath. The treatment of this design, in which the accessorial figures are made to contribute so promiently to the expression, is as rare as it is effective. They evidently are secondary to the main object, and though the figures are life-size, they take their proper place simply as attendants of honour on the great general who reposes in the centre of the composition.

This chapel contains a monument by Roubiliac, which always is pointed out by the guides as one of the wonders of the Abbey. It is in memory of Mrs. Nightingale. In the lower part of the pyramidal composition, a skeleton, partially draped, issues from a dark recess or tomb, in the act of hurling a dart at a female above, who, fainting, is supported by her husband. He endeavours to ward off the fatal stroke, leaning forward and extending his hand as a shield or guard between the sinking lady and the weapon of death. The execution of this work is well worthy the great reputation of its author, and there are many points of excellence in the details of this remarkable work. The expression of the dying figure, and the action and form of the falling hand, deserve the highest praise. The poetry of this conception makes its instant appeal to the feelings. It is full of pathos and touching sentiment. But here is seen the danger of not observing the proper limits between the ideal and the real. A mere skeleton, which could not by any means be held together, is here represented with life, power, and expression, grasping an ordinary spear, with which he intends to slay his victim. The dying wife and her protector are supposed to see all this impossibility, and the husband endeavours, by a common action, to ward off the threatened evil. But a skeleton is not that broad, mysterious visitation called Death; it is simply a distressing and repulsive result of dissolution. The allegory, therefore, is both extravagant and false. With all its excellence in point of intention, and especially in its marvellous execution as a piece of marble-carving, this monument offends against artistic propriety and good taste. Roubiliac is the author of another remarkable and, in many respects, superior work, in the monument to the Duke of Argyll, who died in 1743. The duke is represented falling at the base of a pyramid. Around him are statues of Minerva, History, and Eloquence. The latter is full of action and expression; and, with extended arms, appears to be addressing the spectators. It is a characteristic work of the time, and shows the great powers of Roubiliac in invention and execution; but, like almost all his works, it is utterly deficient in the repose so essential to give the proper effect to monumental works designed for a place of worship. The same criticism applies to a composition by the same master, near the Argyll monument, in the south transept, in memory of Handel, the eminent composer. The expression of rapt attention with which the great master appears to be listening to celestial music is admirably rendered, and the execution of the work is, as usual, wonderful; but the whole design is too theatrical for its destination. It is a composition more adapted to a music-hall than a church.

Scarcely any of the works after this time, however remarkable for other qualities, preserve the characteristics appropriate to church monuments. It is rare that allusion is made to death, a future state, or to the prayerful last moments of the Christian. The statues have a mere portrait character. The action of the figures have reference only to their worldly business and occupation, and the inscriptions record the virtues, the abilities, the prowess, and the accidents of life. The compositions are crowded with allegorical figures, more or less good, as they are founded on or copied from the *antique*. There is nothing to arrest the attention of the ordinary passer-by; and the recondite classical allusion can only be understood by the few. Such designs as those representing Mr. Thynne attacked and murdered in his carriage; of Admiral Tyrrell ascending out of the sea to heaven, while on all sides are the most preposterous accessories, including several life-size allegorical figures,—only require to be alluded to as being totally unfitted for church monuments; while they have little or no recommendations as works of sculpture.

It scarcely is necessary to multiply examples of the art that now characterized monumental sculpture. Prominent illustrations have been pointed out, by which the intelligent visitor will be able to realize for himself the leading peculiarities of the styles of the different ages. Hitherto, it is to be observed, the motive or purpose of the generality of works, however strangely expressed in some cases, has had reference to the repose of death; with suggestions of prayer and resignation; and with such accessories as are fitting in memorials, of the kind, placed in a Christian church. Less simple, indeed, than the early

Mediæval monuments, still, the later monuments continued to show the religious impulse, and invite serious reflection. In the eighteenth century this principle began to be lost sight of, and in the end utterly disregarded. Truthfulness and individuality were, as has been shown, first sacrificed to the absurd fancy of introducing classical details in the mounments. From ornamental the artist proceeded to personal *pseudo*-classical decoration; and we find the deceased English nobleman, statesman, or soldier, dressed in a Roman cuirass, or toga, or paludamentum, mixed up with modern costume. The large monument of Sheffield Duke of Buckingham, before alluded to, in the chapel of Henry VII.; that of Sir Cloudesley Shovel, in a Roman cuirass, sandals, and a full-bottomed wig, in the south aisle of the nave; and many others, will show the extent to which this absurd fancy was carried. It may not be amiss, to notice another class of monumental design, in which it is difficult to trace any motive. One example of this utterly unmeaning application of art,—if, indeed, it can come into the category of art at all,—is the huge monument in the chapel of St. Paul, in memory of Lord and Lady Hunsdon. The date is about 1600. This composition, measuring between 30 ft. and 40 ft. in height, and occupying one end of the chapel, consists of various stages of merely architectural details over and around a sarcophagus; while obelisks, columns, with capitals, architraves, and a variety of details, crowd the work from the pavement upwards; the most striking object being the large shield with the emblazoned coat of arms of the family. The whole has been profusely decorated and enriched with colour; now, in the course of time, sobered down to a most sombre blackness. Another unmeaning work of the kind is a military monument in the north aisle of the nave. It consists entirely of various arms used in military life, and has more the appearance of an advertising card of an army accoutrement maker that a memorial record of a deceased soldier. These works are simply referred to as belonging to our general subject. It will neither be necessary nor profitable to continue the review of such trifling and unmeaning art.

Having now rapidly reviewed the monuments preserved in Westminster Abbey from the earliest regal monument—that of Henry III., of the thirteenth century, down to the end of the eighteenth century—it is not necessary to make particular remarks upon the monumental productions of a more recent time. It may merely be observed, generally, that while they often exhibit very advanced knowledge and technical power in sculpture, highly creditable to their authors, they are usually simply personal memorials, and have no serious ecclesiastical character or treatment to make them fitting objects to occupy places in a church. The more ambitious designs are made up of classically draped or even of nude statues, imitations of the antique. Others, expressing the views of the realistic or naturalistic school, appear dressed in the ordinary coats, waistcoats, and breeches of their day. Some are represented in the full vigour of life, making speeches, brandishing swords, or calling up their troops. Some are standing, in attitudes more or less graceful, doing nothing. Some are sitting comfortably in their arm-chairs, unoccupied, or, it may be, thinking. In none of these is there the slightest idea of fitness or propriety, with reference to place. Indeed, there are instances in which the extreme want of harmony with surrounding monuments and associations makes such productions not merely inappropriate, but positively offensive to good taste and feeling. They ought never to have been placed in the positions they occupy; and it is even now much to be desired that the more prominent of these statues, especially the single ones,—the most easily dealt with,—should be removed to other sites where, while the deserts of their originals may be honourably recognized, and the statues raised to their memory be seen by their admiring countrymen, they should no longer be permitted to crowd the floor of a place of worship; where the mind should be occupied with other thoughts than those likely to be suggested by such incongruous associations.

It is not intended, nor is it desirable, that works once admitted into the Abbey should be removed with anything like contumely and disrespect, simply because they do not harmonize with religious sentiment, or are out of *keeping* with the architecture of the church. Honourable sites might still be found for them within the sanctuary, as it were. A cloister, for example, might easily be erected, fitted to receive them, or they might be arranged within the restored Chapter-house. Many of the detached statues, especially, might so be placed with great propriety, and with distinguished effect. Many of the larger compositions, which interfere fatally with the architecture of the church, cannot, it may be feared, be removed; but the floor or pavement of the church itself would thus be freed, in a great measure, from the crowding of works as inappropriate as they are obstructive.

THE NEW CHEMICAL LABORATORIES AT BONN AND BERLIN.

The thirteenth report of the Department of Science and Art has an appendix communicated by Professor Hoffman on the laboratories now being built at Bonn and Berlin under his superintendence. The professor's report is interesting for the special information which it contains, and remembering the intimate and increasing connection between chemical science and our manufactures, is very suggestive of what might be done in England for similar purposes. The following abstract of the report refers to the laboratory at Bonn.

Dr. Hoffman states that of the six Prussian universities, two —and these the most important ones—the Universities of Bonn and Berlin, had hitherto remained without chemical institutions in keeping with the advancement of science and corresponding to the demands of the present day; and after referring to the difficulties that stood in the way of the realisation of this great undertaking, expresses his belief that the foundation of the two great chemical institutions now being carried out under the auspices of the Prussian Minister of Public Instruction, has a significance far beyond the more immediate impetus they are sure to give to the prosecution of chemical studies in the universities to which they belong. By the grant of means unusually large for the organisation of these new schools, a tribute of recognition has been paid to the influence of chemistry on the modern aspect of the world that cannot remain without effect upon other departments of physical science which have not been less productive of useful results.

Side by side with the two new chemical schools now springing into existence, other institutions are sure to be founded, similar in nature and appointed with the same liberality, for the prosecution of the two other great branches of natural science, physics and physiology, to which, as well as to chemistry, the future belongs.

This subject is already being freely agitated in the Prussian universities, especially those of Bonn and Berlin. The leaders in the several branches of natural sciences are pursuaded, that the great efforts at the present moment being made for chemistry will, sooner or later, benefit their own departments. It is not, however, in Prussia, or in Germany alone, that the wholesome influence of this example appears to be felt. The exertions of the Prussian Ministry of Public Instruction in the cause of chemical science have attracted the attention even of foreign governments. Inquiries respecting the new institutions have already been made by several other countries, more especially by England and France, and it is not unlikely that the noble precedent set by Prussia will soon be followed by the establishment of similar schools elsewhere. It is in this sense, at all events, that the writer ventures to interpret the desire expressed by Her Majesty's Government to obtain information on the subject of the two institutions in process of organization in the Universities of Bonn and Berlin, which, at the request of the Prussian Minister, he has endeavoured to supply by drawing up the following statement. He would, indeed, consider himself fortunate if this report, which, from the nature of the case, cannot be more than an outline, should assist in augmenting the interest already felt for the establishment of a great chemical institution in the metropolis of the world, an institution which England can no longer dispense with, since no country is more deeply interested than she is in the rapid diffusion of the latest results of chemical inquiry. The reporter proposes, in the first place, to give an account of the laboratories of the University of Bonn, which were earlier conceived and earlier begun, and are, consequently, in a far more advanced stage than those of the University of Berlin.

The first negotiations respecting the building of a new laboratory in Bonn go back as far as 1861. In the summer of that year the reporter was invited by his friends, Professor Plücker and Sell, to an interview with Mr. Beseler, the Curator of the University of Bonn. But little time elapsed before the first steps for the foundation of the new chemical school were taken. The negotiations already pending between the Minister of Public Instruction and the Curator of the University were soon concluded, and in the beginning of 1862 Mr. Beseler was commissioned by the Minister to inquire of the reporter whether he would undertake the organization and direction of a chemical laboratory to be established in the University of Bonn, on a magnificent scale, and liberally provided with all the requirements for modern investigation. The question thus opened led to a series of negotiations which ended, in the spring of 1863, in the reporter complying with this proposal.

The important duty of drawing out the plans of the new institution devolved on Mr. Augustus Dieckhoff, architect to the University, and in preparing the programme, the composition of which fell to the lot of the reporter, it appeared all-important to gather information as exact as possible respecting the chemical institutions already in existence, and the reporter was fortunate enough to obtain drawings and plans of nearly every existing laboratory. The chief experience, however, was gathered during a journey of several months through Germany, in the autumn of 1863. On this trip nearly all the German laboratories were studied, from that of Giessen, the first German university laboratory, which the father of the reporter built more than a quarter of a century ago for Liebig, down to the more recently-founded chemical schools in Karlsruhe, Munich, Zurich, Heidelberg, and Göttingen, and the splended institution just completed in the University of Greifswald.

Ultimately a plan, the detailed contract for which amounted to 183,000 thalers (£18,450), passed, with scarcely an alteration, the several stages of supervision, and was sanctioned by Government.

The first turf was turned late in the autumn of 1864; the spring of 1865 saw the foundation stone laid; and the building, the construction of which was entrusted to an able young architect, Mr. Jacob Neumann, who had already efficiently assisted in laying out the plans, is at present being roofed in, so that in the summer of 1867 it can be handed over to the university.

The new chemical institution is provisionally intended for 60 students; the space, however, has been meted out so liberally, that accommodation could be supplied without inconvenience to a much greater number; besides this, the building has been so constructed as to allow of enlargement at any future time, by raising a second story, without detracting from the harmony of its structure.

In addition to the various apartments required for educational purposes, for practical analysis, for scientific and technical investigations, and, lastly, for the lectures, there are in the new building sets of rooms for the castellan of the institution, for the *famulus* and servants, apartments for three assistants, and also a magnificent residence for the director, consisting of a suite of rooms which as regards number and extent, could be very seldom met with in a private house. Lastly, there is a considerable number of well-lighted basement rooms, which have as yet no special use assigned to them, but the construction of which could not be avoided.

The various departments of the building are spread over three floors, the basement, the ground floor, and the first floor. The first floor, however, extends over but a small portion of the structure, and is exclusively occupied by the private apartments of the director. But few of the rooms devoted to the purposes of the institution are found in the basement, as, for instance, the store-rooms, the rooms for metallurgical and other operations requiring large quantities of fuel, those for medico-legal and chemico-physiological research, &c. All the remaining space intended for educational purposes, viz., the laboratories, with their adjoining rooms for special operations, and side-rooms, balance-rooms, rooms for volumetric analysis, combustion-rooms, lecture-theatres, the hall for collections, the study and private laboratory of the director, the apartments of the assistants and other officers of the institution, are, one and all, on the ground floor, an advantage which would not have been obtained had the site of the building been of more limited dimensions.

As the ground floor had to contain no less than 44 rooms, exclusive of vestibule, corridors, and closets, its dimensions necessarily became very considerable. Four outer wings enclose an area of very considerable size, divided into four quadrangles or courts by a cruciform interior building. Those parts of the edifice surrounding and two back courts are exclusively devoted to the purposes of practical instruction in chemical analysis and research. The wing of the central structure which separates the two front courts from each other includes the lecture theatre, with the rooms pertaining thereto; in the south-west side wing of the left front court is the private laboratory of the director, with the rest of the rooms devoted to his use. The corresponding north-east side wing of the right front court is occupied by the apartments of the assistants and other officers. The ground floor of the front part of the building, lastly, is devoted to the scientific collections of the institution and a small theatre for special lectures.

The main entrance for students, as well for those working in the laboratory as for those who only attend the lectures, lies in the principal side-front facing the city of Bonn.

After ascending the stairs we enter a large vestibule richly decorated. Before the spectator stretches a long corridor of considerable width, the main artery of the entire building, brilliantly lighted by a number of windows on the left side. The large folding doors at the further end of the corridor, visible from and directly opposite to the main entrance, lead to the director's spacious study, which is provided with a large bow-window for microscopic observations; from this central situation the various parts of the great building are quickly and easily accessible. On the right-side the great corridor branches out into three side-corridors leading to the entrances of the three pricipal laboratories, each lighted by ten windows, symmetrically arranged on the two sides, and providing 20 students with more than sufficient space and every convenience for work.

Permanent working-places for 60 students, which, as already mentioned, the institution is to accommodate, were thus secured. According to this disposal of the space, the students range themselves in three classes :—1. Beginners, that is to say, those who having become acquainted with the rudiments of chemistry by attending lectures, enter the laboratory to become exercised in chemical manipulation, to make preparations, and to go through an elementary course of qualitative analysis. 2. Advanced students, or those who, having acquired practice in qualitative experiments, are occupied with quantitative analysis, both ponderal and volumetric. 3. Young chemists, sufficiently conversant with the principal department of chemistry to engage in the original experimental investigations, either suggested by the director or chosen by themselves.

A division of this nature, whereby the three classes are distributed in separate rooms, seemed expedient for more than one reason. Not only was it possible to fit up each laboratory in a manner suitable to the wants of each particular class, but the situation of the rooms themselves could be so adapted to the remaining parts of the building as to offer the greatest facilities to each division. And higher still must be rated the advantages as regards readier supervision and increased means of maintaining discipline in all parts of the institution afforded by an arrangement of this kind.

The good arising from a large number of students working together in an extensive institution is unmistakable. If the student have but his eyes open to the work of his neighbours he has opportunities of gaining, in a comparatively short time, an amount of experience which, working alone or in company with only a few, he could scarcely gather during years of diligent labour. It is the chemical atmosphere in which he works that promotes his progress.

These advantages, on the other hand, cease when the number of learners exceeds those limits within which personal supervision is still possible. As soon as the beginner is no longer conscious that he is able to procure help at any moment—as soon as the more advanced student no longer feels that he receives individual attention—lastly, as soon as the young chemist, though working independently, is no longer satisfied that an experienced eye watches over his steps—the chemical institution, however excellently it may be organised in other respects, will yield very small results indeed. It is, therefore, of the first importance for the director of such an institution to have the necessary teaching power by his side. According to the reporter's experience it is not possible for an assistant to superintend, for any length of time and with satisfactory results, the labours of more than twenty students. Acting upon this experience, the Minister of Public Instruction decided to appoint for the Institution of Bonn three scientific assistants, who, under the guidance of the director, are to watch over, the experimental studies of the students. The disposal of the students in three separate laboratories seemed to accord particularly well with this provision.

In these three laboratories the students have their permanent working places. To each one is allotted, for this purpose, a table amply supplied with gas and water, as well as lock-up drawers and cupboards in which to keep apparatus, re-agents, &c. At these working benches all ordinary chemical work and all operations, not requiring the special arrangements provided in other parts of the institution, are carried on.

Turning now our attention to the side apartments attached to the three laboratories, we have, in the first place, to mention three closets in direct communication with the main rooms. They are in charge of the respective assistants, and are intended for preserving delicate and costly apparatus, platinum and silver vessels, expensive re-agents—everything, in fact, of which special care has to be taken.

There are certain operations which cannot be well conducted in the three laboratories referred to. On this account they are connected with a series of rooms devoted to special purposes. There are three rooms, directly communicating with the laboratories, called "operation rooms;" and here all kinds of work, such as distillations, making of gases, heating of bodies in particular gas atmospheres—in short, all experiments requiring large and complicated apparatus, are conducted at the benches fitted up in these rooms or in the "evoporation niches" let into the walls. In case, however, on any particular occasion, even more space should be required, each operation room communicates with a covered colonnade, opening towards a back court, and fitted up with gas and water and all the requisites for work. From these colonnades the basement of the building, containing a variety of rooms devoted to the objects of the institution, and more especially the metallurgical laboratories, is accessible by means of spiral staircases placed in spacious semi-circular projections from the outer walls. Flights of steps on the other hand, lead from the open sides of the colonnades down to two back courts lying between the three laboratories, and here the student finds an additional supply of water in large central reservoirs, the tabular parapets of which serve as working benches for a variety of operations.

The three operation rooms, situated behind their respective laboratories, are not of equal dimensions. In apportioning their size especial attention had to be paid to the wants of the beginner and of the independent worker. The beginner who practises the various forms of chemical manipulation, preparing gases, making chemical preparations of all kinds, &c., requires ample space in which to develop his activity. In like manner the young chemist engaged in actual research may at any moment want to fit up new or reconstruct old apparatus, often of a complicated nature, for the particular objects of his investigation; tools of the most various description, hammers, files, vices, &c., are thus constantly required, not to mention the blowpipe-table scarcely ever at rest. For him too it is of vital importance that he should not be cramped in space. For this reason the operation rooms connected with the two wing laboratories, and expressly intended for the classes just mentioned, are made as large as possible. The students of the second laboratory, principally occupied with quantative analysis, have therefore had a less spacious operation room allotted to them. By this arrangement an additional small apartment was gained, symmetrical with this operation room, and serving as an approach to a very important part of the institution, viz., the laboratory for gas analysis. This spacious apartment projects from the middle of the building at the back, and is thus almost equally accessible from the three laboratories; it is on the other hand sufficiently removed, more especially by the intervening ante-room, from those parts of the building where the chemical business of the institution is most active, to allow of the delicate measurements here made being carried out without disturbance. It is lighted by two large side windows and also by three smaller windows situated in a central projection; but all the light coming from the south can be shut out by means of strong well-closing shutters, thus securing to this apartment the uniform temperature so important in gas analysis.

Along the main corridor lies a series of rooms opening upon it, and lighted by windows looking into the back courts of the institution. Close to the vestibule, immediately to the right and lying between the entrance to the first and second laboratories, is, first of all, the volumetrical analysis room, where are kept the standard solutions, daily increasing in variety, as well as the graduated vessels.

The balance room, the next in order, is not only intended for the reception of chemical balances, but also of the more delicate physical instruments made use of in analysis, such as air-pumps, barometers, &c.

Next follows a room for fusions and ignitions, capable of being carried out by means of gas. Here are the necessary appliances for the various heating operations occurring in mineral analysis. This room is also fitted up with all the requirements for organic analysis (carbon and nitrogen determination), likewise exclusively conducted by means of gas, and carried on in special "combustion niches" let into the walls, and communicating directly with the outer air by means of wide tubes of glazed earthenware. This room also contains the ranges of water ovens required for drying the substances to be submitted to analysis. In these ovens, which are heated by the steam of the stills for distilled water in the basement, every student has his own compartment under lock and key. With respect to the uses of these three rooms, they are more especially intended for the workers in the middle laboratory; they are, however, accessible to the beginners. The balance-room is purposely situated in the middle, and separated from the laboratories by the volumetric analysis room on the one side, and the room for fusions and ignitions on the other, so as to protect as effectually as possible the costly instruments of this room from the fumes which, in spite of all ventilation, at times escape in a laboratory. The situation of the balance-room, between the two others, affords an additional and a by no means trifling advantage; numerous operations preceding the weighings, such as drying substances in the water bath, heating crucibles, collecting the combustion products in organic analysis, &c., all take place in the immediate neighbourhood of the balance, whilst on the other hand the preliminary weighings, invariably forming the first step in volumetric analysis, can be made in close proximity to the room devoted to the subsequent stages of volumetric observation. The three rooms therefore communicate directly with each other.

Between the second and third laboratories are, in addition to a small flight of steps leading to a number of attics over the ground floor, three precisely similar rooms, accessible from the corridor, and with doors opening into each other. Of these, the one nearest the second laboratory is intended for the library.

The main results of chemical investigation are duly registered in treatises and manuals, and are therefore easily within the reach of students. But the statements to be found in books of this description cannot be more than abstracts, always very considerably condensed, and often more or less garbled, from the memoirs of the first observers. As soon, therefore, as the student has got beyond the first rudiments he can no longer dispense with original sources of information. The main bulk of chemical observation is collected in a series of periodicals and journals, the volumes of which are counted by hundreds, and if all were collected certainly by thousands. Again, many important investigations have been communicated by their authors to the various academies and learned corporations, and are printed in the transactions of these societies. Thus it happens that the literature of chemistry, though the youngest of sciences, has already attained to very considerable dimensions; and to collect the works which have to be consulted in the prosecution of even limited investigations in most cases far exceeds the power of any single individual. These books could of course be readily procured from any public library, but reference to original communications is but too frequently omitted if the work is only to be had by specially sending for it. On this account every chemical school possesses a library, more or less complete, offering to the student a copious collection of original memoirs, which he can consult at the very moment he may require their assistance. The use, it may be said the necessity, of such libraries is so apparent that students themselves have in a great many instances most materially participated in their foundation and subsequent development. In this way, from but small beginnings, some most complete collections of chemical works have been formed. The reporter, when a young student, had the good fortune to take part in the establishment of such a laboratory collection, under the auspices of his illustrious master, Baron Liebig, at Giessen; this is now the oldest and probably the largest chemical library extant. In later times he had the pleasure of assisting in the inauguration of a similar collection for the Royal College of Chemistry, London. Such a library it is of course in contemplation to establish for the Bonn laboratory, and already, long before its opening, a number of books have come in as presents. The situation of the room set apart for their reception, between the second and third laboratories, is peculiarly appropriate, because it is more especially to the students of these two laboratories that the library will be of use, whilst its slight distance from that part of the institution where the director carries on his own researches is likewise a great convenience to him and his assistants.

The two remaining rooms lying between the second and third laboratories are a balance room and a room for fusions and ignitions. With these rooms, on the right-hand side of the principal corridor, terminate the ground-floor apartments intended for practical instruction. We have now only to glance at the theatre and adjoining rooms for preparing lectures and preserving apparatus, models, drawings, and collections of all kinds.

The students attending chemical lectures in the German universities are always much more numerous than those who work in the laboratories, and, therefore, more accommodation had to be provided in the lecture hall. A lecture room capable of holding 250 students appeared to meet the requirements of the University of Bonn. An area of 40 feet square was found sufficient for this purpose, and at the same time to afford ample space for the lecture table, as well as for the free movement of the lecturer and his assistants.

In the great lecture hall, the seats are arranged like the tiers of an amphitheatre, and in the lower part, just opposite the entrance, is placed the lecture table, 40 feet long and 3 feet 4 inches wide. In the lower part of the wall, behind the table, are the evaporation and ventilation niches for experiments, whilst on its upper part drawings and diagrams can be exhibited. The lecture room is lighted from both sides, so that neither professor nor audience is obliged to face the light, an advantage sure to be appreciated by any one who has been either lecturer or hearer in a room of different construction. The fourteen windows which supply light on either side are arranged at a height of nine feet above the floor of the hall, except the two next the lecturer, which descend to the level of the table, enabling him to exhibit many colour-phenomena by means of transmitted light, and to employ sun-light, under favourable conditions, as an agent in his experimental illustrations.

The theatre communicates with the laboratory of the lecture assistant by means of two side doors, and a large niche in the centre of the wall. Here everything required for the lecturer is got in readiness, and for this purpose all the necessary furnaces and benches are provided. In this room larger pieces of apparatus can be fitted up upon a table moving on rails, which can be run through the niche already mentioned in the theatre during the course of the lecture. This laboratory is lighted from two sides, on the north-east by a large window, and on the south-west by a glass door communicating with a platform; whence a staircase leads down to the front court. These steps also communicate with the rooms of the basement underneath, for the storage of compounds requiring a low temperature, sealed tubes containing condensed gases, &c., and likewise give access to a well-ventilated closet immediately under the lecture-table, containing a large galvanic battery, the wires of which pass through the ceiling into the theatre above. The room where the experiments for the lectures are prepared is of course in close connexion with the store-room for apparatus, models, drawings, and diagrams; this room likewise is lighted from both sides. Further on we come to the last room of this series, having but one window, which is used for the preservation of the various documents belonging to the lectures, such as printed forms, registered lists of students attending, &c., and where the professor may stay before entering the theatre, and receive those students after the lecture who wish to consult him. This room, called the lecturers' waiting-room, communicates with the mineralogical museum, one of the great halls assigned to the scientific collections of the institution. This hall, as well as the one next to it, which being profusely lighted by six windows symmetrically disposed on both sides, is intended for the chemical museum, is in the front block of the building. Close to the mineralogical museum is a small lecture room for recapitulations and special lectures to be conducted by the assistants.

All the rooms for apparatus, chemical preparations, &c., used in the lectures are situated between the two rooms devoted to oral demonstrations, so that all requisites for the lectures can be conveyed with the greatest ease either to the larger or the smaller theatre, and back to the collections. It was not without intention that the museums were somewhat removed from the busier departments of the institution. The experience of the reporter, which is not unlikely to receive confirmation from others, has taught him that the love of research and zeal for discovery in young chemists, however praiseworthy in itself, is at times anything but conducive to the increase of scientific collections.

The large halls for the mineralogical and chemical collections, together with the smaller theatre and its preparation room, occupy almost the entire ground floor of the front block of the building. In addition to these are still to be mentioned two vestibules, leading the one to the main staircase, the other to the back staircase ascending to the apartments on the first floor; then immediately to the left of the north-east entrance a lodge for the house porter; and, lastly, close to the south-west entrance, apartments for one of the junior assistants of the Institution.

Of the two sideways, the one stretching out at right angles from the left of the main vestibule in the north-east front contains the porter's lodge and other apartments while the other side wing is entirely devoted to the scientific purposes of the director, with whose study this part of the building is in immediate communication. Of the rooms situated in this wing mention must first be made of the private laboratory of the director, which is lighted by four windows. On one side of this lies the director's waiting room, accessible from the main corridor, and communicating with his study by a short private passage. Beyond the other end of the private laboratory are two small apartments, one to be used as a balance-room, the other as a room for ignition, fusions, and combustions. The latter has egress to a little portico for experiments required to be performed in the open air.

The basement is, to all intents and purposes, a repetition of the ground-floor, the greater thickness of the walls, however, lessening the amount of space to some extent. The rooms in this part of the building are 12 feet in height from the floor to the top of the arch, and are sufficiently lighted throughout, by numerous windows of comparatively large dimensions.

Along the main corridor of the basement are two spacious rooms, of which the first is intended for the storage of solid, the other for that of liquid re-agents. Both store rooms are close to the flight of stairs leading on one side into the courts, on the other to the ground-floor, whereby the carriage of chemicals to the store rooms, and thence to the main body of the institution is greatly facilitated. The same accessibility to the floor above pertains to the other two rooms along this corridor, and has determined their especial uses. In the one nearest to the staircase a steam boiler will be set up; while directly communicating with the steam boiler room, and at the same time accessible from the corridor, is a large and well lighted apartment intended for rougher kinds of work, and especially for a general wash-room, where apparatus of all kinds can be readily cleaned. For all these purposes the close proximity of the steam boiler is an especial advantage. In this room, moreover, a large press will be fitted up, in the use of which for hot pressing purposes the steam, close at hand, may likewise be turned to account. At the extreme end of the corridor is a fine well-lighted room, corresponding in form and size with the director's study on the floor above; this is a store-room for the large stock of glass and porcelain, under the charge of the castellan.

The two rooms next in succession are provided for chemico-physiological researches; the large well-lighted room at the end being the laboratory for physiological chemistry, whilst the adjoining room is fitted up as a stable for the housing and feeding of animals required for the investigations.

In addition to this laboratory, the basement of the back block of the building contains two furnace rooms for smelting operations, carried on by means of coal and coke. The larger of these, that situated in the middle, is for students of the second and third laboratories; while the smaller one is for the beginners. These laboratories are purposely located in the basement, the greater height of the chimneys of this flat ensuring a considerable increase of draught. They are, moreover, far less frequently used than the rooms on the ground floor. Lastly, the dust and dirt invariably attending the use of coal is thus almost entirely excluded from the flat above. The furnaces and appliances set up in these laboratories are of a varied nature; among them specially protected niches for operations carried on under great pressure, such as digestion of substances in sealed tubes, &c., deserve particular attention.

For the storage of the fuel required for the furnace-rooms, four coal cellars have been provided.

With regard to the courts themselves, it deserves to be mentioned that the two front courts communicate by means of a thoroughfare cutting the front wing of the cross building immediately under the landing of the theatre staircase; in this manner any one of the four courts can be reached through the carriage-way facing the town, without entering the interior of the building. Such a disposition is of great use for the preservation of cleanliness throughout, and of absolute necessity in order to render all parts of the building accessible in case of fire.

Attention must still be directed to some of the rooms situated on the basement of the front part of the middle wing.

On descending from the ground floor to the basement, we pass through the vestibule into a large workshop lighted by three windows. Here the rougher work required for the lectures is performed; here liquid carbonic acid would be prepared, and here, in a well-ventilated niche, stands the large galvanic battery already mentioned, the wires of which, passing through the floor of the theatre above, communicate with the electric lamp, now rapidly becoming an indispensable appliance of the lecture-table. Further on is a small laboratory for medico-legal investigations; it is lighted from both sides, and being accessible only to the director and the lecture-assistant, is effectually protected from all undesirable intrusion. Beside the room for the rougher lecture work there is a small cellar communicating with the vestibule, in which compounds requiring a low temperature, explosive bodies, such as gases condensed in hermetically-sealed tubes, like sulphurous acid, chlorine, &c., are preserved, Substances readily undergoing decomposition, generating corrosive vapours, or in any way dangerous, can thus be conveniently excluded from the general collection.

The external aspect of the new laboratories is in perfect keeping with the scale of grandeur of the ground plan. The street front is 180 feet in length; the side-front, with the main entrance for students, has a depth of 250 feet.

Only the front block of the building has a second story; this contains a most splendid suite of apartments provided for the director of the institution. This residence is richly ornamented, and will in all respects be worthy of the institution to which it belongs. The reporter "must not enter into any details upon this subject, but he cannot leave unnoticed the imposing entrance hall, illuminated by a glass cupola above, and the splended ballroom, extending through two stories, amply satisfying the social requirements of a chemical professor of the second half of the nineteenth century."

SELF-ACTING HYDRAULIC COAL-CUTTING MACHINE.*

By W. E. Carrett, Engineer.

In the general detail of mining operations, the cutting away of the under portion of a valuable seam or bed of mineral to facilitate its subsequent removal, is at all times one of the most laborious and difficult operations, and is often effected by the miner under the greatest physical disadvantages; more especially when the seam of coal is very thin, and is cut on the "end" to improve its saleable qualities. This "holeing," or "bareing," or "kirving," or "undercutting," is usually performed by about 40 blows per minute from a pick, handled with such experience, as to cut 3 to 4 feet under, at the rate of 1 to 1½ yards lineal per hour, and destroying much of the coal to make room for the operator, and enable him to work partly into the hole, to produce the requisite depth for a fall.

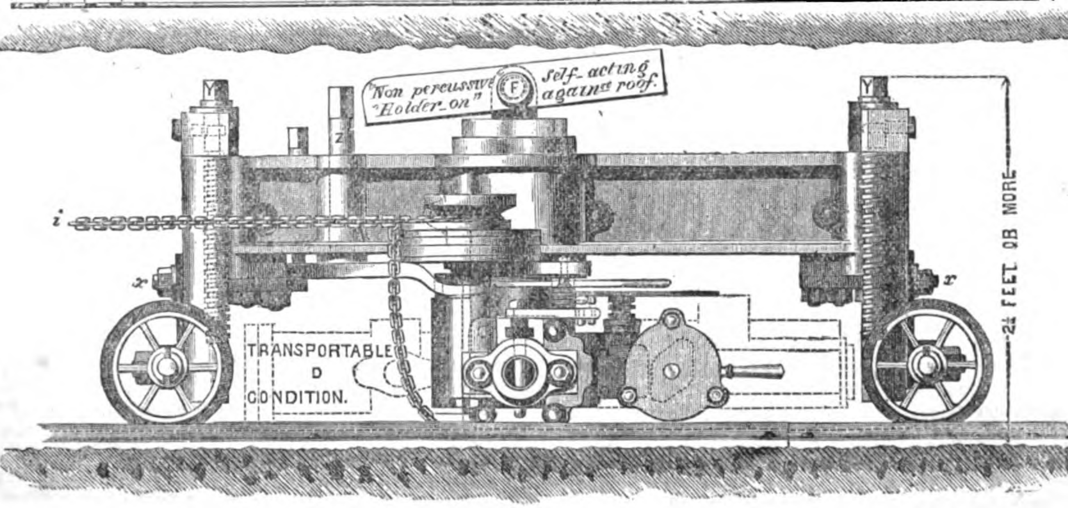
The speed and effort with which this picking tool is moved, combined with its weight, represent the power of one man applied in the shape of "percussive force," and this, under advantageous circumstances, is equal to about one-sixth of a horse power. The miner could not, with his limited power, force his pick, or any other shaped tool into the coal as if he were cutting cheese; he is like the mechanic, who has to chip all his iron work with hammer and chisel for want of a planing or slotting machine, and must reduce it by little as best he can, "in lieu" of suitable mechanical expedients to concentrate and apply power in a continuous, undeviating, and determined line. Yet the introduction of planing or slotting machines has not injured the mechanic, nor the morticing machine the joiner; there is ample work which the machine cannot do; and there are innumerable mines where no machinery can compete with the skilled miner. To apply the power of horses in lieu of manu-motive power, even though one horse is as powerful as six men, is practically very difficult. The power of both is dependent on the produce of cultivated lands; and the fewer horses required the cheaper the necessaries for human sustenance.

There is yet a far more effective substitute for the power of both man and horse, which has been inviting our use for centuries, in the form of what George Stephenson conceived to be "bottled up sunshine." A coal-fed steam engine, of one horse power, is twelve times cheaper than one animal horse power, and our obedient servant for 24 hours daily, consuming the produce of uncultivated lands on which the sun shone ages ago.

Now it is desirable that in many favourable circumstances this "undercutting" operation of the miner should be accomplished indirectly by this steam power, and one of the practical methods of accomplishing this object is the subject of present consideration.

If one collier had the power of say 18 men, and when necessary

* Paper read before the Nottingham Meeting of the British Association, Aug., 1866.



Hydraulic Coal-Cutting Machine Fig. 1.—Elevation.

could make himself 2 feet high, and hold himself down upon the floor of the mine by pressing his head against the roof, and hold firm in his hands a kind of cheese scoop in lieu of a pick, and could force it steadily into the coal at the necessary height from the floor, and to the required depth, he would then be exactly what is in many cases wanted: he would be a travelling morticing machine, and do more in one minute than 700 blows from a hand wrought pick can do, and would, in fairness, demand a very stiff wage, which he would undoubtedly obtain.

This is what the Iron Man or Hydraulic Coal Cutter accomplishes. "He" is, if necessary, two feet high, has four legs, of adjustable length; his head is also adjustable to touch the roof,

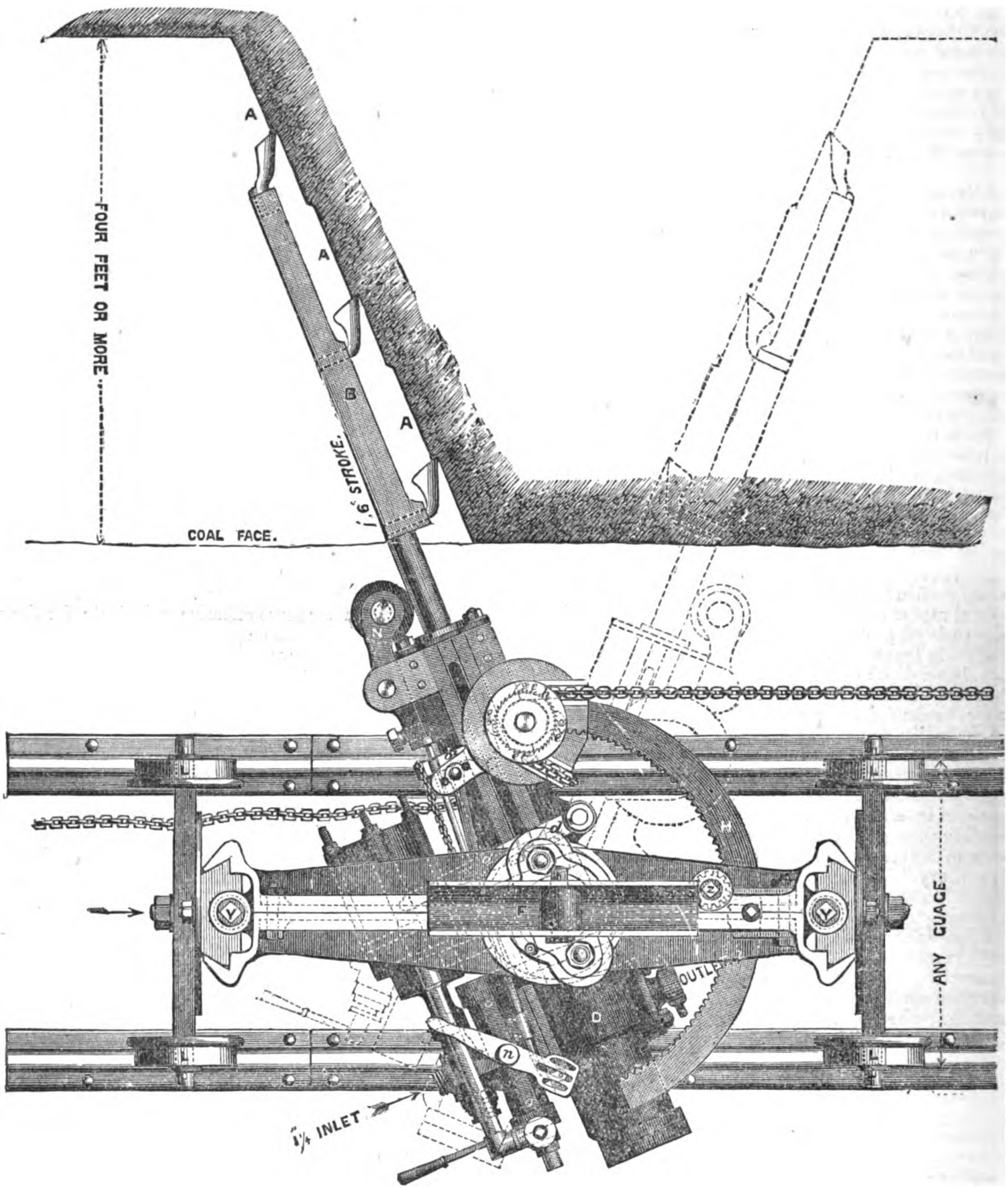


FIG. 2.—GROUND PLAN. SCALE, ½ INCH TO 1 FOOT.

and he weighs one ton. He is fed by a 2 inch flexible pipe with sober drink, at 300lbs. pressure, and at the rate of 30 gallons per minute.

This water pressure acts vertically on a 5 inch piston pressing against the roof, and horizontally on one about the same size, reciprocating 18 inches and 15 to 20 times in a minute. There is a pressure of 5000lbs. against roof, and the same pressure acting horizontally, forcing three "cheese scoops" into the coal. These cutting tools are 3 inches wide, and penetrate 4 feet, with a power equal to 3 horses or 18 men; and this is effected by a consumption of 50lbs. of coal per hour to feed the boiler of the engine, which makes the water pressure, and pumps the same over and over again. Thus this Automaton Iron Man is dead fast when forcing the cutters into the coal, and only requires to lower his head 1 inch at the return or back stroke, and advance, which he does also self-acting, at its termination, half-an-inch to one inch, and then again he elevates his head and is ready for the next cutting stroke; his sober veins being filled by incompressible if not exhilirating "water," and retained therein by a keep valve, for the necessary time, enabling him at that moment to defy the roof to crush him. This Self-acting, Hydraulic, Coal-cutting Machine, or "Iron Man," which has now been two years at work, is the miners' best friend: it does not dispense with his labour, but performs for him the undercutting, which is a most laborious operation, either in the end or face of coal, and in a more efficient and economic manner than he can do it himself. The coal so operated on by the Machine does not fall forward when becoming detached from the roof, but settles on the lower bed, thereby avoiding serious accidents. The saving in coal alone more than pays for the outlay; and it is practicable to cut with the most perfect ease into the floor of mine, thus preventing all waste of coal whatever—(See Fig. 3). The size of the coal is improved, the amount of slack is considerably reduced, and a single seam will yield more by one thousand tons of coal per acre, than when worked by hand labour in the usual manner.

The Machine undercuts "holes," or "kirves," with a man and boy as attendants, and completes the work with once going over, at the rate of fifteen yards per hour, and at any angle and height from floor or rails, being suitable for either "dip" or "rise" workings, and is capable of cutting the thinnest seams. The pressure of water which actuates this apparatus can be obtained either from the stand pipes in the pit, or from pumps attached to any existing engine, or from an engine and pumps specially made for the purpose. The quantity necessary is only what is sufficient to fill the circuit of the pipes, using it over again when desirable, as in the Bramah press. Any idea of a large volume of water being necessary may therefore at once be dispelled. There is also no leakage whatever.

Each Machine uses thirty gallons per minute, at about 300 lbs. pressure, according to the hardness of the coal or mineral to be operated upon. In cutting the shale of the Cleveland ironstone band, a somewhat greater pressure is found to be necessary. There is no limit to the pressure of water that may be used, nor the distance it may be forced without loss of power, beyond that due to its friction along the pipes. The same water pressure is also applicable to work pumps and rotative engines for hauling, &c., and other requirements in the mine, at a distance from the engine power. In cases where there is a fall of water, say of 100 lbs. pressure, it can be "intensified" by a self-acting Machine to 400 lbs. pressure, to work the coal cutter, but sacrificing three-fourths of its bulk, which is thereby set free.

The water is supplied in a continuous stream; it is, in fact, the medium through which the mechanical power is applied direct from the first coal-fed motor, (a Steam Engine and pumps) in lieu of the usually-developed power derived from vital energy, and applied to the handle of a pick, effecting the desired object by a series of percussive blows or impacts. The power of six men is equal to one horse, and is six times more costly; and the power of one horse steam motor, or engine, is eighty times cheaper than six men. The machine is about three horse power, and weighs one ton, and will work either right or left. (See dotted lines on ground plan). It is self-acting in all movements, and will ascend the steepest gradients; being simple in all its parts, it is not liable to get out of order, and is easily managed by an ordinary miner, and transported from place to place, on the ordinary rails, about the mine.

Although the length of stroke of each cutting tool is eighteen inches, the practical cutting length is sixteen inches, and, consequently, the three cutters jointly give a total effective depth of four feet at each stroke of the machine, finishing the work as it goes along. The mechanism employed consists of an Hydraulic reciprocating Engine, adjustable to any height and angle, having a self-acting valve motion. The cylinder is four and a-half inches diameter, and lined with brass, and the piston made tight with ordinary hydraulic leathers, easily renewable.

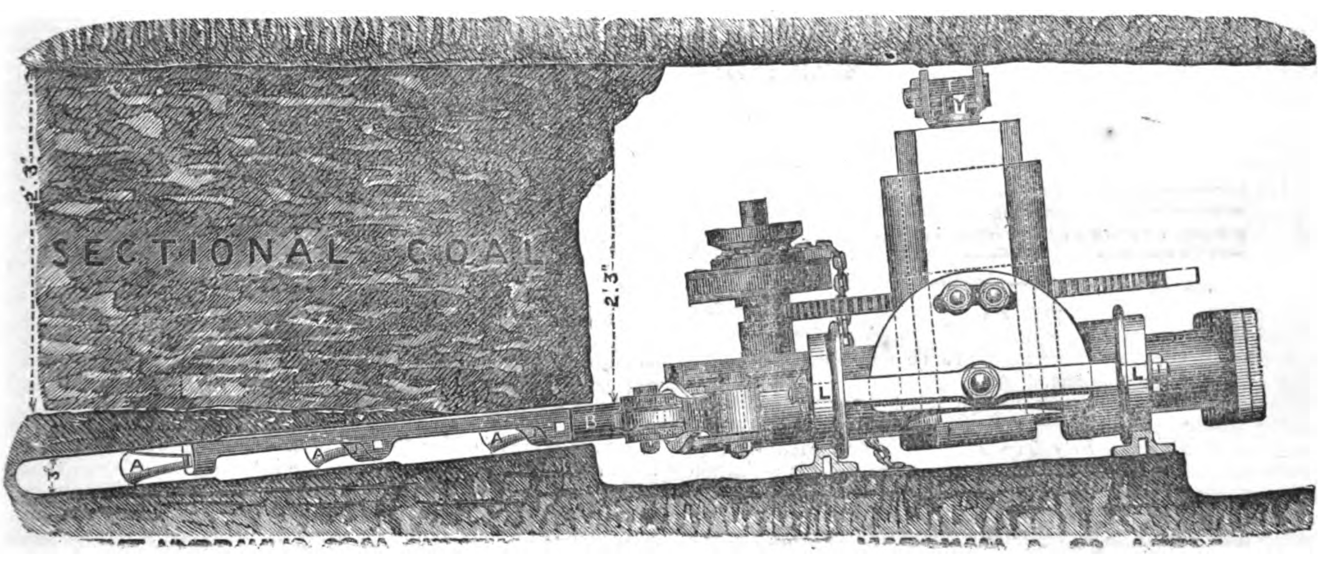


FIG. 3.—END VIEW.

Within the piston rod is attached the cutter-bar of steel, carrying the tools or cutters. These can be varied in number to suit the depth to be holed at one operation. The cutting tools are of double sheer steel, easily made, and very strong, and can be removed and replaced in a few moments; they are readily sharpened on an ordinary grindstone. The cutter bar is also removeable, when transporting the machine from place to place, for which purpose the main cylinder is, for the time being, placed longitudinal with the rails. (See dotted lines in Fig. 1).

The machine in operation fixes itself dead fast upon the rails during the cutting stroke, and releases itself at the back or return stroke, aud traverses forwards the requisite amount for the next cut, without any manual labour. Should the tools be prevented making the full stroke at one cut, they will continue to make more strokes at the same place, until the maximum depth is attained, when, "only" the Machine will traverse itself forward the required amount for the next cut. Thus, at one operation, a uniform straight depth is attained, parallel with the rails, inducing an even fracture when the coals are brought down, and thereby a straight line for the new coal face. There is no percussive action, either against the roof or into the coal, but simply a concentrated pressure, producing a steady reciprocating motion, at fiteen strokes per minute. There is consequently, no dust or noise, and little wear and tear. For the same reason, when cutting pyrites, the tools throw out no sparks, and the workman can hear any movement in the coal or roof.

The required height from the line of rails in the "holeing," "kirving," or "barcing," varies in different mines, it follows that the hydraulic cutting cylinder, and its direct action cutting tools, have sometimes to be arranged above the carriage, and sometimes beneath the main carriage, or close down upon the sails, as is illustrated in Figures 1 and 2. Figure 1 is the main carriage, with four wheels far enough apart to allow the machine to be placed longitudinally when being transported from place to place. The screws YY are for raising and lowering the carriage and its cylinder and cutting tools. The pinion Z and the segmental rack H regulate the desired angle of the tools cutting into the coal face, and the two nuts at each end of carriage, *xx*, regulate the angle required, when necessary that it shall not be in the same plane as the rails.

AAA are the cutting tools, B the cutter bar, N a guide roller for the same; D is the main cylinder, with its self-acting hydraulic valve motion, which passes a portion of its water alternatively above and below the piston of the holder on, which thus rises and falls without percussion, and follows the uneven line of the roof of mine, so that the required stability is given to the machine for the time being, an instant before the cutters enter the coal. The "holder on piece" can be any length necessary to bridge over gaps in the roof: it is loose on the pin F and droops at its leading end to enable it to ride over the varying projections in roof. The traverse motion is actuated by the pin *b*, which connects cutter bar with piston rod, and at the termination of each end of its stroke actuates the lever *d* in both directions, which operates on the pall *e* which causes the chain-pulley to revolve on the chain *i*, made fast ahead by an anchor-prop between floor and roof.

ON THE HEIGHT OF ROOMS.

TO THE EDITOR OF "THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL."

SIR,—I forward the enclosed paper to you, thinking that it is likely to be of interest to architects.

My object has been to show that perfection, or something approaching thereto, is possible, in fixing the proportions of rooms, by which word is to be understood not only all kinds of private apartments, but also public halls, theatres, &c. I am perfectly aware that the theoretical perfection of the cube, the idea developed in the first part of my paper, is no novelty; but, since it forms the corner stone of my theory, I have deemed it advisable, before going further, to demonstrate that it is a sound stone and one on which we may safely build.

As to the practical results to be looked for, I venture to hope that the suggestion I make will be found to exert an influence on the design of public buildings and country houses; but, so long as the staircase forms a necessary feature in a house, the limit of available space must unavoidably dwarf the rooms in town structures. I am, &c.,

1, Dorset Place, N.W. H. N. CRELLIN, JUN.

In order to solve the problem of finding the ratio which should obtain between the plan and elevation of a room, we have first to ascertain whether there be any such thing as a body of perfect proportions.

Now perfection, we must bear in mind, is completeness; a state in which there is neither defect nor redundancy; a symmetry such that nothing can be either taken away or added without deterioration, if not destruction. Making use of this definition as a test, we discover two forms, each perfect; the cube, among those bounded by straight lines; and the sphere, among those bounded by curved lines. For our present purpose we have to do only with the first.

The cube is a form the proportions of which are perfect, inasmuch as it admits of no alteration; there is perfect harmony among all its parts—each side is equal to every other, each line to every other,—so that no one part can be either diminished or increased without causing absolute destruction of the cube. We adopt this form then as our standard.

If therefore the four sides together with the top and bottom of a room be made equal each to each, the proportions thereof will of course be perfect. But that all our rooms should consist of a number cubic spaces would be not only monotonous but practically impossible. We have then to discover some formula by which we may determine the perfect height, or the height which in proportion to other measurements most nearly approaches perfection, of any parallelopiped whether cubic or not. And we can discover this only by observing the ratio which the height of a cube always bears to the area of the base or side on which it stands. Now we know that this is invariably: As the square root of the area of the side is to the area of the side; consequently, given a superficial square, we see at once that the line of height to be adopted, in order to erect upon it a cube, must be the square root of its area. We apply this to any parallelogram.

Let R be a room, the length of which is to be L, and the breadth of which is to be B. L B is then the area of its floor, and $\sqrt{LB}$ should be its height. For thus, not only does the height $\sqrt{LB}$ bear the same ratio to the area of the floor L B, whether those letters represent equal or unequal quantities, *i.e.* whether the room be cubic or not, but also the volume L B $\sqrt{LB}$ bears the same ratio to area of floor L B, whether that floor be a square or other parallelogram.

I append the following as illustrations:—

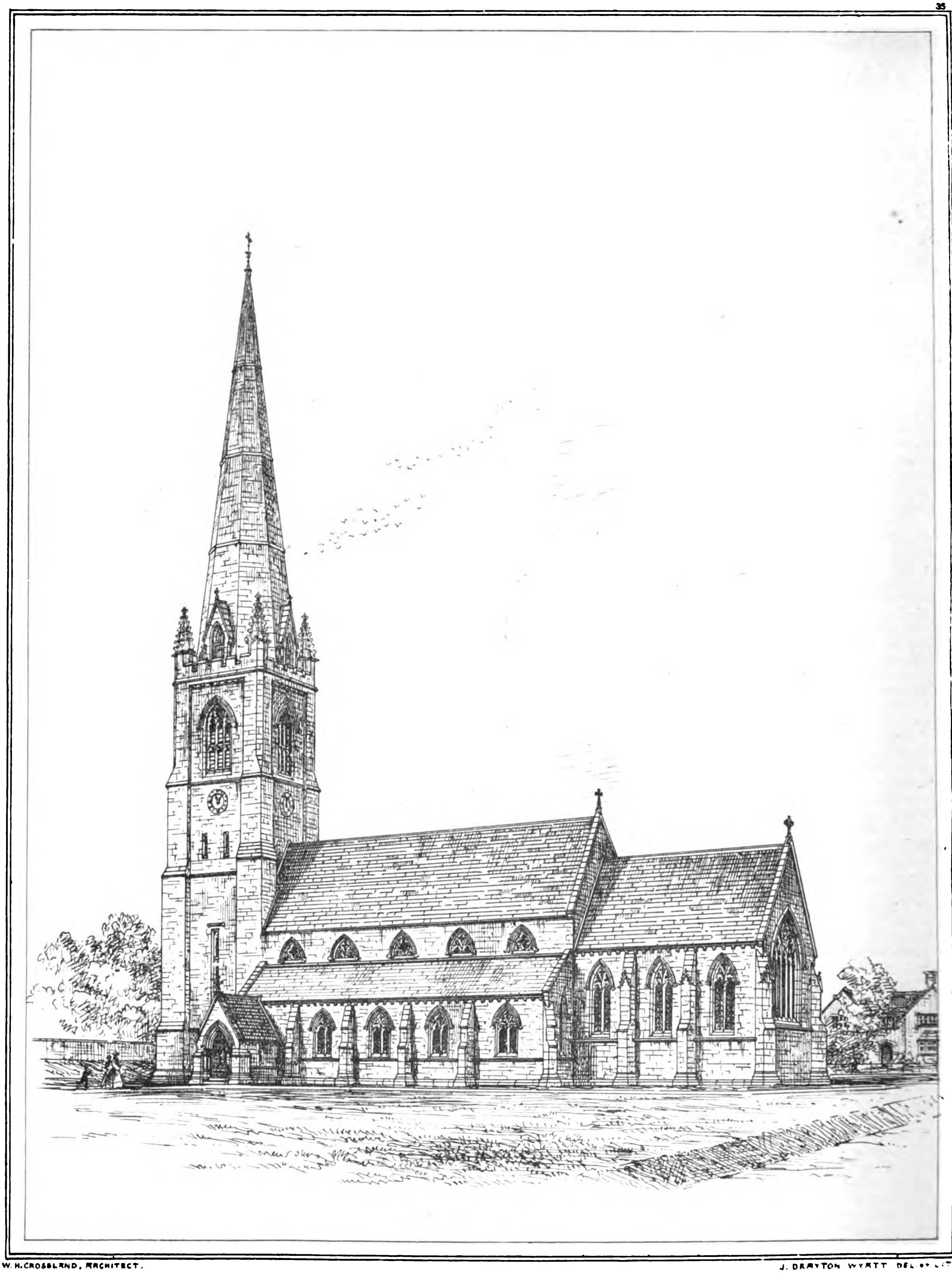
House of Lords: 90 feet long, 45 feet broad, 45 feet high. Height according to formula: $90 \times 45 = 4050$. $\sqrt{4050} = 63{\cdot}63$ ft.

House of Commons: 75 feet long, 45 feet broad, 41 feet high. Height according to formula: $75 \times 45 = 3375$. $\sqrt{3375} = 58{\cdot}09$ ft.

Guildhall: 152 feet long, 50 feet broad, and 55 feet high. Height according to formula: $152 \times 50 = 7600$. $\sqrt{7600} = 87{\cdot}17$ ft.

Egyptian Bricks.—Professor Unger, in a paper recently communicated to the Imperial Academy of Sciences at Vienna, shows that Egyptian bricks possess a special interest, for they contain a variety of evidence preserved, as it seems, in an imperishable form. In his latest researches he has examined a brick from the pyramid of Dashour, which dates from between 3,400 and 3.300 B.C., and found inbedded among the Nile mud or slime, chopped straw, and sand of which it is composed, remains of vegetable and animal forms, and of the manufacturing arts, entirely unchanged. So perfectly, indeed, have they been preserved in the compact substance of the brick that he experienced but little or no difficulty in identifying them. By this discovery Prof. Unger makes us acquainted with wild and cultivated plants which were growing in the pyramid building days; with fresh water shells, fishes, remains of insects, and so forth, and a swarm of organic bodies, which, for the most part, are represented without alteration in Egypt at the present time. Besides two sorts of grain—wheat and barley—he found the teff, the field pea, the common flax, the latter having, in all probability, been cultivated as an article of food, as well as for spinning. The weeds are of the familiar kinds: wild radish, corn chrysanthemum, wart-wort, nettle-leaved goosefoot, bearded hare's ear, and the common vetch. The relics of manufacturing art consist of fragments of burnt tiles, of pottery, and a small piece of twine, spun of flax, and sheep's wool, significant of the advance which civilization had made more than five thousand years ago. The presence of the chopped straw confirms the account of brickmaking as given in Exodus and by Herodotus; and the whole subject is so interesting that it is pleasing to know that Prof. Unger intends to follow it up. He is of opinion that, by careful examination of a large number of bricks, some light may be thrown on the origin of Egyptian civilization.

Public Works in New South Wales.—A sum of £10,000 having been voted by the Parliament for the improvement of the rivers Murray, Murrumbidgee, and Darling, active measures have been taken for carrying out the work. Clearing parties have been formed for cutting away and removing the snags and other obstructions that impede the navigation of the rivers. An extensive scheme of improvement to Darling Harbour has been proposed by the Engineer-in-Chief for Harbours and Rivers, and submitted to the Government. It is proposed to construct a range of wharves to enclose the whole of the head of Darling Harbour, with a view to the establishment of a railway terminus there, and in connection with it to deepen the whole of that part of the harbour to twenty feet, so that vessels of the largest class may lie alongside the wharves to discharge or take in cargo. In the event of this scheme being carried out, many of the large London ships with goods for the country would doubtless discharge at one of these wharves, where they would be enabled to transfer cargo from their holds into railway trucks without any intermediate carriage; and they would also be in a position to take in, from the railway trucks, the produce of the country. It is the intention of the chiefs of the works department to have, if possible, all the more important public works in the colony photographed for the Paris Exhibition of 1867. This would undoubtedly be one of the most effectual means of exhibiting the importance of the colony, and the progress made within the last few years.



W. H. CROSSLAND, ARCHITECT. J. DRAYTON WYATT DEL. et LITH.

— CHRIST-CHURCH, STAINCLIFFE, YORKSHIRE. —

STAINCLIFFE CHURCH, YORKSHIRE.

(With an Engraving.)

The accompanying view shows the exterior of a church now commencing at Staincliffe, in the parish of Batley, to supply the wants of a new district. The architect is Mr. Crossland, of Leeds, and the contracts, which are let out to different trades, as is the local custom, will, with some additions, render the cost of the building about £7,000. Of this sum, £5,000 has been already raised in the neighbourhood. The walls are of dressed stone, and the roofs will be covered with Westmoreland slate. The site, and a donation of £500, have been given by J. B. Greenwood, Esq.

RECENT IMPROVEMENTS IN THE APPLICATION OF CONCRETE TO FIREPROOF CONSTRUCTION.*

By Mr. J. Ingle.

Amongst the various methods of fireproof construction as applied to the floors, ceilings, and roofs of buildings, which have been in use within the last twenty or thirty years, those in which concrete forms the fire-resisting medium have been most frequently adopted. The main reason for this preference, no doubt, is that the horizontal form in which it is generally disposed suits best the requirements of modern construction.

Brick arches, though used almost without exception to carry the floors of the large fire-proof mills and warehouses of the manufacturing districts, have disadvantages which almost preclude their use in buildings of a more general or domestic character. They require walls and girders of great strength to sustain their weight and to withstand the outward thrust which they exert, and the depth which they occupy on account of their rise, when added to the board and joist arrangement above, and the ceiling underneath, is so great as to involve a considerable increase of height in the building to obtain the same clear space between the floors and ceilings of the rooms. Of the systems of fire-proofing in which concrete forms the chief element, that of Messrs. Fox and Barrett is the one which has been most extensively used.

It consists of a series of light rolled iron joists fixed 2 feet apart, upon the lower flanges of which are placed fillets of wood at intervals of an inch or an inch and a-half. Upon these a mass of concrete is thrown, the depth of the same being regulated to some extent by that of the iron joists, the concrete being generally brought up flush with their upper flanges.

The whole is then paved, or covered with an ordinary wood floor upon light sleeper joists. The underside of the floor receives a second series of wood fillets nailed transversely to the first, and at intervals of 12 in. or 15 in., and upon these the ceiling is then formed in the ordinary manner.

The concrete used in this construction, in common with all others in which ordinary lime forms an ingredient, is not strictly speaking, a fire-proof body. The cementing material which occupies the interstices between the fragments of stone or gravel becomes, like ordinary mortar, in setting, a weak carbonate of lime, and like the stone, from which it was originally burnt, is reduced by calcination to a state of lime. This effect would undoubtedly be produced upon any lime concrete which formed part of the construction of a floor exposed to a severe conflagration.

The application of water to lime in the caustic state converts it, of course, to a hydrate; and while undergoing this change it assumes double its original bulk and falls to powder. The consequences, therefore, which might naturally be expected to ensue from the play of water from the fireman's hose upon concrete floors in a calcined state, would be the overthrow or fracture of the outer walls by their expansion. Some of the numerous instances of the destruction by fire of buildings, which were supposed to be secure from that danger, are probably owing to this circumstance.

I have more especially alluded to this radical defect of ordinary concrete as a fire-proof medium, because, in the system which I am about to describe, a kind of concrete is employed which retains its cohesion and a considerable portion of its original strength, though water be thrown upon it while in a red-hot state.

This method is a local invention, and is known as "Dennett's fire-proof construction." I shall speak first of the composition of the concrete, and then proceed to describe the manner in which it is applied.

Gypsum, known chemically as the sulphate of lime, and which is one of the most perfect non-conductors of heat, is the most important constituent of the concrete, and is used in lieu of the ordinary lime as its cementing material. This gypsum, however, unlike that manufactured into the plaster of Paris which is used for ornamental purposes, undergoes a thorough calcination. The latter is simply roasted in ovens, the finer lumps of gypsum being carefully selected for the purpose. The effect of this roasting is merely to drive off so much of the water which enters into its chemical composition as to allow the gypsum to be ground by millstones.

The rapidity of setting which is peculiar to this kind of plaster is owing to the fact of its having but little water to take up in order to resume a state of consolidation.

For the manufacture of the plaster used in Dennett's concrete the coarser qualities of gypsum are used, such as in fact, except for this purpose, would be thrown aside as mere waste. These inferior qualities are largely impregnated with clay, with the beds of which it alternates, and this clay when burnt becomes the very kind of material which is afterwards added artificially in the mixing up of concrete.

For this purpose any hard material possessing a high degree of porosity is used: such as furnace drosses, oolitic stone, or broken brick. The latter being in most cases readily procurable is generally used. It is necessary that all dirt and dust should be carefully screened out so as to prevent the choking of the pores of the brick.

The sizes of the lumps are graduated so that the smaller ones shall fill up the interstices of the larger. By this means, and by considerable force used in consolidating the concrete, it is made to consist of a large proportion of the hard material, and its strength is much increased by the proper observance of these precautions.

Some considerable time is occupied by the concrete in setting, as a great amount of water is required to be taken up by the plaster on account of its thorough calcination.

When the setting process is complete a degree of hardness is attained, however, to which that of ordinary plaster of Paris will bear no comparison, and which is equal to that of the best cements.

The form in which the concrete is generally applied to the construction of floors is that of an arch, or series of arches, with small rise. These are formed upon temporary centres, which may be removed after an interval varying from two to six days, according to the state of the atmosphere and the size of the arches.

Spans of from 6ft. to 12ft. can be bridged over in this manner, the thickness of the arch varying from 3in. to 5in. in the crown, and from 5 in. to 10in. in the haunches. Rolled or rivetted iron girders form the intermediate supports of the arches, while the outer haunches rest upon projections or corbel courses in the brickwork. Floors of corridors and cottage rooms can be formed, however, without the aid of any joists or girders whatever. Of course the arch form presupposes a certain amount of support from the abutments, but from the transverse strength and thoroughly homogeneous character of the material very little if any lateral thrust is exerted on the outer walls.

If a wood floor is required, sleeper plates and light joists and boards are laid in the ordinary way; but if there is no necessity for this kind of finish, or if it is desirable to make the upper surface fire-proof, the haunches of the arches may be filled up to a horizontal line and paved with stone, tiles, cement, or asphalte, as may be desired.

The cheapest and best kind of paving, however, is that which may be formed by the concrete itself. To do this the porous material is graduated in size until the surface can be finished with the trowel. This surface can be executed in various tints, and with different degrees of polish,

For bedroom floors this method of finish is particularly adapted; it is cleanly, non-absorbent, free from vibration, and therefore comparatively noiseless; and what is a very important

* Read at the British Association, Nottingham, 1866.

consideration, particularly in the crowded districts of large towns, affords no harbour for vermin. Any objection which might exist against these floors on the score of coldness may be removed by placing a sheet of hair felt or matting of cocoa fibre under the carpet.

Floors of coarse plaster laid upon reeds or laths on the ordinary joists were formerly very common, and are still used to some extent in Nottingham and other towns of the Midland district; and it is no doubt owing to this circumstance that the destruction of a dwelling-house by fire is here a matter of very rare occurrence indeed.

The mode of finishing the underside of these floors depends upon the character and architectural requirements of the building. For banks, offices, hospitals, and many other public buildings, there is often no objection to the curved surface which the soffits of the arches present, and which are moreover, well adapted to receive coloured decoration. Where, in buildings of a more domestic character, a flat ceiling is indispensable, a series of light joists to receive the ordinary lathing is affixed to the lower flanges of the girders. As these form no part of the main construction of the floor their destruction in case of fire would not impair the stability of the arch, which forms the fire-proof medium.

With regard to the strength of the concrete, very severe tests were applied to some of these arches at the new town-hall at Hackney, under the direction of the district surveyor, and with very satisfactory results. These experiments were tried with reference to their capacity for sustaining dead pressure, and also with regard to their resistance to impact. In the latter case a rough block of stone weighing 250 lb. was dropped from a height of 14ft. upon the centre of an arch which was but 3½in. thick in the crown, and bruised but did not break it; while another block weighing 750lb., let fall from a similar height upon an adjoining arch, went through with a clean fracture, causing no disturbance of the general construction.

Some further idea of the strength and capabilities of the material may be formed when it is stated that vaults and domes have been executed therein at the new Foreign Offices, of spans varying from 10ft. to 36ft. The vault of the latter dimension is semi-circular on the section, and the concrete is 9in. in thickness, with occasional ribs and groins to the side windows.

Mr. G. G. Scott, who first adopted this method of construction seven years ago for the thorough fire-proofing of Kelham Hall, near Newark, the seat of Manners Sutton, Esq., speaks of it in the following terms:—

"I have made use of Messrs. Dennett's material for fire-proof arching, and though I have happily had no practical experience of its efficiency as against fire, I can bear witness to its strength, and its extreme convenience of application. I have made use of it in positions in which I should have found it difficult to introduce any other fire-proof material, and it has this advantage, that the arches constructed of it are so entirely in one mass that they cover the space like a compact shell or inverted basin, and are consequently almost wholly free from lateral pressure."

The cost varies, of course, with the distance of the place where the system is adopted, from the localities where the gypsum is quarried, but in most parts of the country it is found to be cheaper than any other method of fire-proofing, while in the immediate neighbourhood cottage floors can be formed at a cost less than that of ordinary wood construction.

TRACTION ENGINE.

A train drawn by a locomotive on the common roads has recently arrived at Paris. The locomotive has a tubular boiler, carries a tender, a water-tank, and foot-plate in front of the engine. The engine is on the top of the boiler; it has two cylinders, with reversing gear. It is worked from the front, by means of a guide-wheel, which is moved by one man; it works with ease and perfect regularity; it can turn in curves of a very small radius, and can follow all the windings of the road. This engine, travelling on a level road, or on one that presents no gradients of more than three per cent., draws an actual load, after deducting the weight of the waggons, of twelve to fifteen tons, at a speed of 2½ to 3¾ miles per hour. It draws at high speed, nine or ten miles per hour, a clear weight of from one to four tons and a-half. The waggons are coupled one to another as well as to the locomotive, by a mode of coupling which allows them to follow all the movements of the engine, however much it may deviate from the straight line.

RAILWAY ENTERPRISE IN ITALY.

In Italy there will be shortly working 5,235 kilometres, or about 3,271 English miles, of railway. Besides the completion of the Venetian lines, which will reach in a few days as far as the borders of Illyria, and 302 kilometres recently finished in the valley of the Tiber and the Arus, that is to say, Ancona, Orte, and Montevacchi Torricella, within two months there will be opened to the public 317 kilometres of new line, namely, those of Pavia and Cremona, Bresica, Mesina, and Catania, the completion of the Aretuna and Ferrara and Rovigo, which includes the temporary bridge over the Po. Within a month Florence will be directly united by railway on the one side with Rome and Naples, and on the other side with Venetia and the Friou; the working of the Italian railways will then begin to acquire a systematic character. They will have for basis two great lines without interruption; the one, 1,080 kilometres in extent, will traverse the peninsulation Udine to Naples, by way of Padua, Ferrara, Podetta, Arezzo, Foligno, and Rome, and will cross at the Bologna station the other line, 1,200 kilometres in length, and which already unites Susa with Lecce, by way of Turin, Alexandria, Piacenza, Modena, Rimini, Ancona, Bari, and Bridisi.

ON THE CONNECTION OF PLATES OF IRON AND STEEL IN SHIPBUILDING.

By Nathaniel Barnaby, Assistant Constructor of H.M. Navy.

Much yet remains to be done to make iron shipbuilding a perfect art, and there is, perhaps, no one step remaining to be taken in the path of improvement more important than that of substituting a simple and efficient means of joining plates by welding, should it ever be discovered, for the present system of rivetting. The loss of strength caused by the present system is considerable in iron, but appears to be still more serious in steel. It forms, in fact, the great bar to the introduction of this most promising material into ships of war. As an illustration of this, one or two of the many experiments which have been made by the Admiralty at Chatham Yard on Bessemer steel of the best quality may be given. A piece of steel 4 feet long and 12 inches broad was cut from a half-inch plate, of which the proof strength was 33 tons per sq. inch. This piece was reduced to 5 inches in width at the middle, was supported at the ends by square plates rivetted to it, and was carefully centred. The plate should have broken at 82½ tons, and through the narrow part. It actually broke at 95¼ tons, and then, strange to say, broke through the wide part of the plate, tearing away through the rivet holes. Thus, while the material in the middle of the plate withstood a strain of 38 tons per square inch, it actually broke through the holes at 16·38 tons per square inch, or less than one-half the strain.

In a precisely similar plate, differing from the other only in the fact that the rivets connecting the end pieces were 1¼ inches from the edge instead of 2½ inches, the plate broke in a similar manner at 73 tons, which is only 15 tons per square inch of the section of steel broken. The holes in both these cases had been punched, and in order to ascertain whether these curious results were due to the injuries supposed to result from punching, an exactly similar arrangement of plates was again tried, in which the holes were, as in the first, 2½ inches from the edge, but were drilled instead of being punched. The plate then broke through the narrow part at 106·75 tons, or 47·53 tons per square inch of the steel broken. I do not propose to draw here any inferences from the experiments detailed, or from the series of which they form part, further than this, that all which I propose to advance concerning the necessity of bestowing greater attention on the comparative strength of different modes of connecting plates intended to give tensile strength, is even more applicable to steel than to iron. Admitting, then, that for the present at least, we must be content to connect iron plates by rivets placed in holes punched or drilled out of the material, and, therefore, by the sacrifice of a considerable portion of the strength of the plate, it is manifestly the duty of the engineer and shipbuilder to study to make this connection with as little sacrifice of strength as possible. In every such connection, the tensile strength of the plates across the outer line of holes, of the butt strap or straps across the inner line of holes, and the resistance of the rivets to shearing, should be all equal. Two plates may be connected, for example, by butt straps, so as to reduce the strength of the plate by one hole only. The strength of the several parts has in this case been estimated on the assumption, verified by careful experiment at Chatham, that the shearing value of a ¾ Bowling rivet, including friction, and taken either singly or in conjunction with others, is 10 tons, and that of rivets of other diameters is in proportion to the squares of the diameters; also, that the tensile value of the iron between the holes is reduced in proportion to the number of the perforations, and that this reduction is about 25 per cent. when the holes are punched three or four diameters apart.

This description of butt strap is of no value in shipbuilding, because the stringer and tie plates, to which it might otherwise be applied, have to be perforated between the butts by rows of holes to connect them with the beams. In such plates, in order to economize material, it is therefore desirable to reduce the amount of fastening at the beams as much as possible. I do not think it necessary to punch away for this purpose more than ⅛ of the iron: the remaining strength of the iron would then probably be $\frac{7}{8} \times \frac{8}{9} = \frac{7}{9}$ths of the whole, so that the straps connecting them should also give $\frac{7}{9}$ths of the full strength of the plates. Any greater strength at the butts would, of course, be thrown away. If the butt strap has to be caulked, this proportion of strength cannot be retained, as the rivet holes must then be placed nearer together. I take, for example, the connection, by means of a butt strap, of two plates ¾ inches thick and 12 inches wide, in which the rivets are 1 inch diameter, and are spaced three diameters apart. Then we punch out ⅓ of the iron, reduce the strength of the remaining iron about one-fourth, and have left only $\frac{2}{3} \times \frac{3}{4} = \frac{1}{2}$. The tensile strength of the plate at 20 tons to the inch is 180 tons, and the tensile strength through the holes about 90 tons. If the connection is made by means of a single strap, the value of the rivets will be about 71 tons; and if by a double strap, 142 tons. No appreciable advantage could be obtained from a second row of rivets in this case, unless the spacing along the edge could be increased. If the rivets are no nearer together than is necessary for caulking, a second or third row could give no advantage, except in enabling us to reduce the thickness of the butt straps to less than the thickness of the plate, by reducing the number of rivets in the inner row where the butt straps are obliged to break. None of these considerations are new, but they have been so much neglected that those who are familiar with them will justify me in thus restating them. But there are certain other considerations equally important, which have altogether escaped the notice of shipbuilders. Let us suppose that we have a stringer or tie plate, the strength of which is, at the beams, and at the butts, 7 of the full strength of the plates, and that we have no means of increasing the strength at these points. Have we any means by which we can, without altering the strength at these points, increase the tensile power of the plate? I think the answer would generally be, we have not—the strength of the tie will be measured by the strength at the weakest place, and this strength is fixed. What I want to show is that this is not the case, and that we have overlooked an important element of strength, which is conducive to economy of material. Take the case of a stringer or tie plate crossing a number of beams, say 3ft. 6in. apart, at each of which the strength is reduced to $\frac{7}{9}$ths of the full strength of the plate. If this plate is brought under the action of a steady strain it is a matter of indifference practically how many such points of weakness there may be, and how much stronger the material may be lying between the weak points. But when strains are suddenly applied, we have to consider not only the number of tons required to break the weakest section, but the amount which it would stretch before breaking. It is, in fact, the work done in producing rupture, viz.: the force applied, multiplied by the distance through which it acts, which is the true measure of the resistance to rupture. Under these circumstances no elongation will take place in the strong parts of the plate lying between the beams: it will all be thrown on the weak points; and if any one of these be weaker in any sensible degree than the rest it will be confined to that point. This being the case a large increase of power may be obtained by reducing the strength of the plate between the weak points to the strength at these points, or even to less than this, provided we get long spaces of uniform strength to give elongation.

To illustrate this I will refer to some experiments made at Chatham with armour bolts, with reference to a proposal of Captain Palliser's. The proposal was to apply to armour bolts, having screws cut on them, the well-known principle that the bolts would be strengthened at the screw thread, and become less liable to break by a sudden jar, if the bolt, or a portion of it beyond the thread, were reduced in section to the same area as the iron left uncut at the thread.

The experiments referred to, made under my own careful observation, showed—

1. That iron bolts of good quality and of uniform diameter, subjected to a steadily increasing strain, elongate before breaking about one-fifth of their original length.

2. If the diameter is not uniform, but is decreased through a portion of the length, then the reduced part elongates about one-fifth of its length before breaking, and the larger portion scarcely stretches at all.

3. If this reduced part is very short, as in the thread of a screw, the strain required to break the bolt, is the same per square inch of the unstretched or original section as in the previous cases, but there is scarcely any elongation before rupture.

4. If the whole length of the bolt is made to the reduced diameter of the screw thread, so that the thread projects from the bolt, the breaking strain (gradually applied) is the same as before, but as the bolt will stretch one-fifth of its length before breaking, it becomes thereby less liable to rupture by a sudden blow, because, as already stated, the work done in producing rupture is in proportion to the weight or strain applied, multiplied by the elongation or the distance through which it is applied.

The details of one portion of these experiments were as follows:—

Four bolts were taken, all made of best selected scrap iron, for the purpose of the experiment, and all of the same diameter, viz., 2¼ inches; screw threads were cut in the ends of these, and nuts fitted. The other ends were formed with heads, leaving a length of 21 inches between the heads and the nuts. The four bolts being thus as nearly alike in every respect as they could be made, two of them were reduced down on the anvil for a length of 4½ inches in the middle of their length, to a diameter of 1⅞ inches, which was the same as that of the iron remaining within the screw threads. The two other bolts retained the full diameter throughout. They were broken in the hydraulic press, with the following results:—

		Breaking Strain in Tons.	Sq. In. in Sec. broken.	Tons per Sq. In. of this Sec.	Elongation. In 5 in.	Elongation. In 15 in.	Elongation. In 2 in.	Where broken.
Bolts not reduced	No. 1	63	2 76	22.8	Nil.	¼	¼	At thread
	No. 2	69	2.76	25.0	Nil.	$\frac{5}{16}$	½ bare	Ditto
Bolts reduced.	No. 1	64	1.67	38.33	¼	1⅜	1½	In reduced part.
	No. 2	65.5	2.07	31.58	⅞	1	1⅛	Ditto *

The fact that the strains of greatest magnitude in a ship are sudden in their nature, makes the principle under consideration one of no slight importance, because we see that by its application we are able to increase the time during which a given force must be applied in order to produce rupture. As the material is disposed at present in iron decks, and stringer and tie plates, the plates are perforated in the lines of the beams, not only by the holes required for the rivets to attach the plating to the beams, but by the deck-bolts which secure the wooden deck lying on the iron plating. The loss from the iron punched out, and the weakening of that which remains, amounts, on the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 feet 6 inches, and between them the plate has its full strength, except where a butt occurs.

The consequence of this is that when the deck is put in tension, the stretching is confined to these weak places, and the amount of work which the whole combination is capable of doing before rupture is extremely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beam. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across

* At the shoulder where there was a slight defect.

the lines of rivetting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates; but instead of this I propose to omit the butt straps, and to arrange the plates so that in each of these spaces there shall be a continuous series of butts and plates, in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spaces of uniform strength between the beams.

The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the shearing value of the rivets, and allows about one-third of the distance between the beams to be admitted. The advantages of one system over the other are, I think, the following:—

1. In the ordinary system one-fifth or one-sixth of the iron is punched away: by that proposed only one-ninth or one-tenth is punched out. There is from this cause a gain in direct tensile strength, to which must be added an increase of strength in the iron between the holes. These are together equal to about 12 per cent.

2. The strength of an iron deck under *compression* is limited, not by the area of section, but by its resistance to buckling between the beams. According to the ordinary mode this is very small, since it is quite free to bend downwards between the beams. But by spacing the deck fastening, as shown, at intervals of about 2 feet instead of 3 feet 6 inches, the tendency to buckling would be reduced. The wooden deck would thus, both by its own direct resistance to compression, and by the support it gives to the plates, play a most useful part in compression, although it is powerless as against extension when in connection with iron. I therefore conclude that no loss of compressive strength is incurred by the holes in the plates.

3. All the holes for receiving the deck fastening may be punched, whereas if the fastening is in the beam flanges, the holes for them must be drilled either in the plates or in the beams.

4. The expense of cutting, fitting, punching, and rivetting butt straps is avoided. Where the material employed is steel, the gain is more considerable, as all the holes in the butts of the plates and in the straps have to be drilled to prevent the injury done by punching.

5. The weight of material admitted at the butts amounts to one-seventh of the whole material employed.

6. There is a gain in strength against injury and rupture by the action of sudden forces, the amount of which is not susceptible of calculation, but which, being in proportion to the extent of the spaces of uniform strength which have been introduced, is, I think, very considerable.

The novelty of this proposal may be said to consist in so arranging the iron or other metal plates forming the flanges of girders, bridges, and other structures, or employed in decks, partial decks, stringers, or ties in a ship or vessel, as to make the tensile strength of the unperforated plates, intervening between adjacent butts, equal or nearly equal to the strength of the said intervening plates taken together with that of one of the butted plates where they are perforated, *i.e.*, across the row of holes made for the purpose of attaching the plates to the beams, angle irons, stiffeners, or other iron framing, and by this means rendering the use of butt straps in such combinations unnecessary. In other words, a section through the plates between the beams or stiffeners is made to have, without butt straps, about the same tensile strength as a section through the fastening at the beams or stiffeners, for the purpose of forming spaces of uniform tensile strength not greater than that of the weakest place in the combination. In these intervals elongation will take place (to an extent depending on their length) before the materials can be ruptured, so that an increased amount of work will require to be done by the operation of a given strain in producing rupture. Also, in increasing the resistance to rupture under sudden strains in single plates, by reducing the tensile strength throughout certain intervals between the beams, angle irons, or stiffeners, and approximating to that at the beams, angle irons, or stiffeners, by cutting out portions of the plate.

I am aware that iron decks are not used in merchant vessels, although they are in all iron war ships built for the Admiralty, and I consider it to be false economy to substitute, for such decks or partial decks, stringers on the ends of the beams, tie plates near their middle, and diagonal braces between them; as I think it clear that from the round up of the beams, and other causes, a considerable portion of this material is unable to succour the rest when the top of the ship is put in tension or compression. The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top. Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I hope that the economical considerations pointed out may be not only useful in lightening and strenthening ships designed for war, but in inducing private shipbuilders to introduce partial iron decks, so formed, into ships designed for commerce. These proposals do not form the subject of any patent.

THE PARISH CHURCH, BIRSTAL.

(*With an Engraving.*)

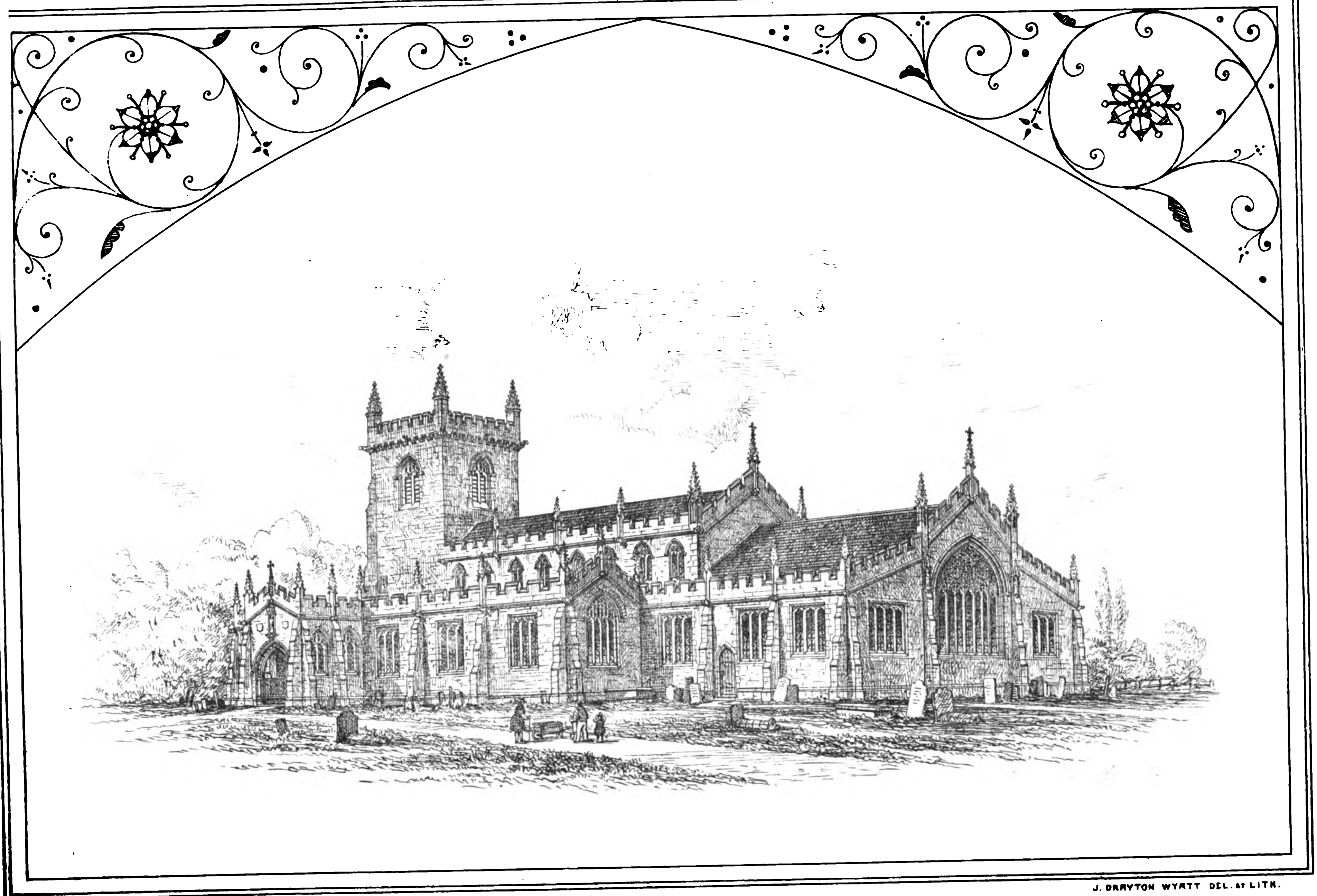
Birstal, a place of some importance a few miles from Leeds, has a large parish church, upon which the work of restoration and enlargement has been started. The plan is unusually large, and consists of nave and chancel, with an aisle on each side extending the whole length of the building, while an extra aisle on each side occupies the length of the nave only. A small tower, situate within the building, rises from the west end. The style of architecture partakes largely of the "Perpendicular." but in the new features the "Decorated" style has been followed. This is particularly observable in the aisles and clerestory windows, which are being reconstructed. The chancel is of very "Late" character. The architect to whom the restorations are entrusted is Mr. W. H. Crossland, of Leeds.

THE WORKS ON THE MONT CENIS TUNNEL.*

By Thomas Sopwith, Jun,. C.E.

This tunnel is to be the completing link of the Victor Emmanuel railway, which will put France in direct railway communication with Italy, and place Turin within eighteen hours' journey of Paris. In June, 1863, the railway was opened on the French side to St. Michel, in Savoy, and on the Italian side to Susa, in Piedmont. Modane, near to which is the French, or north entrance to the tunnel, is about 10 miles from St. Michel, on the 'grande route' to Turin. Thence the tunnel will pass under the Col de Frejus, about 18 miles west of the actual Mont Cenis, coming out in Italian territory near Bardonnêche, about 24 miles from Susa. The traffic is at present conveyed from St. Michel to Susa, a distance by road of about 50 miles, by the 'grande route' originally made by the first Napoleon, and known as the Mont Cenis pass, the lowest of the Alpine passes. When the tunnel is finished, it is not unlikely that postal communication and traffic with India may be advantageously transferred from Marseilles to some Italian port. By referring to a map it will be observed, that the line of rail is nearly straight from Paris to Maçon, Culoz, and by the tunnel, to Turin; it afterwards continues by railways already opened, or in course of construction, to Ancona, thence to Brindisi, on the east coast of Italy. A north-west wind prevalent at Marseilles and in the Mediterranean, more particularly during the winter months, makes the entry and 'beating up' to that port extremely difficult, and sometimes obliges the captains of steamers to abandon the direct line from Malta, and to keep along the coast by the South of Sardinia and France.

* Paper read before the Institution of Civil Engineers.



W. H. CROSSLAND, ARCHT.

J. DRAYTON WYATT DEL. ET LITH.

PROPOSED RESTORATION OF THE PARISH CHURCH, BIRSTALL,

— YORKSHIRE. —

The advantages that might be expected to arise, from the establishment of railway communication between Italy and the rest of Europe, have not been underrated; and Italian engineers have, for more than twenty years, considered various projects for overcoming the natural difficulties which intercepted it. Of the proposed routes, that selected seemed to be the most feasible; and, indeed, it was only a question whether the mountain should be crossed by a series of inclines, with engines specially adapted to them, or whether a tunnel should be constructed.

In 1857, MM. Sommeiller, Grandis, and Grattoni, engineers, who had already surveyed the line of railway now adopted, and who were then engaged upon other works in which compressed air was employed, brought before public notice a plan for using it to drive machinery for replacing the ordinary method of boring by hand-labour. Experiments, at the expense of the Italian Government, were made near Genoa with machines on this principle, and with compressed air as a motive power. These were so satisfactory that a Commission was appointed to examine how far these machines were applicable to the proposed tunnel, as well as to ascertain if there was sufficient water-power for compressing the amount of air necessary for working them. An abundant water supply having been found to exist at each end of the proposed tunnel, and the report being otherwise favourable, the project was accepted, and, pending the construction and erection of the machinery, a commencement was made, at both ends, by ordinary mining, in the beginning of the year 1858. A careful examination of the geological features of the district showed that no particular difficulties were to be apprehended in the rocks to be pierced by the tunnel, these being, for the most part, micaceous, and talcose schists, traversed by strings and veins of lime and quartz. It was predicted that a bed of quartz, 100 mètres thick, might be encountered near the north end; but, so far as can be judged, the 'forehead' is already in advance of the place where it should have occurred; so it is to be hoped that some change of inclination diverts it altogether from the line of the tunnel. The ordinary difficulties of making a tunnel 7⅝ miles in length are in this case much increased, on account of the impracticability of sinking shafts on the line to ventilate it; and its progress must necessarily be slow for the same reason, only two points of attack, the ends, being available. Without being sanguine that, by the aid of machinery, the time which would be required to make it by ordinary means could be greatly reduced, the work would perhaps never have been undertaken, as, judging from the usual rate of progress in such cases, it must have required from thirty to forty years to complete it. It was feared, and urged as an objection, that the ventilation before the tunnel was finished would be so imperfect as to prevent, or at least materially to retard, its construction. The Author never entertained any apprehensions on that account, as the ventilating air-current in many coal-mines passes over a longer distance, and far exceeds in quantity any possible requirement at Mont Cenis; and by the introduction either of a horizontal or a vertical brattice, the tunnel may be placed under the same conditions as many parts of a coal-mine. It would have been almost impossible to employ any other power than compressed air for working the machines in the 'fórehead,' which affords, after its escape, a supply of fresh air to the workmen, and by expanding from a greatly reduced bulk to its former volume, and consequent absorption of heat, the temperature, when the men are at work, is considerably reduced, seldom exceeding 70° Fahr. It is also readily applicable for general purposes, and small engines for pumping, &c., are driven by it. Gas made at the surface, is used for lighting the tunnel at the Bardonnêche end, and is introduced by pipes up to the 'forehead.'

The tunnel, on leaving Modane, is of the following dimensions: 25 feet 3¼ inches wide at the base, 26 feet 2¾ inches wide at the broadest part, and 24 feet 7¼ inches in height, the arch being a semicircle nearly. At Bardonnêche the height is increased 11¾ inches, and the arch is made elliptical, to resist the greater strain caused by a different inclination of the strata. The exact length between the ends is 7·5932 miles, or 7 miles, 4 furlongs, 7 chains, 9 yards. The present ends will not, however, be the actual entrances when the tunnel is finished. To avoid sharp curves, the line will leave the tunnel about 415 yards from the tge Modane end, and 273 yards from that at Bardonnêche. The tunnel at Modane is built entirely with stone; at Bardonnêche the side walls only are of stone, the arch, with the exception of 327 yards at the beggining, being of brick. The northern entrance, at Modane, is at an elevation of 3,945 feet, and the Southern entrance, at Bardonnêche of 4,379 feet, above the sea. There is a difference in level therefore of 434 feet between the ends. On this account the tunnel will leave Modane with a rise of 22·20 per 1,000, or about 1 in 45½, and will continue so for one-half its length, when it should attain the elevation of the rails from Bardonnêche, which are to have a rise towards the middle of 0·50 per 1,000, or 1 in 2,000 only. The highest point on the surface in the line of section is 9,525 feet above the level of the sea. When once the work is completed it is expected that there will be a constant draught from the north to the south, as the latter is not only higher and the air more rarefied, but it is exposed in a greater degree to the heat of the sun.

Before proceeding to state the rates of progress made by the ordinary means, and those obtained since the introduction of the machinery, the Author will give a brief description of the system of tunnelling pursued at Mont Cenis, as a general idea of this system is indispensable for the appreciation of the statements which will shortly be made; and he will reserve for subsequent consideration more detailed notices of the machines employed. The establishment at each end of the tunnel consists of machinery for compressing the air, workshops for making and repairing machinery, offices, storehouses, residences for the engineers, barracks for the workmen, forges, &c. At Modane the entrance is about 328 feet above the bottom of the valley, up which the railway passes, and where the workshops are placed. The railway, to gain this elevation, makes a 'détour' up the valley. The entrance is, however, in direct communication with the shops, by an inclined plane, with two lines of rails, worked by a water-balance, the inclination being about 30°.

Experiments and attempts have already been made, both in England and in America, with a view to introduce machinery for tunnelling, but never with complete success. In England a machine introduced by Captain Penrice, R.E., was made and tried near Newcastle-upon-Tyne, and was afterwards used by the Ebbw Vale Iron Company. It was intended to bore a gallery about 4½ feet in diameter, by means of a frame with six radiating arms, or ribs, finished with cutters fixed on a shaft worked direct from a steam cylinder, making as many as one hundred strokes, or blows, per minute. By this system the whole of the material extracted would be in the form of chippings and coarse grains, and in thus reducing it to so small a size, much unnecessary work would be performed. Any means of tunnelling by machinery, in which the power afforded by the expansion of gunpowder is not made available, must fail to be economical. M. Sommeiller's system has the great advantage of using it. His object has been to apply machinery to bore small holes to receive the charges of gunpowder, and to do this in less time than can be accomplished by hand labour. This has been effected by mechanism of very ingenious construction, composed of two distinct machines. One is a fixed rotary engine, and its duty is to work the valve of the larger cylinder, to advance or withdraw the latter on its frame as may be required by the increasing depth of the hole, or to allow of the borer being replaced, and, finally, to give a rotary motion to the borer itself. The other machine comprises a larger cylinder for propelling the tool, or borer, against the rock, the tool or borer being a direct continuation of the piston rod. The piston rod is large, and a constant pressure is kept on the annular surface of the piston, to return it after each propulsion, without the use of a valve with double action. The air for driving these machines is at about 5 atmospheres above atmospheric pressure, and each machine makes two hundred and fifty strokes per minute. The pressure on the piston in striking, deducting that required to overcome the constant pressure on the other side, is 216 lbs. Calculated by the pressure of the air, and the number of feet travelled by the piston per minute, each of these machines is of $2\frac{4}{10}$ H.P.; presuming, as the Author believes to be the case, that the compressed air is not used expansively, or cut off before the end of the stroke. The length of the stroke may be varied from 2 inches to 7½ inches, and the diameter of the cylinder is 2¾ inches. Each of these machines weighs about 6 cwt. A stock of the machines is kept on hand to replace those that are injured. The work is so severe that, although simplified as much as possible, the machines are still liable to frequent derangement. On an average, after eight or ten 'shifts,' or, say, after boring from sixty to eighty holes, a machine needs repacking, and perhaps the replacing of some working part. It may not perhaps be too much to say, that four machines must be kept in reserve for one that is working. The cost of each machine is about £80. A strong iron frame, weighing with the apparatus it carries 15 tons, provided with levers, crossbars, adjusting screws, &c., moves on rails close to the 'forehead,' and on it are fixed the machines. Each machine can be made to work at almost any inclination; but as, in doing so, it is likely to interrupt the efficient working of the others, the holes may practicably be considered as being bored nearly horizontal, an increased number making up for any loss on account of their not being so well placed as they might have been. This is not so great a disadvantage as it may appear at first sight. Miners consider it of great importance that the holes should be so situated as, when exploded, to lead to the disruption of the largest quantity of matter. It is, however, of equal importance at Mont Cenis, that the rock brought away should not be in large pieces, as a longer time would then be required to remove them, and possibly in some cases, the pieces might have to be again broken up by blasting. The frame carries at Modane eleven machines, and at Bardonnêche nine machines. The size of the advanced gallery is about 10 feet square: but an experiment is being made with a gallery of 7 feet square, in which case the necessarily smaller frame can only carry 7 machines. If this is successful the system will be much more practicable, and will be an important consideration for mining proprietors; as the original size of 10 feet square, if indispensable to the efficiency of the machines, is too great for ordinary mining galleries. Behind the frame there is a truck, bearing wrought-iron vessels filled with water, which is kept at a pressure of about 5 atmospheres, by being in communication with the compressed air, and is used for the jets, one to each machine, which keep the tools cool, and remove the borings. The air is conveyed along the tunnel in pipes about $7\frac{5}{8}$ inches in diameter. Some distance from the 'forehead' a caoutchouc pipe conveys it to a small reservoir on the hinder part of the frame, from which it is taken by caoutchouc pipes, about 2 inches in diameter, to each machine.

Each time of working, or 'shift,' about eighty holes are bored. When these are completed, the frame and machines are withdrawn, and another set of men charges and fires them, again relieved by others, who remove the rock shot down. The division of time amongst them is very variable. It may, however, be assumed as from

6 to 8	hours	for the	machinist,
$1\frac{1}{2}$ to 2	„	„	charging and firing,
3 to 5	„	„	removing 'déblais,'

or hardly two complete 'shifts' every twenty-four hours. In June, 1863, during twenty-seven working days, forty-six 'shifts' were worked; except, as in June, when there was a fête more than usually popular amongst the workmen, and when the works were suspended for three days, for the Fête d'Italie, the works are continued day and night, without interruption, Sundays included. An alignment is made once in three months, from an observatory at each end. As yet no error has been detected.

The frame is provided with an engine, worked by compressed air for advancing it into, and withdrawing it from, the 'forehead." At the completion of a 'shift' it is withdrawn from 60 yards to 100 yards, to the shelter of some doors, removed from time to time as the 'forehead' progresses. When it is again required, it can be taken to the 'forehead' in two or three minutes; owing to the length of borers used, 6 feet is quite near enough, and once there, little time is required for setting the machines to work; within five minutes, two or three perhaps are in operation, and in ten minutes nearly all. Three or four large holes $3\frac{1}{2}$ inches in diameter, are bored about the middle of the 'forehead;' the remainder are about $1\frac{3}{16}$ inch diameter and 2 feet 8 inches to 3 feet deep. The larger holes are the same depth, but are not charged, their purpose being to ease the others only, and to increase the effect of their explosion. The holes round these larger ones are the first charged and fired, making a cavity in the middle, or 'laying in' as it is called by miners. The remainder are exploded in turn from the cavity outwards. The workmen—Piedmontese for the most part—are hardy and courageous under circumstances which require more than ordinary perseverance. An inducement to work is given in a premium upon more than a certain advancement per day in the advanced gallery. The distance on which the premium is based varies with the nature of the rock. The standard is now 1 mètre per day.

For $1\frac{1}{10}$ mètres	$1\frac{1}{10}$	day's wages	are	paid
„ $1\frac{2}{10}$	„ $1\frac{2}{10}$	„		„
„ $1\frac{3}{10}$	„ $1\frac{3}{10}$	„		„
„ $1\frac{4}{10}$ and above,	$1\frac{1}{2}$	„		„

This is reckoned and is subject to adjustment every fortnight.

For removing 'déblais' produced by explosion, there are two lines of rails at Modane, one on each side of the line which carries the support and the machines. It is removed in small wagons to the end of the advanced gallery, is there tipped into larger wagons, and is thence taken by horses outside the tunnel. The removal of the products of explosion is very well organized, and could only be improved by a system of removing *en masse*, which would be difficult to carry out. It may be possible, however, to construct an iron frame running on wheels, to be placed at the 'forehead' at the time of explosion, which would receive the greater part of the products of explosion, and this is now under consideration. Much time would be saved if such a system were practicable.

Before giving some data as to the number of men employed, the progress, &c., a few words must be said about the machinery for compressing the air. Water is the motive power for this purpose, and a system of applying it has been adopted by M. Sommeiller, which though novel, is expensive in construction and erection, and not very effective. A canal, about 2 miles long, brings the water at Bardonnêche to a height of 85 feet above the level of the machines. At each end there are ten machines of the kind about to be described. Each machine communicates by a pipe, 24 inches in diameter, with the reservoir of water above, as also with a wrought-iron vessel, of boiler shape, and about 610 cubic feet capacity, one being attached to each machine. The air is compressed up to 5 atmospheres above atmospheric pressure. The compressed air introduced into the reservoirs is kept at a constant pressure of 5 atmospheres by a water pipe from a reservoir with that pressure. A pipe, $7\frac{5}{8}$ inches diameter conveys the air from the reservoir to the tunnel. The joints of this pipe are very tight, being turned and a caoutchouc ring compressed in each. The pipes rest on rollers, carried on stone pillars, and expansion joints are introduced occasionally outside the tunnel, where the temperature is variable.

This system of compressing air (à coup de belier) is also established at Modane; but there was a further difficulty at that place, in not having water available at a sufficient pressure, although there was an abundant supply at a lower level. M. Sommeiller therefore carried out the singular idea of using the same machines as at Bardonnêche, to avoid the additional cost of constructing others of different dimensions, although in doing so he was obliged to erect a large cistern, near the machine house, 85 feet above the machines, as at the other end of the tunnel, and pump the water into it, for effecting the compressure, by means of water wheels, at a greatly increased cost of construction, complication of machinery, and loss of power—the more to be regretted as a subsequent introduction of pumps for compressing the air, worked direct from water-wheels, gave better results and were cheaper.

The system last introduced at Modane, consists of a horizontal pump, with a vertical branch at each end, worked by connecting rods from the cranks of a water wheel; two such pumps being worked by each wheel. The pump is $21\frac{3}{8}$ inches diameter, and the stroke 5 feet long, Each makes 12 strokes per minute, and each is capable of sending more air into the reservoirs than one of the other more complicated machines, and with a less expenditure of power. The piston is surrounded by water, which rises with each stroke of the piston, in the two vertical branches alternately; the variation of pressure, or resistance against the wheel, is very considerable, increasing, of course, towards the end of each stroke; a heavy fly-wheel is therefore placed inside each water-wheel. This system is obviously to be preferred to the other, in any application of machinery to be used for compressing air.

Such being a general description of the machinery, both for compressing air and for applying it to the advancement of the tunnel, the remainder of this Paper will be confined to statements of, and considerations on, the progress actually made, and to be expected, in comparison with that already made, under nearly similar circumstances, by hand labour,—the probable duration of the works,—the number of workmen employed,—and the principal points of an agreement made between France and Italy, on the acquisition of Savoy by the former country, when nearly half the section of the tunnel became French territory; but the Italian Government undertook the responsibility of finishing the whole of the works.

The Author has twice had the privilege of visiting the works on the Mont Cenis. The first time was in the autumn of 1860; the second was in July of 1863. At the date of his first visit, machines had not been applied at either end. The machinery was first applied at Bardonnèche, in the beginning of 1861, and at Modane on the 25th of January, 1863. As before stated, the tunnel was commenced by ordinary means in the beginning of 1858.

The following are the rates of progress in the advanced gallery:—

MODANE.

Hand labour.* From 1858 to end of 1862, 5 years, 1·655 feet per day.

Machine.† From January 25th, 1863, to June 30th, 1863, 156 days, but 153 working days only, advancement of 171·25 mètres = 1·119 mètres, or 3·686 feet per day.

BARDONNECHE.

Hand labour. From 1858 to end of 1860, 3 years, driving 724 mètres = ·6612 metre, or 2·148 feet per day.

On the introduction of machines in 1861, but little progress was made, owing to the breakage of compressing machinery (170 mètres about). In 1862 there was an advancement of 380 mètres = 1·040 mètre per day, or 3·411 feet per day.

The following notes of advance at Modane were copied from the shift book of the Mining Engineer, in which every detail relating to the progress made is entered, and afterwards tabulated:—

				Advancement per month.	Total length of Advanced Gallery completed.	
1863,	January	25th		..	921	mètres.
,,	,,	31st	(6 days)	4·43	925·43	,,
,,	Feb.	28th	(28 ,,)	23·31	948·74	,,
,,	March	31st	(31 ,,)	34·44	983·18	,,
,,	April	30th	(30 ,,)	31·42	1,014·60	,,
,,	May	31st	(31 ,,)	38·80	1,053·40	,,
,,	June	30th	(27 ,,)	38·85	1,092·25	,,

January and February apart, when the men were unaccustomed to the new work, it seems that the rate of progress was 1·206 mètre, or 3·953 feet per day, and taking June alone, 1·439 mètre, or 4·719 feet per day. In June there were 46 shifts; the mean progress per shift must then have been ·8445 mètre, or 2·769 feet. Comparing the progress made from 1858 to 1863 by hand labour (·5047 mètre per day), with that obtained during the entire time the machinery has worked (1·119 metre per day), the latter is in the proportion of 2·217 : 1. Or, what is fairer, considering the disadvantages the machines laboured under before the workmen were disciplined in their use, taking the progress in January and February apart, 1·206 mètre per day; the proportion is 2·389 : 1, and taking June only, 1·439 mètre per day 2·851 : 1, or nearly 3 to 1 at Modane.‡

The above progress was, both in the case of machine and manual labour, in a gallery 10 feet square, 11 machines being employed, of an aggregate force of 26½ H.P., estimated by the ordinary rule applied to steam engines.

PROBABLE DURATION OF WORK.—June 30th, 1863.

1,092·25	mètres had been pierced at Modane		
1,450·00	,,	,,	Bardonnèche
2,542·25	,,	in all	
9,677·75	,,	yet to complete	
12,220·00	mètres.—Total length of tunnel.		

Assuming the progress to be as in June last, at the rate of 1·439 mètre at each end, 9 years 2½ months will be required from June 30th, 1863. In view, however, of the greater facility with which the machines will be worked when the men are more habituated to them, and of better results when their power is increased, as is now proposed, and their construction and application simplified, although quite aware of the increased difficulties to contend with as the 'forehead' advances, the Author thinks it probable that an advance of 2 mètres per day will shortly be made at each end. A great delay is now caused by the length of time required to remove the 'déblais.' If indeed a system were introduced for removing the 'déblais *en masse*, instead of by small wagons, then 60 shifts might be worked per month, and 2 mètres would be a moderate estimate. That rate at each end would require 6 years 7 months only, compared with 26 years 3 months at the rate (·5047 mètre per day) made at Modane before machinery was introduced.

The advanced gallery is enlarged to full tunnel size, and walled by ordinary means. A conduit is made between the two lines of rail, for drainage.

Any favourable judgment on the results obtained at the Mont Cenis must be modified by the consideration of the enormous cost of establishing and working the present system at that place, as well as the large number of workmen required. Of the cost of the establishment it would be difficult to make even an approximate estimate. The machinery was nearly all made at Seraing, near Liége,

The expense of applying M. Sommeiller's system depends, necessarily, very much on local conditions. And although ignorant, as he has already said, of the cost of establishing and working it at Mont Cenis, the Author will endeavour to institute a rough comparison, between the cost of boring any large tunnel by machinery and by hand labour. In this he is greatly assisted, by having been able to obtain some information about the number of men employed under the present system, which he believes to be reliable. As first in importance the men in the tunnel will be enumerated. In the advanced gallery at Modane, the machinists work a shift of from 6 to 8 hours and are relieved by charges, who in turn are replaced by men to remove the 'déblais.' A second set of machinists follows the latter, but the same charges and labourers serve, their work not lasting long. There are therefore 2 sets of machinists, 1 set of charges, and 1 set of labourers, The machinists for 2 shifts amount to 88, or 44 per shift. The charges to 9 per set. The labourers for removing the déblais' to 30, making a total of 127 in the advanced gallery.

For enlarging the tunnel there are three sets of miners per twenty-four hours, and two sets of masons, all working eight hour shifts, in number amounting to 344, which added to 127 previously enumerated, makes a total of 471 employed underground. There are, however, stone-dressers, quarrymen, blacksmiths and labourers at the surface to be taken into account, increasing the number at the tunnel and entrance to 700. The establishment below, workshops, machinery, canals, &c., afford employment to about 240, and at the time of the Author's visit, as indeed nearly always, from 150 to 200 were employed as 'occasional:' total for Modane 1,140. The number was rather greater at Bardonnèche, from 1,200 to 1,400 being generally employed, giving a total of 2,540.

In making a comparison of the cost of driving an advanced gallery by machinery, and by hand labour, a judgment must not be altogether based upon the works and the results at Mont Cenis. There is no doubt that establishing, as M. Sommeiller has done, on so large a scale, an entirely new system, without experience in its use and application, many expenses have been incurred, that would be avoided hereafter.

The following comparison will, therefore, be general to any work on a sufficiently large scale to justify the adoption of machinery, rather than special to the Mont Cenis. The data are insufficient to enable the calculation to be made with accuracy, but it will be based on statements already made. It will be confined to mining charges only, *i.e.*, labour, tools, gunpowder, and candles. Removing the 'déblais' is common to both, as is also enlarging and walling the tunnel, and timbering the advanced gallery. The rate of progress of the gallery at Modane, which is ten feet square, will be taken into consideration; but the Author feels certain, that in a 7-feet gallery the machines would compare with hand labour to better advantage. Previous to the introduction of machinery the miners drove, on an average, 1·655 foot per day; 36 men in three shifts

* Referring to previous notes, the Author finds it mentioned that at the date of his first visit to Modane, twelve miners were constantly engaged in driving the advanced gallery; there were three sets, each working eight hours; at Bardonneche twenty miners per shift were so employed.

† The progress at Modane, since the introduction of machinery, seems better than at the other end. It must be remembered that it was only applied there two years after its introduction at Bardonneche, where the first and greatest difficulties consequent to applying new machines were to be contended with.

‡ In making these calculations three days are subtracted in June, in which the works were suspended during the Fete d'Italie. No allowance is, however, made for delays for repairing machinery, or air-pipes, during which the works have been suspended for a few hours occasionally.

of 12 men each being employed. This advancement would then cost—

36 miners at 2s. 6d.	£4	10	0
Tools, gunpowder, and light	1	10	0
Cost per day and per advancement of 1·655 foot	£6	0	0

or £10 17s. per yard.

It is hardly necessary that the Author should allude to the small portion of the total cost, of either advanced gallery or tunnel, expressed by 'mining charge.' To compare, in like manner the cost of driving the same gallery by machinery, it will be necessary to take—

1. The cost of motive power for compressing the air to drive the perforators.
2. The working charges of shops to repair the machinery, in excess of what would be required if no boring machines were used.
3. Men employed: mechanics, blacksmiths, &c., in such shops; as also engineers and stokers, and those to attend to air-pipes, water supply, engine for pumping water, &c.
4. Men employed during the machine shift.
5. Wear and tear of machinery, and many other incidental expenses, which in a fair comparison, would require full and careful considerations, and would vary according to local conditions.

The points on which this comparison is based are stated, to show how the proportional cost has been arrived at: the Author has only made it, in the hope that the attention of the members of the Institution may be drawn to its better consideration. As water power could only be obtained in exceptional cases, steam will be assumed as the motive power for compressing the air used for driving the boring machines. At the rate of driving practised last June, a mean progress of 2·769 feet per shift was made. The labour of miners and machinists would amount to £4 14s. 8d. per shift, and say, £3 10s. for gunpowder, tools, and light, amounting to £8 4s. 8d. per shift and advancement of 2·769 feet, or £8 18s. 4d. per yard. Eleven machines were used, expending in compressed air a power of 26½ horses at the end of the gallery. Each machine, however, requires a motive power in the system of compressing applied at Bardonnêche of 8 H.P.; but as they are not working continually, a constant power of 40 horses would be sufficient to supply them. Assuming that the motive power was steam, and that 4 tons of coal per day were consumed, at 10s. per ton, say £2, and the wages of engineers and stokers cost 15s. per day, there would then be for cost of motive power per day £2 15 0

About 240 men are now employed in the shops and about the machinery at Modane, say, this was reduced to 120, at 3s. per day	18	0	0
And calculate for steam power to drive machinery, &c., for coal and attendance per day	1	10	0
Wear and tear on machinery, say 20 per cent. on £20,000, say per day	5	10	0
Cost per day and per advancement of 4·719 feet . .	£27	15	0

Or £17 12s. 9d. per yard at the rate accomplished in June, 1863, which, added to the mining charge of £8 18s. 4d., would amount to £26 11s. 1d. per yard, as compared with £10 17s. by hand labour. From which it appears, so far as may be judged from so rough an estimate, that by machinery a progress three times as fast as by hand labour may be effected, but at two and a half times the cost. For mining charges, in the case of a gallery for mining purposes, the comparison might stop there; but not so in the case of a railway tunnel. For the enlarging, timbering, walling, and general charges are quantities common to both, and the proportion will be notably diminished when they are added. The estimated cost of making the Mont Cenis tunnel was £120 per mètre. It makes but little difference, therefore, whether the mining charge there is £10 or £23 per yard. The ultimate proportion of cost to put against an increased advancement of three to one, would thus, instead of being two and a half to one, not exceed £126 to £110, assuming the charges common to both systems to amount to £100 per yard, which, in the case of the Mont Cenis tunnel, they will not fail to do. In ordinary cases, to which the preceding comparisons are supposed to refer, rather than to the Mont Cenis, say in the case of a tunnel costing £30 per yard, which is perhaps not too much to assume for a tunnel of sufficient length to make it advisable to apply machinery, the comparison would naturally be more disadvantageous than in the Mont Cenis, where the general charges are so exceptionally high. Say, therefore, in the case of a tunnel to cost £30 per yard when completed, that £5 per yard was for mining charge in the advanced gallery, and £25 per yard for general charges. By applying machinery, the mining charge would be increased to £13 per yard; and the £25 per yard for general charges might be increased to £27 per yard, as air-pipes would not be required if machinery were not introduced; the proportion of cost would then stand as 40 : 30, which would not purchase at all dearly an advancement in the proportion of 3 to 1.

Although not prepared to go into an estimate, with any pretensions to accuracy, of the cost of establishing works on the scale assumed in the preceding comparison, the Author would mention £20,000 as the result of a rough calculation. He must again repeat, that this estimate does not refer to the Mont Cenis in particular. The improvements recently introduced, and the better results lately obtained, point to the conclusion, that an increased rate of progress may be looked for. M. Sommeiller has proposed several alterations, by which it is hoped to increase the actual rate of 1¼ mètre to 3 mètres at each end per day, with a less cost per yard than is now incurred, as the work will be done in the same time, and with nearly the same amount of labor. If these hopes are realized, an increase of six times the speed might be attained, without seriously increasing the cost. At such an averge rate from June 30, 1863, the work would be completed in four years and eight months and a half.

Without entering into calculations as to the amount of air required by any given number of men, and for the dilution of noxious gases arising from the combustion of gunpowder, it may be stated that the exhaust air from the perforators is adequate to the requirements of the advanced gallery. The greatest number of men employed there at one time is during the machine shift, when there are 44. During the charging and removing of the 'déblais' a jet of air is left open near the forehead. Each machine uses about 8 cubic feet per minute of compressed air=48 cubic feet at atmospheric pressure, and if eight machines are working together on an average throughout the shift, there will be a supply of 384 cubic feet per minute. But though in the advanced gallery the ventilation is sufficient, it is not so in the large gallery, as the miners and labourers, 250 mètres from the forehead, have been working for some time past in an extremely vitiated atmosphere, at a high temperature; and it is evident that a more efficient means of ventilation is required. Ample power is available for compressing air at the surface, and it could always be used as a means of supplying fresh air to any part of the tunnel; but the waste of power would be such as no engineer would be inclined to santion. Therefore separate means are being adopted, of the efficacy of which until the completion of the tunnel, no doubt can be entertained. The tunnel is to be divided horizontally by a brattice slightly arched. The upper section is about 75 square feet, and communicates with a chimney (by means of a brick conduit), placed 200 feet up the mountain side, near the entrance. The brattice at Bardonnêche is formed of planks, covered with 3 inches of soil, well beaten. The present draught is very strong, but the brattice is only finished for about one half the distance. If the natural draught should not be strong enough when the forehead advances, a furnace will be placed in the chimney. The air enters the tunnel on the underside of the brattice, passes up the entire length, and returns by the upper part.

Such are, in outline, the general observations the Author has been able to make upon an engineering work, which in magnitude is inferior perhaps to one only (Isthmus of Suez) in execution at the present day. He has been induced to prepare this communication, because he considers the attention of Engineers in this country has not been sufficiently drawn, either to the work, as a whole, or to the ingenious machinery used for its prosecution. Already with the short experience that has been gained in its use, the results are sufficiently satisfactory to show, that the system contains the elements of success—success which can only be developed and perfected like all the great inventions of the past and present age—by the untiring perseverance of those whose interest or ambition it is to devote themselves to its accomplishment, and by continually encountering and overcoming the many and great difficulties which oppose it. Attention must and will be drawn to it; for with the enterprise of this age, the necessity will be felt of improving the present system of tunnelling. That necessity right felt, the means will not be long in following.

(*To be continued.*)

THE HYDRAULIC LIFT GRAVING DOCK.*

By Edwin Clark, M. Inst. C.E.

(*Continued from page* 260.)

Mr. W. R. Kinipple had watched the progress of these pontoon docks with interest, and thought that great credit was due to the Author for the perfect way in which he had brought hydraulic lifts to bear so successfully upon such enormous weights. The pontoons were, however, somewhat defective, as it was impossible to render them perfectly rigid, without using such a quantity of material as would render them useless. When a pontoon was 300 feet in length, and only 6 feet in depth (which was in the proportion of only 1 to 50), to make it rigid so much metal must be inserted as to sacrifice altogether its floating powers. He remembered seeing one of the longest pontoons, which had, with a ship on it, a deflection of 7 inches or 8 inches out of the straight line. Reference had been made to the pontoon sunk at the London Docks, with which he had had to do. He believed the construction of that pontoon to have been perfect, although it had failed at present. The side girders were 180 feet long, 17 feet deep, and 3 feet wide. A ship might be put upon the deck between the girders without injury to her straight line. He attributed the sinking of that pontoon cheifly to the want of compartments and stiffeners to the bottom plates, between the cross girders, which were 8 feet apart. She was built like a long flat tea-board. The water went in at one end, and there was a consequent depression of that end. This caused an almost instantaneous rush and accumulation of water to one spot, the parallels gave way under the violent strain thereby produced, and the pontoon went down rapidly at one end, whilst the other was some hours in sinking. Pumping at the rate of 66 tons per minute, had not the slightest effect in reducing the water; and it was not until this great pumping power had been found useless, that forcing air down had been resorted to, when her deck was blown off. With regard to the pontoon docks in these two instances, it seemed to him a great waste of money to construct them in a tidal river, in order to do artificially, that which could be done naturally by the rise and fall of the tide. He had lately finished a dock at Limehouse called the Limekiln Dock; it was 355 feet long, 55 feet wide on the floor, 53 feet at the entrance, and 20 feet of water over the sill. The outer apron was laid in Portland cement, the entrance was of brick, the sides and bottom of timber and concrete, and the cost had been only £17,000. There were, at the present time, two vessels in that dock of the aggregate tonnage of 3,000 tons.

Mr. A. M. Rendel said, his responsibility in regard to the pontoon which was now lying at the bottom of the London Docks was small. Messrs. Rose and Crowder, who worked, for some time, the hydraulic lift at the Victoria Docks, proposed to the London Dock Company, to lease a part of the eastern dock, and to build a pontoon there on their principle. The proposal was referred to him; he reported favourably on it, and the pontoon was constructed. He heard nothing more of the matter till he was informed, that the pontoon had gone down head foremost to the bottom of the dock. On looking into the plan of the pontoon he found that it had no bulkheads; consequently, the water, when let into it, caused a violent oscillation; and the parallels, by which it should have been steadied, being constructed in a most inefficient manner, were torn from the ground, and the whole structure sank. The fact that the water could not be reduced by pumping led him to think that the caulking of the decks was blown out; he did not think there was a hole in her bottom. On the general subject he would say, there could be no question that the hydraulic lifts were very useful in their actual situation; but he was not prepared to admit their applicability to all docks. For instance, at the London Docks, he apprehended that land alone would cost about £40,000 per acre. He would mention that he had completed a dry dock at Leith, 400 feet long, 84 feet wide, with 24 feet 6 inches of water on the sill, the cost of which, including caisson, engine-house, pumps, and all complete, had been under £40,000. The engines worked up to 100 H.P., and were applied to a large Appold pump. So long as ordinary docks could be constructed at that cost, he did not think docks of the character under discussion would be again constructed in this country.

Mr. A. Giles thought many advantages would attend the application of this beautiful invention in ports such as London and Liverpool, and perhaps Hull; but, apart from those ports, he considered there were no others where docks upon this large scale were called for. There was one fact to be remarked, that when a vessel was placed upon this pontoon, she had the advantages of light and air which she could not have in an ordinary graving dock; at the same time the operation of lifting the vessel on the pontoon was attended, he thought, with certain disadvantages. In removing and replacing the boilers, he did not think the objection which had been stated applied, because the boilers were not generally put on board while the vessel was in a dry dock; at the same time, in matters of general repairs, it might be a disadvantage to have to raise materials to a height of 30 feet, or 40 feet, instead of their being supplied from the level of the deck. With regard to the shoring of ships on the pontoons, some merit was claimed for the absence of strain upon the ship, by the putting in of the bilge blocks. He did not know what there was to prevent the same sort of shores being used in ordinary dry docks. The fact, however, that bilge blocks were not used seemed to be good evidence that such shores were not wanted, and, during an experience of twenty years, in docking vessels of all sizes, up to 4,000 tons, he had never yet heard of an injury having arisen from the want of bilge blocks. The position of a vessel on bilge blocks was similar to that of a vessel on the beach, and there was great objection to the beaching of steam vessels from their liability to strain. He thought there must be some advantage in grounding upon the keel, and in putting in, when the ship touched the blocks, horizontal shores against the altars, for the purpose of keeping her upright on her keel. As the water was pumped out of the dock, raking shores were added. Comparing the statistics supplied by the Author with those of the Southampton Docks, it appeared that at the Victoria Docks 1,055 vessels of an aggregate tonnage of 712,380 tons had been docked by these lifts in seven years. At Southampton, during the last seven years, 693 vessels had been docked of an aggregate tonnage of 965,000 tons. The average tonnage of the vessels docked by the pontoon system was only 675 tons per ship, while the average of the vessels docked at Southampton was 1,400 tons per ship. With that experience, if no damage had been sustained from the absence of the bilge blocks, it might be safely inferred that they were not necessary. As to the cost of docking vessels, the Author had given it at £3 per vessel, for putting on the pontoon, pumping, and lifting; if that calculation was correct, the system at the Victoria Docks had a great advantage over that at Southampton in respect of the cost of docking. His experience was, and he could vouch for the correctness of the figures, that the total expense of docking including pumping, labour, and repairs was, on an average, £13 per ship, but that was for ships of double the average size of those docked by the Thames Graving Dock Company. It was evident that there must be some other element of expense which had not been reckoned. The charges for docking ships on the patent lift were about the same as at Southampton, viz., 6d. per ton for docking, and 1d. per ton per week for the use of the pontoon. For a 1,000 ton ship, the charge for docking at Southampton was £25, and the rate for the use of the dock was in about the same proportion as for the use of the pontoons. With those 965,000 tons docked at Southampton during the last seven years, the Company had earned £39,000 and the expenses had been about £8,000; the average amount paid by each ship being £55, and the expenses £13. If, therefore, the charges were practically the same in both cases, and the expenses so much less in the hydraulic lift system, how was it that the Company had been such a commercial failure? These figures, if correct, ought to have shown a good profit. With regard to the first cost of the hydraulic lift docks, it was stated to be £88,000; but it must be borne in mind that sum did not include the cost of land, engineering, patent rights, and other things, which were usually included in the capital cost. The capital of the Graving Dock Establishment at Southampton was taken at £150,000; but, he believed, interest had been charged to capital to swell it to that amount, for this was considerably beyond the actual cost of the docks. If, by the system under discussion, the sum of £88,000 gave a capability of docking seven ships at a time, he confessed that, by the ordinary system, with the same number of docks, it could not be done at the same price. He then explained a drawing showing the sections of two docks which he had lately constructed at Bow Creek. In the larger one, he had drawn the sections of two ships, one being the 'Warrior,' of 6,000 tons, and the other the paddle steamer 'Napoleon Third,' of 4,000 tons; neither vessel could be docked by the hydraulic lift as constructed. These docks were placed on a part of the Thames where the foundations were notoriously deep; the cost of the two docks, including coffer-dams, pumping- power, caissons, and everything complete, was £85,000. One was 400 feet long, with a 64 feet opening, and 24 feet of water, over the sill. The other was 300 feet long, 46 feet opening, and 21 feet of water over the sill. If he were asked to design a system of docks, one of which should accommodate vessels of 6,000 tons or 7,000 tons, and the others, vessels of smaller size, he believed he could build six or seven docks for £150,000; but if the hydraulic lift and seven pontoons, one of which should be capable of carrying the 'Warrior,' could be constructed for £88,000, that system would surpass any other he knew of in point of economy. A system of docks, sufficient for almost any port, comprising six docks of various sizes (the largest of which was capable of docking the 'Warrior'), including six acres of land, with pumps and every necessary appliance, could be completed for £150,000.

As to the capability of doing work in hydraulic docks compared with ordinary docks, the time occupied in lifting a ship had been given as twenty-five minutes. That could not, however, be meant to include the whole operation of putting a ship on the pontoon, lifting, and moving her into her berth; for he understood that, practically, the time actually occupied in preparing a ship for the pontoon, taking her lines, preparing the bilge blocks, floating her into position, sinking the pontoon, lifting the ship, and getting her into berth, occupied about four and a half hours; whilst the operation of undocking occupied about one hour and a half. If that were so, the capability of work on one lift (though there might be fourteen pontoons or fifteen pontoons), was limited. By

* Read before the Institution of Civil Engineers.

the ordinary system, one ship could be docked at each tide; but in the large dock at Southampton, which had been constructed twelve years, more had been accomplished. Upon one occasion, three large ships, each of more than 2,000 tons, required to be docked in a hurry; two were docked and undocked, and the third was docked and placed on the blocks between daylight and dark. He therefore believed the capability of that dock was almost as great as that of one lift.

Mr. John Heppel said, having had the advantage of being associated in the preparation of the plans for this work, a few words from him might not be out of place. He necessarily became intimately acquainted with all the mechanical details of the construction, and the considerations which led to the adoption of them. To this part of the question he proposed strictly to confine himself, leaving the commercial and general aspects of the case to those who were better qualified than himself to deal with them. In doing this, however, he might perhaps he anticipating what would be better left to the Author; but he could not help thinking, it would be satisfactory to that gentleman to know, that those who concurred with him so many years ago in the views which he took concurred with him still, and were able to give some reasons for that concurrence.

Many observations had been made as to the flexibility of the pontoons in connection with these operations; and great doubts had been expressed whether some disadvantages to the vessels raised did not result from this flexibility. This was a subject which was carefully discussed at the time the apparatus was designed, although no great point was made of it; for even if the pontoons had been rigid, he did not remember that either the Author or hinself thought any great harm would result. But a certain amount of flexibility appeared rather advantageous than otherwise, and he thought, reasons might be shown for it. It had been admitted, that if the vessel itself possessed the quality of rigidity in a sufficient degree, the rigidity of the pontoon became comparatively unimportant. He agreed in that view, and he thought, therefore, it was not necessary to say much about the raising of iron vessels, because it was known that all those vessels possessed such an amount of rigidity, that when once placed on the pontoon, however flexible the latter might be, the rigidity of the two together would prevent any deflection which could possibly be considered injurious. That being the case, he thought the small amount of flexibility the pontoon possessed was an advantage, because it acted upon every wedge and block as a spring to keep it fairly up to its work. In fact, as compared to a rigid floor, it stood in the same kind of relation as a spring mattress to a deal board.

A strong point was however made with respect to wooden vessels, and an instance was adduced of an old crazy vessel which had a considerable amount of 'hogging.' He would even admit, for the sake of argument, that it might be considered desirable to bring such a vessel to a straight keel, though he thought that was admitting a great deal; but if this was desirable, he could hardly conceive anything better calculated to straighten the keel, without injury, than the apparatus in question.

To follow the steps of the operation; the vessel came upon the lift, the keel blocks having been prepared approximately to correspond with the curve of the keel when afloat, the vessel, having taken the keel blocks, the lifting began. As this went on, the slight difference in the distribution of the force between the weight (which was more in the middle than at the ends) and the lifting force, which was uniformly distributed, produced an action tending to deflect the pontoon, to a certain extent, and that tended to bring the keel nearer to a straight line, and so far to accomplish the desideratum. If any strain, or symptom of strain manifested itself, this apparatus gave instant means of obviating it, because, by cutting off a pair of the presses, the lifting power might be brought to correspond with the distribution of the weight to be lifted; so that, by the time the vessel was lifted out of the water its keel might be, by a simple process of manipulating the presses, adjusted to any line required; and that was done not by any violent process, as in a dry dock, where the vessel would be left to settle at once to a straight line, but was effected by means that were always under the most perfect control. When the pontoon was lowered into the water, after having been emptied, the same thing which was done by manipulating the presses, might be done by letting in water in the required proportion into the compartments, by which the lifting power of the pontoon might be brought into perfect adjustment with the weight above it. Nothing was more calculated to deal with the requirements of the kind noticed than this apparatus; and if it were correct, as had been stated, that some vessels had suffered injury from deflection (and an instance had been given of a hogged vessel which when set afloat on the pontoon was found to be deflected the other way), he could not help thinking it must have been from some want of judicious management in the operation; because he could not conceive that anything inherent in the apparatus itself could lead to such a result; on the contrary, he thought the Author had claimed for the machinery, in this respect, less applicability to the requirements of the case than was due to it.

He would not go into the question of comparison between this mode of lifting vessels and the system pursued in dry docks, because everything that could be said on that subject had been already very clearly stated. The matter had been put in a very fair point of view, because a comparison had been drawn between pontoons of this kind and an equal number of graving docks. A few observations of a qualifying character had been added, but it was a fair comparison; and he understood it to be admitted, that a series of dry docks, equal in number to the pontoons of this lift, could not be established for the same amount of expenditure. With regard to floating docks, a great number of examples had been instanced. Those which could only accommodate one vessel at a time could not be put in comparison with the apparatus under discussion, in respect of the amount of accommodation. A model had been placed on the table, in which, by a system of railways and cradles, something like the same results were proposed to be accomplished as by the present apparatus. He was far from being disposed to say that the proposed was not a good one; but he thought, it must be obvious that dragging a vessel about upon cradles must expose it to greater strains than the smooth and easy way of dealing with it by the hydraulic lift. However, it might be said, with regard to such a lifting dock, it would be easy to use it in connection with pontoons, in the same way as the hydraulic lift; and in that case the Author of the Paper would be entitled to the credit of the most original and valuable portion of it; but even then it would be inferior. He spoke under correction; but he hardly imagined, that a floating dock of that kind, having equal lifting power with the hydraulic presses at the Victoria Docks, could weigh less than 2,000 tons. If his conjecture was correct, it was obvious, that for every vessel, large or small, lifted with that apparatus, a dead weight of 2,000 tons was being lifted with it, instead of less than 700 tons at a maximum, which was capable of reduction in proportion to the load to be raised. He therefore thought the floating dock, even in the best form, must be inferior, in respect of efficiency, and economy of power, to that which was now the subject of discussion.

There was one other point. It was admitted, that for a fixed water-level, the Hydraulic Lift was not an inconvenient apparatus; but it had been asserted that its use would be confined to exceptional cases. He only wished to draw attention to the fact, that in this case, there was a free choice between the Victoria Docks and the tideway of the Thames, and it was considered, on all accounts, more desirable to establish the graving dock in connection with the former, than with the latter, the greater facility of communication with the dock being considered of more value than the mechanical power derived from the tide, and he thought, that similar considerations would prevail in most cases where there was a similar choice. But if it were not so, and if the use, of this system was to be confined to cases of fixed, or nearly fixed water level, there would still be the Baltic, the Mediterranean, and nearly all the ports on the Pacific; and he thought, perhaps, the Author would be satisfied with that to begin with. He had recently seen this apparatus, and he was struck with the remarkably good condition in which it was kept. Every part was in good working order, and in charge of highly intelligent people. He thought the mechanical results had been such as to place the professional reputation of the inventor beyond all danger; and he hoped the commercial results that would follow would be such as to remunerate those individuals who had ventured to try, what was considered at the time, a very bold experiment.

Mr. J. B. Readman said, it must be acknowledged, that the thanks of the commercial community were due to the Author for this attempt to facilitate the raising of vessels in the port of London. Some years ago he placed a Paper before the Institution on the variety in direction of the different Metropolitan dry docks, and he was bound to say that the variety in direction, in reference to the tideway, was as greatly exemplified in the mode of construction of the various docks upon the Thames. Whether the Thames—a tidal river, which had hitherto done what was now attempted by means of this most ingenious apparatus—was the best site, remained to be proved by experience. Undoubtedly, a graving dock, at the end of the Victoria Docks, might have been drained by the action of the tide, and the dock might have been arranged as others had been on the Thames. Certainly the element of cost was one of great importance; but, he could not help thinking a comparison of the cost of this system with that of the docks at some of the outports where the formation was different to the valley of the Thames, must be to a great extent illusory. The former were artificial docks in all respects, but the geological formation of the districts was so different, as to afford a comparison on the question of expense with the Port of London, to which the system of the Author had been applied.

The Trafalgar Graving Dock, at the west end of Woolwich Dockyard, was constructed for the Admiralty, by the late Mr. James Walker, after the failure of a prior experiment, by Mr. Ranger, of a dock of concrete. That dock was never free from a percolation of water through the sand and natural substratum; and the invert blew up. With that experience before the designing of the present dock, it was natural that every care should be taken that the work should be sound. When he said the pit of that dock was 40 feet from the surface, it was clear it was not comparable with a dock like that of Sunderland, where the rock was so close to the surface, that the work involved did not commence before an amount had been expended which came to more than 30 per cent. or 40 per cent. of the total expenditure incurred in a case like that at Woolwich, where there was 9 feet of concrete, a floor of 18-inch brickwork set in pozzolana mortar, and an invert of solid granite 3 feet 6 inches thick. The entire surface of the dock was faced with granite.

The section of the dock was parallel to that of the 'Trafalgar,' a 120 gunship, and of course the work was carried out in the most costly manner. The early timber docks of London including the old Pitcher's Dock at Blackwall, which was subsequently rebuilt by the present owners (the Messrs. Soames), were built entirely of timber and of clay puddle. The bottom was piled, over the entire surface, the larger number of piles being placed in the direction of the line of the keel. The old Pitcher's Dock had failed in a similar way to that at Woolwich, from the hydrostatic pressure. Another reason why the comparison of cost would hardly hold good was, that almost all the London docks, with few exceptions, were dry docks in two senses of the word; they were not only dry when the gates were shut and the vessel was docked, but any amount of leakage which accumulated in the dock was drawn away at low water. There was never any attempt made to resist the hydrostatic pressure, but the water was led away to the engine-well and taken away by steam power; so that such docks as these were not comparable with the deep-water dock at the mouth of the Lea. He would say generally (having taken the trouble to classify these early docks, taking the internal capacity, the length, breadth, and depth, *i. e.*, the cubical contents), that he found the cost had been from 12s. to 15s. and £1 per yard cube of the internal sectional capacity of the dock, while the figures stated for the docks at Southampton would work out a cost of £1 17s. 6d. to £1 18s. 6d. per cubic yard of internal capacity, and the value of the dock at Woolwich was no less than £4. 10s. per yard cube. The dock at Boston, United States, by published documents, was about equivalent to the latter value. He thought if the eight pontoons at the Victoria Docks were assumed to represent eight timber docks of equivalent superficial dimensions by the depth, with the 18-feet draught over the hoisting gear, the result, taking the Author's figures of £80,000, would give a value for that capacity of something equivalent to the timber-dock value; that was to say, the eight docks, by the mean length and breadth given with the 3-feet above, would be worth about 12s. per cubic yard. If there had been an outlay there of double that sum, then the value would be double; and if, again, the outlay had been £200,000, the value would be 25s. per cubic yard. Taking the cheapest value, the comparison was not favourable to the Southampton Docks. There was an example at Sunderland, frequently quoted, in which he believed the value and the dimensions gave about 27s. 6d. per cubic yard of internal capacity. Some surprise had been expressed, that no notice had been made of the hydrostatic screw dock at New York: it was equally surprising, he thought, that no notice had been taken of the patent of John Evans, of New York, which was described, very minutely, in the first number of Weale's 'Quarterly Papers' in 1845, as consisting of a series of cylinders and presses, precisely similar in principle to the Bramah Press, and connected by vertical chains to the ends of the transverse beams, underneath the pontoon gridiron. When the enormous increase of the trade of the port of London was considered, and the efforts which had been made to develop the commerce, the thanks of the commercial community were due to the Author. He had, however, had one advantage which no other engineer, acting for a public Company, had previously possessed. The Victoria Docks was the first Company that obtained powers to construct graving docks. The old Wapping Dock Act contained clauses for graving docks, but the shipbuilding interest was too powerful in that day, and those clauses were struck out in every Dock Act afterwards. Whether a dock Company could build and repair ships with the same expedition as private builders, was another question; but he felt convinced, from the experience of some years, that that exclusive principle, together with the tyranny of trade unions amongst shipwrights, had, to a great extent, driven the old ship-building trade from the port of London. The late Mr. Duncan Dunbar had frequently told him, that on the Tyne and other outports, he could get his ships built, with lower masts and standing rigging, at the same price as that which he paid for the hull alone, in the port of London.

Mr. John Murray remarked, that in the discussion which had taken place, he considered they had not arrived at the full cost of this pontoon dock. Mr. Clark had given the expense of the excavations, the coffer-dams, and other details; but he had not alluded to the land occupied by the works—some 26 acres in extent, 16 of which were water, and ought to be added to the sum of £88,000. A comparison between this pontoon dock and ordinary dry docks of masonry or brickwork might fairly form a subject of discussion. He had ascertained the cost of graving docks in various parts of the country, which, combined with the information already given, might prove useful. Mr. Abernethy had stated that the average cost of the seven docks at Birkenhead and the two at Falmouth was about £14,000 or £15,000. The dock at Holyhead, constructed by Mr. Telford, cost £14,419; that at Dundee, £26,000; that at Belfast, in 1840, £19 362; and the dock built by himself at Sunderland, including pumps, engine, and enclosure, cost £16,185. Taking an average of the four docks, it amounted to £18,990. Those docks were all nearly of the same class, viz., from 240 feet to 320 feet long, and 70 feet across at the coping, and 36 feet at the bottom, and they were each capable of admitting two ordinary vessels, or one large ship. The dock of Sunderland had altars on the side, with a temporary end, so that it might be lengthened when required. Docks of this kind had been constructed, therefore, at an average cost of £18,000 to £20,000 each. They were all of good masonry and substantial workmanship. But in the port of Sunderland and on the River Tyne docks of a slighter description had been constructed, capable of holding one ship at a time, and at a cost of from £3,000 to £5,000. Besides these, the shipbuilders generally had floating docks alongside of their shipbuilding yards, into which vessels were brought for repairs. One of the earliest of these docks was an old gunbrig ship cut down for the purpose. The deck and upper works being taken away, moveable gates were placed across her stern, and she was thus changed into a floating dock. The shipbuilders had since constructed other floating docks in the ordinary manner. Docks of a better description, such as those at Liverpool, lined with granite and of a large size, had been constructed at a cost of from £25,000 to £50,000. Another class, capable of admitting men-of-war, had amounted to £100,000 and upwards. But in general a good graving dock of ordinary construction might be said to cost from £15,000 to £20,000, capable of admitting all ordinary vessels, and two at a time of the smaller class; and when once properly constructed they wanted no repairs, and therefore might be called permanent structures. He thought they might well be compared with floating pontoons, admitted separately into one entrance or receptacle, having a great amount of apparatus connected with it, liable to get out of order, and requiring much manipulation, which he considered a more costly affair than a substantial graving dock of the ordinary form.

Mr. G. B. Rennie said, in reference to a model, which he had placed on the table, that it represented the works constructed at Carthagena, and was designed for the purpose, after the vessels were lifted on the floating dock, of hauling them ashore by hydraulic presses, or on cradles. The ways were perfectly level, and the amount of power required to haul them on shore might be calculated on the consideration, that the launch-ways of a heavy vessel were made with an incline of $\frac{1}{2}$ inch on the foot, or 1 in 24: so that, about one twenty-fourth of the weight of the vessel had to be pulled by a hydraulic pump and portable ram. This was not altogether a new idea, for it was in operation at the present time at the arsenal of Pola, on the Adriatic, where there were four lines of horizontal ways, which were used for hauling the vessels on shore. He believed the largest vessel operated upon by this system, was the 'Kaiser,' a screw line-of-battle ship of 84 guns. The floating-dock at Pola was of wood.

With regard to the Hydraulic Lift Graving Dock, he had several times seen vessels lifted, and it seemed to be done with great ease, regularity, and apparent safety. He did not agree with the Author as regarded the flexible pontoons. It seemed to him, if there was flexibility in the pontoons, there must be a strain on the vessel; and it was always desirable to prevent undue strain, as far as possible. However strong a ship might be, there must be some extra strain if it had to support the pontoon in a horizontal position, instead of the pontoon supporting the vessel. With regard to bilge-blocks he might state that it was proposed to use them in the floating-docks at Carthagena and Ferrol. When those docks were designed it was also thought desirable, that breast-shores should be used; for where a heavy vessel began to rest on the keel blocks it was difficult, with 25 feet of water under her, to place the bilge-blocks properly to support the vessel and prevent canting. He hoped on a future occasion, when this work had been tried more fully, to describe it in a Paper, before the Institution.

Mr. Scamp exhibited three drawings. The first was a section of the hydraulic lift, provided with shoring-altars for supporting vessels with breast-shores, as in an ordinary dock, showing also a pontoon with shoring-altars, for shoring under a vessel's bilge, precisely as in an ordinary dock; and a midship section of the 'Himalaya,' with the breast-shores, &c., attached.

The second drawing represented an ordinary stone dock (that referred to by the Author in his Paper), showing half midship sections of the 'Bellerophon' and the 'Lord Warden.'

The third represented the side view of a ship, with gauge-marks parallel with the original straight line of keel, for ascertaining precisely the hogging or cambering of the vessel.

Referring to the first drawing, he stated that he considered, by the addition of shoring-altars attached to the lift, and shoring-altars attached to the pontoons, that vessels of the tonnage of the 'Himalaya,' in a sea-going state (4,000 tons), might be safely docked by the lifting-dock, with the additional precautions shown by the section. The shoring-altars attached to the lift were only required for about a third of the midship length of the ship, and only to each alternate column; and though he considered the breast-shores to be absolutely necessary, especially if employed in the war establishments of the Navy, yet no great strain would be brought against them, as it was obvious, that the centre of gravity of the load being placed precisely perpendicular over the centre of support on the keel-blocks, it was only necessary to employ the shores for precisely fitting the space between the sides of the ship and the abutment at the altars attached to the dock. The shoring-altars attached to the pontoons were not proposed to be continuous; but to extend to about a third of the midship section, in lengths of about 20 feet, and spaces of about the same lengths alternately, and it was proposed to attach them to such pontoons only as were required for vessels of more than 1,000 tons; vessels of less than that tonnage might be safely docked as at present. The breast-shores being carefully fixed (the keel being only just clear of the blocks), the dock should be lifted sufficiently for the keel to bear on all the blocks; in this position some of the blocks might be drawn under the bilges of large ships, or of those appearing to require them; for small vessels this operation at that time was not necessary. The pontoon might then be lifted, until the keel-blocks were out of the water, and the vessel might, then, be as completely shored, as in an ordinary dock; and such bilge-blocks might be added as might appear to be required. The vessel being completely secured on the pontoon, the breast-shores would be removed, and the vessel might be safely floated away from the dock on the pontoon to a shallow dock, as at the Victoria Docks, or to a wharf, or basin; or for executing extensive repairs, the pontoon might be grounded on a 'gridiron' at a basin wharf.

The docking duties in times of war, for Her Majesty's naval establishments, might be classed under three divisions:

1. Previous to the actual commencement of hostilities.
2. During an action.
3. After an action.

As regarded the preparations, probably every available vessel, certainly those provided with steam power, might have to be commissioned for the service; those already commissioned as well as those taken from the moorings—out of 'ordinary,' as it was called—might require to be docked; until a vessel was in dock, the time that she might require to be there could not be known. For that division of the docking duties, he considered the Hydraulic Lift Dock, with its ten pontoons, or fifteen pontoons, might prove an incalculable advantage, being equal to as many additional docks.

He thought this plan peculiarly adapted for the great naval establishments, particularly in time of war, when all the duties of those establishments had to be carried on with the greatest despatch, and with unerring accuracy, under great pressure. It might probably not be prudent to carry this system to the extent of dealing with ships of war of 10,000 tons, as proposed by the Author of the Paper some years ago, yet it was desirable that the Institution should give an opinion as to that proposition being carried into practice for vessels up to a certain class; he had suggested that vessels up to 4,000 tons, equipped and in a sea-going state, might safely be docked by the method proposed.

The system of shoring he had described was equally applicable to every form of graving dock. He had submitted the drawing of the two half midship sections, to show that the 'Bellerophon' did not require the bilge-blocks, but that the 'Lord-Warden' did require them to a certain extent. That form of support was the best in his experience, and it might be applied to the Hydraulic Lift Dock. It was a matter of great national importance, to determine whether the Author's method of docking ships for repairs, with the additional security proposed by him, was or was not applicable to the war establishments of Her Majesty's Navy; and for arriving at a sound conclusion he considered that the opinion of the members of this Institution could not fail to afford useful assistance.

There were three establishments which must be greatly taxed in event of war, Portsmouth, Devonport, and Malta. If, by a method of this kind, ships could be docked, and prepared to join the fleet again with great despatch, the advantage might be equal to almost double the number of ships; whereas if ships had to be kept waiting to be docked, the most disastrous consequences might be the result.

He would not hazard a positive opinion that the system of lifts and pontoons was not applicable to ships of a larger class than that which he had suggested (4,000 tons) but it should be borne in mind, that his suggestions had reference only to the war establishments of the navy; that vessels of the class proposed by him would not cause inconvenience in management; that to one vessel even of such tonnage, many below of smaller tonnage would have to be employed, and might have to be repaired; that the pontoons would not be unreasonably expensive, or occupy unreasonable space; that, for an establishment such as that at Portsmouth, the pontoons might pass from the basin, in which the vessel would be docked, to other basins less occupied; and if a method of the kind proposed should be adopted, the ordinary docks might not be wanted for small vessels, but would be generally available for such ships of the line as would be required to join the fleet with the utmost despatch, when the time for such duties might not admit of being measured by weeks or days, but by hours and minutes. It should be observed further, that vessels of large tonnage might require to be docked when light, and not in a sea-going state; for such cases 4,000 tons would represent a large class of line-of-battle ships.

It had been suggested that vessels 'hogged' or cambered should be put into dock on blocks, in a straight line, and that the keel of a 'hogged' or cambered vessel should fit itself to the straight line by its weight. In this opinion he did not concur, because when the vessel was again in the water and loaded, the original line of keel would certainly be formed. Three gauge marks should be put on the side of a vessel above the water line, parallel with the straight line of keel; these marks being measured from the water line, the amount of hogging or cambering might be ascertained with great facility, and the blocks on the dock might be thereby correctly adjusted.

He had given great attention to the Author's ingenious invention for many years past, with a view of ascertaining to what extent it might be usefully employed at some of the naval establishments; and recently he had given the subject a full and careful consideration. The result was what he had briefly explained and shown by the section, and this would, in his opinion, provide what he considered to be necessary, and what he had long desired to accomplish. The section was intended to convey the principle only, not the details of his proposition. He did not anticipate that the girders between the points of suspension would, necessarily, require to be increased in length.

Mr. Hawkshaw, Past President, remarked that this subject, like many others, resolved itself into comparisons of cost between graving docks of different kinds. The cost of a graving dock in one place could not, however, be compared with the cost of another, unless all the circumstances were known. There could be no doubt that the Author's invention, which he had so clearly described, was, as a mechanical apparatus, perfectly successful. It did that which he proposed it should do, and did it well, and machinery which lifted 2,000 tons could, probably, be made to lift 4,000 tons. But there was one remark to make upon that point, affecting the question of cost. Where a series of repairing docks was required for repairing vessels of different sizes, the access to the whole of which was to be by means of one lift, if the apparatus were to be made powerful enough to lift vessels like the 'Warrior,' the same apparatus would have to be used for lifting the smallest vessels. Admitting the apparatus, mechanically to be perfectly successful, there arose the question of cost. Now that question could not be usefully treated by comparing these docks with those of the Mersey, which were cut out of sandstone, or with docks in other places, where the circumstances might not be the same. It was difficult, therefore, to arrive at useful conclusions on this point. Still, there was in this case, what rarely happened in other cases, something like a guiding principle on the question of cost. With respect to the repairing docks, apart from the lifting dock, it was evident, that all that could be saved, was the difference of excavation in these docks compared with the amount of excavation in an ordinary graving dock, due to the difference of their respective depths, bearing in mind, that the repairing docks must be deep enough to float the pontoons laden with the weight of the ships. On the Author's plan, the cost of the gates was also saved. Against that saving there was to be set the cost of the pontoon. Now it did not at present appear that the saving in the repairing docks, adding the pontoon, could be much; in other words, the cost of the pontoon would probably, in many cases at all events, equal the cost of deeper excavation and the gates. In fact the cost of gates and of the deeper excavation and masonry might, in many cases, be less than the cost of the excavation and masonry for these repairing docks, including the cost of the pontoon. At all events, that was the form the calculation must assume. With regard to the lifting dock, it was evident the apparatus for lifting the ship, and the machinery of the rams and steam engines, would, generally speaking, be at least as costly as the cost of pumping apparatus, even in the case of a tideless sea. For in those situations the entrance to a lifting dock must be made deep enough, not only for the draught of the ship, but also for the additional depth of the pontoon, and of the girders beneath the pontoon. With regard to the question of economy, in cases where there was a large fall and rise of tide, as in the Severn, and where no pumping was consequently required, the ordinary graving dock would often be cheaper than the one under consideration. After all, the question of cost must be considered specially, having regard to all the circumstances in each separate case; and without going into the question in that form, no satisfactory decision could be arrived at.

Mr. F. W. Sheilds said, it would be most desirable to have the means of comparison with as many other docks of a different kind as possible; and with that view it occurred to him to describe a design he had recently made for a floating dock, and to give a few statistics about it which might be useful. It was a design for a dock 270 feet long and 65 feet wide, intended to lift sailing vessels of 2,500 tons, and the weight of wrought iron in it was calculated at 2,650 tons. In that design he did not claim any invention, as many such constructions had been made before; he had simply been guided by the best experience hitherto attained, and he had endeavoured to employ the materials in the most mechanical and economical way. It was natural to compare the system of that dock with the system of pontoons in the Author's dock, and the first point of comparison was the great difference in the depth of a dock of that nature and the depth of a pontoon which carried the vessel in the lifting dock system. The depth of the sides of the floating dock was 40 feet, while in the Victoria dock the depth of the pontoon was only from 5 feet to 7 feet; and if the ordinary girder rule were taken as an approximate guide, viz., that the deflection of each girder was as the square of its depth, there would be found such an enormous difference in rigidity as to make it evident that the Author had widely departed from the system hitherto in use, and had fully adopted the system of flexibility, instead of perfect rigidity. The first point to consider was, which of the two systems was most adapted for a vessel which was taken out of the water. There was no doubt that any system which would enable the vessel to assume perfectly the same position when out of water as she assumed when in the water, would be the most perfect system; but that was a difficult thing to attain in practice, and it was much to be doubted whether the system of flexibility in a pontoon would effect it: and it was difficult to say beforehand, what form the keel of a vessel would assume, if put upon a flexible platform. It had been said, that the line of the keel could be adjusted, by managing the pontoon properly, and that if the keel took a different shape from that which it had when the vessel was water-borne, it could be corrected and rectified by letting water in the different compartments of the pontoon. Now that appeared to be a delicate operation, and if through carelessness, or any other cause, the water happened to be let in the wrong compartment there might be serious results. On the other hand, with the system of a perfectly rigid dock bottom, the vessel would probably not be got perfectly into the same position in which she was when in the water; but an average result would be obtained, by bringing the keels of all vessels to a straight line when docked; and the line of keel would not be altered to such an extent as to be injurious, unless the ship were a very cranky one indeed; for that reason rigidity in the dock bottom was preferable, in practice, to the system of flexibility.

There was one other point which occurred to him, namely, that if a pontoon were sunk to the bottom of a dock independently of the hydraulic apparatus, then, when the water was simply pumped out of it, the vessel could be raised by the pontoon alone, without the intervention of the hydraulic lift; and thus it would also be possible to diminish the depth of the dock, as the space in the bottom of the lifting-dock, which was occupied by the cross girders, would not then be required. It seemed, at first sight, that it would be practicable to work a series of pontoons in that way, and that, as all the lifting apparatus would be thus dispensed with, it would be a simpler system; but he had no doubt, there were corresponding advantages which induced the adoption of the double system of lift and pontoons, and he mentioned the subject, in order to ask the Author to give some information upon it.

It had been said, rather in the way of objection to the system at the Victoria Docks, that it was commercially unsuccessful until the repairing shops were established. It seemed to him, with regard to such docks in London, that there was such an amount of competition from the graving docks, that if the Company did not afford the shipping public every possible convenience, they could hardly expect to get the amount of trade, which would be secured by rival establishments, and it was hardly fair to compare a dock in London without that accommodation for repairs, with a dock at Southampton, which was exposed to no opposition or rivalry, and which without a repairing establishment, might make a fair return on its capital; while a similar dock in London, where there was a great deal of opposition, would get little business.

Mr. Abernethy said, the question of economy had been dealt with only as regarded first cost; but the cost of working after construction must not be lost sight of, having regard to the various operations to be performed in graving docks. A common operation in a graving dock was the cutting of a vessel in two, and lengthening her. He would like to know how that operation could be performed upon a pontoon, more especially if it were flexible. There were several practical shipbuilders present, who would, no doubt, be able to give information as to the operations to be performed in the repairs of shipping, more particularly of steamers, and as to the advantages, or disadvantages which an ordinary graving dock had, as compared with the pontoon system.

Mr. G. H. Phipps said, it must be clear to all, that before approving of the description of dock which was the subject of discussion, they ought to be satisfied of its perfect mechanical efficiency. He could say, from several visits he had made to that dock, he was quite satisfied with its mechanical action, which was in all respects efficient and satisfactory; that the raising was done in a sufficiently short time; that the pontoons were readily floated into shallow water, and into their berths, and that the vessels were perfectly steady and firm upon the pontoons, whilst being repaired.

The next point he would touch upon was with regard to the effect, advantageous, or disadvantageous, of elasticity in the pontoon itself. He considered, that practically the elasticity was too minute to be of any consequence, either one way or the other, and this was proved by the absence of any ill effects on coppered vessels. The buckling up of the copper was a good indication of a vessel losing her sheer, or becoming 'hogged;' but no such effect had been detected, so far as he was informed; and therefore, the elasticity of the pontoon might be safely neglected in the consideration of this subject.

With regard to the comparison between this and other descriptions of graving docks, the only description of dock with which it could be fairly compared was that where the graving docks opened out of basins, wherein the water was maintained at the level of high water. No doubt the docks in the Thames— Pitcher's graving dock, and others of that class— were very cheaply constructed, but these were only suited to letting vessels in and out at particular states of the tide, and did not apply to the exigencies of the trade as it now existed. Taking a comparison between the hydraulic lift graving dock and docks of the ordinary kind entering out of basins, as above described, one of the advantages of this dock appeared to be the facility and economy, with which the docking accommodation could be increased. Supposing one ordinary graving dock to cost, in the above situation, about £45,000, and as a very full estimate, that a Hydraulic Lift Dock, with one large, pontoon, cost about the same money (in both cases dams, engines, and all other expenses being included), then, by the supply of one additional pontoon, with berth for the same, at an expenditure of, at the outside, not more than £15,000, the dock accommodation would be doubled, whereas, to do the same thing with the ordinary graving dock would cost £40,000, or double the original cost, less steam engines and pumps. He would conclude with a remark as to the larger amount of quay frontage which must be destroyed in the event of constructing six ordinary graving docks out of the main basin, as had been proposed. If the entrances averaged 60 feet in width, there would be a loss of no less than 480 feet of quay, which would evidently be a serious loss commercially.

(To be concluded in our next.)

RECENT PROGRESS OF SCIENCE.*

By W. R. Grove, F.R.S.,

President, British Association for the Advancement of Science, 1866-67.

(*Concluded from page* 256.)

I may perhaps be permitted to recal a forgotten experiment, which nearly a quarter of a century ago I showed at the London Institution, an experiment simple enough in itself, but which then seemed to me important from the consequences to be deduced from it, and the importance of which will be much better appreciated now than then.

A train of multiplying wheels ended with a small metallic wheel which, when the train was put in motion, revolved with extreme rapidity against the periphery of the next wheel, a wooden one. In the metallic wheel was placed a small piece of phosphorus, and as long as the wheels revolved, the phosphorus remained unchanged, but the moment the last wheel was stopped by moving a small lever attached to it, the phosphorus burst into flame. My object was to show that while motion of the mass continued, heat was not generated, but that when this was arrested, the force continuing to operate, the motion of the mass became heat in the particles. The experiment differed from that of Rumford's cannon-boring and Davy's friction of ice in showing that there was no heat while the motion was unresisted, but that the heat was in some way dependent on the motion being impeded or arrested. We have now become so accustomed to this view, that whenever we find motion resisted we look to heat, electricity, or some other force as the necessary and inevitable result.

It would be out of place here, and treating of matters too familiar to the bulk of my audience, to trace how, by the labours of Oersted, Seebeck, Faraday, Talbot, Daguerre, and others, the way has been prepared for the generalization now known as the correlation of forces or conservation of energy, while Davy, Rumford, Sequin, Mayer, Joule, Helmholtz, Thomson, and others (among whom I would not name myself, were it not that I may be misunderstood and supposed to have abandoned all claim to a share in the initiation of this, as I believe, important generalization) have carried on the work, and how, sometimes by independent and, as is commonly the case, nearly simultaneous deductions, sometimes by progressive and accumulated discoveries, the doctrine of the reciprocal interaction of the quantative relation, and of the necessary dependence of all the forces has, I think I may venture to say, been established.

If magnetism, be, as it is proved to be, connected with the other forces or affections of matter, if electrical currents always produce, as they are proved to do, lines of magnetic force, at right angles to their lines of action, magnetism must be cosmical, for where there is heat and light, there is electricity and consequently magnetism. Magnetism, then, must be cosmical and not merely terrestrial. Could we trace magnetism in other planets and suns as a force manifested in axial or meridional lines, *i.e.* in lines cutting at right angles the curves formed by their rotation round an axis, it would be a great step; but it is one hitherto unaccomplished. The apparent coincidences between the maxima and minima of solar spots, and the decennial or undecennial periods of terrestrial magnetic intensity, though only empirical at present, might tend to lead us to a knowledge of the connexion we are seeking; and the President of the Royal Society considers that an additional epoch of coincidence has arrived, making the fourth decennial period; but some doubt is

* Inaugural Address delivered at the Annual Meeting of the British Association, Nottingham, August, 1866.

thrown upon these coincidences by the magnetic observations made at the Greenwich Observatory. In a paper published in the 'Transactions of the Royal Society,' 1863, the Astronomer Royal says, speaking of results extending over seventeen years, there is no appearance of decennial cycle in the recurrence of great magnetic disturbances; and Mr. Glaisher last year, in the physical section of this Association, stated that after persevering examination he had been unable to trace any connexion between the magnetism of the earth and the spots on the sun.

Mr. Airy, however, in a more recent paper suggests that currents of magnetic force having reference to the solar hour are detected, and seem to produce vortices or circular disturbances, and he invites further co-operative observation on the subject, one of the highest interest, but at present remaining in great obscurity.

One of the most startling suggestions as to the consequences resulting from the dynamical theory of heat is that made by Mayer, that by the loss of *vis viva* occasioned by friction of the tidal waves, as well by their forming, as it were, a drag upon the earth's rotatory movement, the velocity of the earth's rotation must be gradually diminishing, and that thus, unless some undiscovered compensatory action exist, this rotation must ultimately cease, and changes hardly calculable take place in the solar system.

M. Delaunay considers that part of the acceleration of the moon's mean motion which is not at present accounted for by planetary disturbances, to be due to the gradual retardation of the earth's rotation; to which view, after an elaborate investigation, the Astronomer Royal has given his assent.

Another most interesting speculation of Mayer is that with which you are familiar, viz., that the heat of the sun is occasioned by friction or percussion of meteorites falling upon it: there are some difficulties, not perhaps insuperable, in this theory. Supposing such cosmical bodies to exist in sufficient numbers, they would, as they revolve round the sun, fall into it, not as an aërolite falls upon the earth directly by an intersection of orbits, but by the gradual reduction in size of the orbits, occasioned by a resisting medium; some portion of force would be lost, and heat generated in space by friction against such medium; when they arrive at the sun they would, assuming them, like the planets, to have revolved in the same direction, all impinge in a definite direction, and we might expect to see some symptoms of such in the sun's photosphere; but though this is in a constant state of motion, and the direction of these movements has been carefully investigated by Mr. Carrington and others, no such general direction is detected; and M. Faye, who some time ago wrote a paper pointing out many objections to the theory of solar heat being produced by the fall of meteoric bodies into the sun, has recently investigated the proper motions of sun-spots, and believes he has removed certain apparent anomalies and reduced their motions to a certain regularity in the motion of the photosphere, attributable to some general action arising from the internal mass of the sun.

It might be expected that comets, bodies so light and so easily deflected from their course, would show some symptoms of being acted on by gravitation, were such a number of bodies to exist in or near their paths as are presupposed in the mechanical theory of solar heat.

Assuming the undulatory theory of light to be true, and that the motion which constitutes light is transmitted across the interplanetary spaces by a highly elastic ether, then, unless this motion is confined to one direction, unless there be no interference, unless there be no viscosity, as it is now termed, in the medium, and consequently no friction, light must lose something in its progress from distant luminous bodies, that is to say, must lose something as light; for, as all reflecting minds are now convinced that force cannot be annihilated, the force is not lost, but its mode of action is changed. If light, then, is lost as light (and the observations of Struvé seem to show this to be so, that, in fact, a star may be so far distant that it can never be seen in consequence of its luminous emissions becoming extinct), what becomes of the transmitted force lost as light, but existing in some other form? So with heat: our sun, our earth, and planets are constantly radiating heat into space, so in all probability are the other suns, the stars, and their attendant planets. What becomes of the heat thus radiated into space? If the universe have no limit, and it is difficult to conceive one, there is a constant evolution of heat and light; and yet more is given off than is received by each cosmical body, for otherwise night would be as light and as warm as day. What becomes of the enormous force thus apparently non-recurrent in the same form? Does it return as palpable motion? Does it move or contribute to move suns and planets? and can it be conceived as a force similar to that which Newton speculated on as universally repulsive and capable of being substituted for universal attraction? We are in no position at present to answer such questions as these; but I know of no problem in celestial dynamics more deeply interesting than this, and we may be no further removed from its solution than the predecessors of Newton were from the simple dynamical relation of matter to matter which that potent intellect detected and demonstrated.

Passing from extra terrestrial theories to the narrower field of molecular physics, we find the doctrine of correlation of forces steadily making its way. In the Bakerian Lecture for 1863 Mr. Sorby shows, not perhaps a direct correlation of mechanical and chemical forces, but that when, either by solution or by chemical action, a change in volume of the resulting substance as compared with that of its separate constituents is effected, the action of pressure retards or promotes the change, according as the substance formed would occupy a larger or a smaller space than that occupied by its separate constituents; the application of these experiments to geological inquiries as to subterranean changes which may have taken place under great pressure, is obvious, and we may expect to form compounds under artificial compression which cannot be found under normal pressure.

In a practical point of view the power of converting one mode of force into another is of the highest importance, and with reference to a subject which at present, somewhat prematurely perhaps, occupies men's minds, viz., the prospective exhaustion of our coal-fields, there is every encouragement derivable from the knowledge that we can at will produce heat by the expenditure of other forces; but, more than that, we may probably be enabled to absorb or store up as it were diffused energy—for instance, Berthelot has found that the potential energy of formate of potash is much greater than that of its proximate constituents, caustic potash and carbonic oxide. This change may take place spontaneously and at ordinary temperatures and by such change carbonic oxide becomes, so to speak, re-invested with the amount of potential energy which its carbon possessed before uniting with oxygen, or, in other words, the carbonic oxide is raised as a force-possessor to the place of carbon by the direct absorption or conversion of heat from surrounding matter.

Here we have as to force-absorption, an analogous result to that of the formation of coal from carbonic acid and water; and though this is a mere illustration, and may never become economical on a large scale, still it and similar examples may calm apprehension as to future means of supplying heat, should our present fuel become exhausted. As the sun's force, spent in times long past, is now returned to us from the coal which was formed by that light and heat, so the sun's rays, which are daily wasted, as far as we are concerned, on the sandy deserts of Africa, may hereafter, by chemical or mechanical means, be made to light and warm the habitations of the denizens of colder regions. The tidal wave is, again, a large reservoir of force hitherto almost unused.

The valuable researches of Prof. Tyndall on radiant heat afford many instances of the power of localizing, if the term be permitted, heat which would otherwise be dissipated.

The discoveries of Graham, by which atmospheric air, drawn through films of caoutchouc, leaves behind half its nitrogen, or, in other words, becomes richer by half in oxygen, and hence has a much increased potential energy, not only show a most remarkable instance of physical molecular action, merging into chemical, but afford us indications of means of storing up force, much of the force used in working the aspirator being capable at any period, however remote, of being evolved by burning the oxygen with a combustible.

What changes may take place in our modes of applying force before the coal-fields are exhausted it is impossible to predict. Even guesses at the probable period of their exhaustion are uncertain. There is a tendency to substitute for smelting in metallurgic processes, liquid chemical action, which of course has the effect of saving fuel; and the waste of fuel in ordinary operations is enormous, and can be much economized by already known processes. It is true that we are, at present, far from seeing a practical mode of replacing that granary of force the coal-fields; but we may with confidence rely on invention being in this case, as in others, born of necessity, when the necessity arises.

I will not further pursue this subject; at a time when science and civilization cannot prevent large tracts of country being irrigated by human blood in ordinary to gratify the ambition of a few restless men, it seems an over-refined sensibility to occupy ourselves with providing means for our descendants in the tenth generation to warm their dwellings or propel their locomotives.

Two very remarkable applications of the convertibility of force have been recently attained by the experiments of Mr. Wilde and Mr. Holtz: the former finds that, by conveying electricity from the coils of a magneto-electric machine to an electro-magnet, a considerable increase of electrical power may be attained, and by applying this as a magneto-electric machine to a second, and in turn to a third electro-magnetic apparatus, the force is largely augmented. Of course, to produce this increase, more mechanical force must be used at each step to work the magneto-electric machines; but provided this be supplied there hardly seems a limit to the extent to which mechanical may be converted into electrical force.

Mr. Holtz has contrived a Franklinic electrical machine, in which a similar principle is manifested. A varnished glass plate is made to revolve in close proximity to another plate having two or more pieces of card attached, which are electrified by a bit of rubbed glass or ebonite; the moment this is effected a resistance is felt by the operator who turns the handle of the machine, and the slight temporary electrization of the card converts into a continuous flood of intense electricity the force supplied by the arm of the operator.

These results offer great promise of extended application; they show that, by a mere formal disposition of matter, one force can be converted into another, and that not to the limited extent hitherto attained, but to an extent co-ordinate, or nearly so, with the increased initial force, so that, by a mere change in the arrangement of apparatus, a means of absorbing and again eliminating in a new form a given force may be obtained to an indefinite extent. As we may, in a not very distant future, need, for the daily uses of mankind, heat, light, and mechanical force, and find our present resources exhausted, the more we can invent new modes of conversion of forces, the more prospect we have of practically supplying such want. It is but a month from this time that the greatest triumph of force-conversation has been attained. The chemical action generated by a little salt water on a few pieces of zinc will now enable us to converse with inhabitants of the opposite hemisphere of this planet, the Atlantic Telegraph is an accomplished fact.

* * * * * * *

The facts made known to us by geological inquiries, while on the one hand they afford striking evidence of continuity, on the other, by the breaks in the record, may be used as arguments against it. The great question once was, whether these chasms represent sudden changes in the formation of the earth's crust, or whether they arise from dislocations occasioned since the original depositions of strata or from gradual shifting of the areas of submergence. Few geologists of the present day would, I imagine, not adopt the latter alternative. Then comes a second question, whether, when the geological formation is of a continuous character, the different characters of the fossils represent absolutely permanent varieties, or may be explained by gradual modifying charges.

Prof. Ansted, summing up the evidence on this head as applied to one division of stratified rocks, writes as follows:—"Palæontologists have endeavoured to separate the Lias into a number of subdivisions, by the Ammonites, groups of species of those shells being characteristic of different zones. The evidence on this point rests on the assumption of specific differences being indicated by permanent modifications of the structure of the shell. But it is quite possible that these may mean nothing more than would be due to some change in the conditions of existence. Except between the Marlstone and the Upper Lias there is really no Palæontological break, in the proper sense of the words; alterations of form and size consequent on the occurrence of circumstances more or less favourable, migration of species, and other well-known causes, sufficiently account for many of those modifications of the form of the shell that have been taken as specific marks. This view is strengthened by the fact that other shells and other organisms generally show no proof of a break of any importance except at the point already alluded to."

But, irrespectively of another deficiency in the geological record, which will be noticed presently, the physical breaks in the stratification make it next to impossible to fairly trace the order of succession of organisms by the evidence afforded by their fossil remains. Thus there are nine great breaks in the Palæozoic series, four in the Secondary, and one in the Tertiary, besides those between Palæozoic and Secondary, and Secondary and Tertiary respectively. Thus in England there are sixteen important breaks in the succession of strata, together with a number of less important interruptions. But although these breaks exist, we find pervading the works of many geologists a belief, resulting from the evidence presented to their minds, sometimes avowed, sometimes unconsciously implied, that the succession of species bears some definite relation to the succession of strata. Thus Professor Ramsay says that "in cases of superposition of fossiliferous strata, in proportion as the species are more or less continuous, that is to say, as the break in the succession of life is partial or complete, so was the time that elapsed between the close of the lower and the commencement of the upper strata a shorter or a longer interval. The break in life may be indicated not only by a difference in species, but yet more importantly by the absence of older and appearance of newer allied or unallied genera."

Indications of the connexion between cosmical studies and geological researches are dawning on us: there is, for instance, some reason to believe that we can trace many geological phenomena to our varying rotation round the sun; thus, more than thirty years ago Sir J. Herschel proposed an explanation of the changes of climate on the earth's surface as evidenced by geological phenomena, founded on the changes of excentricity in the earth's orbit.

He said he had entered on the subject "impressed with the magnificence of that view of geological revolutions which regards them rather as regular and necessary efforts of great and general causes, than as resulting from a series of convulsions and catastrophes regulated by no laws and reducible to no fixed principles."

As the mean distance of the earth from the sun is nearly invariable, it would seem at first sight that the mean annual supply of light and heat received by the earth would also be invariable; but according to his calculations it is inversely proportional to the minor axis of the orbit: this would give less heat when the excentricity of the earth's orbit is approaching towards or at its minimum. Mr. Croll has recently shown reason to believe that the climate, at all events in the circumpolar and temperate zones of the earth, would depend on whether the winter of a given region occurred when the earth at its period of greatest excentricity was in aphelion or perihelion—if the former, the annual average of temperature would be lower; if the latter, it would be higher than when the excentricity of the earth's orbit were less or approached more nearly to a circle. He calculates the difference in the amount of heat at the period of maximum excentricity of the earth's orbit to be as nineteen to twenty-six, according as the winter would take place when the earth was in aphelion or in perihelion. His reason may be briefly stated thus: assuming the mean annual heat to be the same, whatever the excentricity of orbit, yet if the extremes of heat and cold in winter and summer be greater, a colder climate will prevail, for there will be more snow and ice accumulated in the cold winter than the hot summer can melt, a result produced by the vapour (aided by the shelter from the sun's rays) suspended in consequence of the aqueous evaporation; hence we should get glacial periods, when the orbit of the earth is at its greatest excentricity, at those parts of the earth's surface where it is winter when the earth is in aphelion; carboniferous or hot periods where it is winter in perihelion; and normal or temperate periods when the excentricity of orbits is at a minimum; all these would gradually slide into each other, and would produce at long distant periods alternations of cold and heat, several of which we actually observe in geological records.

If this theory be borne out, we should approximate to a test of the time which has elapsed between different geological epochs. Mr. Croll's computation of this would make it certainly not less than 100,000 years since the last glacial epoch, a time not very long in geological chronology—probably it is much more.

When we compare with the old theories of the earth, by which the apparent changes on its surface were accounted for by convulsions and cataclysms, the modern view inaugurated by Lyell, your former President, and now, if not wholly, at all events to a great extent adopted, it seems strange that the referring past changes to similar causes to those which are now in operation should have remained uninvestigated until the present century; but with this, as with other branches of knowledge, the most simple is frequently the latest view which occurs to the mind. It is much more easy to invent a *Deux ex machina* than to trace out the influence of slow continuous change; the love of the marvellous is so much more attractive than the patient investigation of truth, that we find it to have prevailed almost universally in the early stages of science.

In astronomy we had crystal spheres, cycles, and epicycles; in chemistry the philosopher's stone, the elixir vitæ, the archæus or stomach demon, and phlogiston; in electricity the notion that amber possessed a soul, and that a mysterious fluid could knock down a steeple. In geology a deluge or a volcano was supplied. In Palæontology a new race was created whenever theory required it: how such new races began, the theorists did not stop to inquire.

* * * * * * * *

The records of life on the globe may have been destroyed by the fusion of the rocks, which would otherwise have preserved them, or by crystallization after hydrothermal action. The earlier forms may have existed at a period when this planet was in course of formation, or being segregated or detached from other worlds or systems. We have not evidence enough to speculate on the subject, but by time and patience we may acquire it.

Were all the forms which have existed, embalmed in rock, the question would be solved; but what a small proportion of extinct forms is so preserved, and must be, if we consider the circumstances necessary to fossilize organic remains. On the dry land, unwashed by rivers and seas, when an animal or plant dies, it undergoes chemical decomposition which changes its form; it is consumed by insects, its skeleton is oxidized and crumbles into dust. Of the myriads of animals and vegetables which annually perish, we find hardly an instance of a relic so preserved as to be likely to become a permanent fossil. So again in the deeper parts of the ocean, or of the larger lakes, the few fish there are perish and their remains sink to the bottom, and are there frequently consumed by other marine or lacustrine organisms or chemically decomposed. As a general rule, it is only when the remains are silted up by marine, fluviatile or lacustrine sediments that the remains are preserved. Geology therefore might be expected to keep for us such organic remains only as were likely to inhabit deltas or the margins of seas, lakes, or rivers; here and there an exception may occur, but the mass of preserved relics would be those of creatures so situated; and so we find it, the bulk of fossil remains consists of fish and amphibia, shell-fish form the major part of the geological museum, limestone and chalk rocks frequently consisting of little else than a congeries of fossil shells. Plants of reed or rush-like character, fish which are capable of inhabiting shallow waters, and saurian animals form another large portion of geological remains.

Compare the shell-fish and amphibia of existing organisms with the other forms, and what a small proportion they supply; compare the shell fish and amphibia of Palæontology with the other forms, and what an overwhelming majority they yield.

There is nothing, as Prof. Huxley has remarked, like an extinct order of birds or mammals, only a few isolated instances. It may be said the ancient world possessed a larger proportion of fish and amphibia, and was more suited to their existence. I see no reason for believing this, at least to anything like the extent contended for; the fauna and flora now in course of being preserved for future ages would give the same idea to our successors.

Crowded as Europe is with cattle, birds, insects, &c., how few are geologically preserved! while the muddy or sandy margins of the ocean, the estuaries, and deltas are yearly accumulating numerous crustacea and mollusca, with some fishes and reptiles for the study of future Palæontologists.

If this position be right, then, notwithstanding the immense number of preserved fossils, there must have lived an immeasurably larger number of unpreserved organic beings, so that the chance of filling up the missing links, except in occasional instances is very slight. Yet where circumstances have remained suitable for their preservation, many closely connected species are preserved—in other words, while the intermediate types in certain cases are lost, in others they exist. The opponents of continuity lay all stress on the lost and none on the existing links.

But there is another difficulty in the way of tracing a given organism to its parent form, which, from our conventional mode of tracing genealogies, is never looked upon its proper light.

Where are we to look for the remote ancestor of a given form? Each of us, supposing none of our progenitors to have intermarried with relatives, would have had at or about the period of the Norman Conquest upwards of a hundred million direct ancestors of that generation, and if we add the intermediate ancestors double that number. As each individual has a male and female parent, we have only to multiply by two for each thirty years, the average duration of a generation, and it will give the above result.

Let any one assume that one of his ancestors at the time of the Norman Conquest was a Moor, another a Celt, and a third a Laplander, and that these three were preserved while all the others were lost, he would never recognise either of them as his ancestor, he would only have the one-hundred millionth of the blood of each of them, and as far as they were concerned there would be no perceptible sign of identity of race.

But the problem is more complex than that which I have stated; at the time of the Conquest there were hardly a hundred million people in Europe, it follows that a great number of the ancestors of the *propositus* must have intermarried with relations, and then the pedigree, going back to the time of the Conquest, instead of being represented by diverging lines, would form a network so tangled that no skill could unravel it; the law of probabilities would indicate that any two people in the same country, taken at hazard, would not have many generations to go back before they would find a common ancestor, who probably, could they have seen him or her in the life, had no traceable resemblance to either of them. Thus two animals of a very different form, and of what would be termed very different species, might have a common geological ancestor, and yet the skill of no comparative anatomist could trace the descent.

From the long continued conventional habit of tracing pedigrees through the male ancestor, we forget in talking of progenitors that each individual has a mother as well as a father, and there is no reason to suppose that he has in him less of the blood of the one than of the other.

The recent discoveries in Palæontology show us that man existed on this planet at an epoch far anterior to that commonly assigned to him. The instruments connected with human remains, and indisputably the work of human hands, show that to these remote periods the term civilisation could hardly be applied—chipped flints of the rudest construction, probably, in the earlier cases, fabricated by holding an amorphous flint in the hand and chipping off portions of it by striking it against a larger stone or rock; then, as time suggested improvements, it would be more carefully shaped, and another stone used as a tool; then (at what intervals we can hardly guess) it would be ground, than roughly polished, and so on—subsequently bronze weapons, and, nearly the last before we come to historical periods, iron. Such an apparently simple invention as a wheel must, in all probability, have been far subsequent to the rude hunting tools or weapons of war to which I have alluded.

A little step-by-step reasoning will convince the unprejudiced that what we call civilisation must have been a gradual process; can it be supposed that the inhabitants of Central America or of Egypt suddenly, and what is called instinctively, built their cities, carved and ornamented their monuments? If not, if they must have learned to construct such erections, did it not take time to acquire such learning, to invent tools as occasion required, contrivances to raise weights, rules or laws by which men acted in concert to effect the design? Did not all this require time? and if, as the evidence of historical times shows, invention marches with a geometrical progression, how slow must have been the earlier steps! If even now habit, and prejudice resulting therefrom, vested interests, &c., retard for some time the general application of a new invention, what must have been the degree of retardation among the comparatively uneducated beings which then existed?

I have, of course, been able to indicate only a few of the broad arguments on this most interesting subject; for detailed results the works of Darwin, Hooker, Huxley, Carpenter, Lyell, and others must be examined. If I appear to lean to the view that the successive changes in organic beings do not take place by sudden leaps, it is, I believe, from no want of an impartial feeling; but if the facts are stronger in favour of one theory than another, it would be an affectation of impartiality to make the balance appear equipoised.

The prejudices of education and associations with the past are against this as against all new views; and while on the one hand a theory is not to be accepted because it is new and *primâ facie* plausible, still, to this assembly I need not say that its running counter to existing opinions is not necessarily a reason for its rejection; the *onus probandi* should rest on those who advance a new view, but the degree of proof must differ with the nature of the subject. The fair question is, Does the newly proposed view remove more difficulties, require fewer assumptions, and present more consistency with observed facts than that which it seeks to supersede? if so, the philosopher will adopt it, and the world will follow the philosopher—after many days. It must be borne in mind that even if we are satisfied from a persevering and impartial inquiry that organic forms have varied indefinitely in time, the *causa causans* of these changes is not explained by our researches; if it be admitted that we find no evidence of amorphous matter suddenly changed into complex structure, still why matters should be endowed with the plasticity by which it slowly acquires modified structure is unexplained. If we assume that natural selection, or the struggle for existence, coupled with the tendency of like to reproduce like, gives rise to various organic changes, still our researches are at present uninstructive as to why like should produce like, why acquired characteristics in the parent should be reproduced in the offspring. Reproduction itself is still an enigma, and this great question may involve deeper thoughts than it would be suitable to enter upon now.

Perhaps the most convincing argument in favour of continuity which could be presented to a doubting mind would be the difficulty it would feel in representing to itself any *per saltum* act of nature. Who would not be astonished at beholding an oak tree spring up in a day, and not from seed or shoot? We are forced by experience, though often unconsciously, to believe in continuity as to all effects now taking place; if any one of them be anomalous, we endeavour, by tracing its history and concomitant circumstances, to find its cause, *i. e.* to relate it to antecedent phenomena; are we then to reject similar inquiries as to the past? is it laudable to seek an explanation of present changes by observation, experiment, and analogy, and yet reprehensible to apply the same mode of investigation to the past history of the earth and of the organic remains embalmed in it?

If we disbelieve in sudden creations of matter or force, in the sudden formations of complex organisms now, if we now assign to the heat of the sun an action enabling vegetables to live by assimilating gases and amorphous earths into growing structures, why should such effects not have taken place in earlier periods of the world's history, when the sun shone as now, and when the same materials existed for his rays to fall upon?

If we are satisfied that continuity is a law of nature, the true expression of the action of Almighty Power, then, though we may humbly confess our inability to explain why matter is impressed with this gradual tendency to structural formation, we should cease to look for special interventions of creative power in changes which are difficult to understand, because, being removed from us in time, their concomitants are lost; we should endeavour from the relics to evoke their history, and when we find a gap not try to bridge it over with a miracle.

If it be true that continuity pervades all physical phenomena, the doctrine applied by Cuvier to the relations of the different parts of an animal to each other might be capable of great extension. All the phenomena of inorganic and organised matter might be expected to be so inter-related that the study of an isolated phenomenon would lead to a knowledge of numerous other phenomena with which it is connected. As the antiquary deduces from a monolith the tools, the arts, the habits, and epoch of those by whom it is wrought, so the student of science may deduce from a spark of electricity or a ray of light the source whence it is generated; and by similar processes of reasoning other phenomena hitherto unknown may be deduced from their probable relation with the known. But, as with light, heat, magnetism, and electricity, though we may study the phenomena to which these names have been given, and their mutual relations, we know nothing of what they are; so, whether we adopt the view of natural selection, of effort, of plasticity, &c., we know not why organisms should have this *nisus formativus*, or why the acquired habit or exceptional quality of the individual should re-appear in the offspring.

Philosophy ought to have no likes or dislikes, truth is her only aim; but if a glow of admiration be permitted to a physical inquirer, to my mind a far more exquisite sense of the beautiful is conveyed by the orderly development, by the necessary interrelation and inter-action of each element of the cosmos, and by the conviction that a bullet falling to the ground changes the dynamical conditions of the universe, than can be conveyed by mysteries, by convulsions, or by cataclysms.

The sense of understanding is to the educated more gratifying than the love of the marvellous, though the latter need never be wanting to the nature-seeker.

But the doctrine of continuity is not solely applicable to physical inquiries.

The same modes of thought which lead us to see continuity in the field of the microscope as in the universe, in infinity downwards as in infinity upwards, will lead us to see it in the history of our own race; the revolutionary ideas of the so-called natural rights of man, and *a priori* reasoning from what are termed first principles, are far more unsound and give us far less ground for improvement of the race than the study of the gradual progressive changes arising from changed circumstances, changed wants, changed habits. Our language, our social institutions, our laws, the constitution of which we are proud, are the growth of time, the product of slow adaptations, resulting from continuous struggles. Happily in this country, though our philosophical writers do not always recognise it, practical experience has taught us to improve rather than to remodel; we follow the law of nature and avoid cataclysms.

The superiority of man over other animals inhabiting this planet, of civilized over savage man, and of the more civilized over the less civilized, is proportioned to the extent which his thought can grasp of the past and of the future. His memory reaches further back, his capability of prediction reaches further forward, in proportion as his knowledge increases. He has not only personal memory which brings to his mind at will the events of his individual life,—he has history, the memory of the race; he has geology, the history of the planet; he has astronomy, the geology of other worlds. Whence does the conviction to which I have alluded, that each material form bears in itself the records of its past history, arise? Is it not from the belief in continuity? Does not the worn hollow on the rock record the action of the tide, its stratified layers the slow deposition by which it was formed, the organic remains imbedded in it the beings living at the times these layers were deposited, so that from a fragment of stone we can get the history of a period myriads of years ago? From a fragment of bronze we may get the history of our race at a period antecedent to tradition. As science advances our power of reading this history improves and is extended. Saturn's ring may help us to a knowledge of how our solar system developed itself, for it as surely contains that history as the rock contains the record of its own formation.

By this patient investigation how much have we already learned, which the most civilized of ancient human races ignored! While in ethics, in politics, in poetry, in sculpture, in painting, we have scarcely, if at all, advanced beyond the highest intellects of ancient Greece or Italy, how great are the steps we have made in physical science and its applications!

But how much more may we not expect to know?

We, Ephemera as we are, have learned by transmitted labour, to weigh, as in a balance, other worlds larger and heavier than our own, to know the length of their days and years, to measure their enormous distance from us and from each other, to detect and accurately ascertain the influence they have on the movements of our world and on each other, and to discover the substances of which they are composed; may we not fairly hope that similar methods of research to those which have taught us so much may give our race further information, until problems relating not only to remote worlds, but possibly to organic and sentient beings which may inhabit them, problems which it might now seem wildly visionary to enunciate may be solved by progressive improvements in the modes of applying observation and experiment, induction and deduction.

THEORY OF THE INFLUENCE OF FRICTION UPON THE MECHANICAL EFFICIENCY OF STEAM.*

By W. J. Macquorn Rankine, C.E., LL.D.

1. Attention has been called to the fact that the heat produced by the friction of the pistons, piston-rods, and trunks of steam-engines must be wholly or partly communicated to the steam, and must thus affect the work of the steam and the expenditure of heat upon it. The object of the present paper is to point out how that fact, when treated according to the principles of thermodynamics, affects the efficiency of the steam.

2. The most general and elementary way of considering the subject is as follows:—Let W denote the whole indicated work of the steam in a given time, including that which is lost through friction in the cylinder; let F be the part of that work which is so lost, so that W — F is the available work; also let H be the whole expenditure of heat upon the steam in the same time, expressed in units of work by the aid of the first law of thermodynamics. Then $\frac{W}{H}$ is the efficiency of the steam when friction is not taken into account. If we take into account the loss of work through friction, but not the gain of heat, the efficiency is reduced to $\frac{W-F}{H}$. With respect to the gain of heat through friction, it is to be observed that if the cylinder is properly jacketed and protected, the whole of the heat due to the friction of the piston must be communicated to the steam, and that, if we consider the great superiority of slightly moist steam above air in conducting power, it is probable that a small fraction only of the heat due to the friction of piston rods and trunks escapes without being taken up by the steam also. If, then, we suppose that sensibly the whole due to friction in the cylinder is taken up by the steam, there is a corresponding saving in the expenditure of heat, and the efficiency of the steam becomes

$$\frac{W-F}{H-F}; \quad \cdots \quad (A)$$

being less than $\frac{W}{F}$, the efficiency neglecting friction; but greater than $\frac{W-F}{H}$, the efficiency when the loss of work is taken into account, but not the saving of heat.

3. For example, let the case be taken of an engine in which the steam is admitted to the cylinder at an absolute pressure of 40 lb. on the square inch, being 25·3 lb. on the square inch above the atmosphere, the back pressure being 4 lb. on the square inch, and the rate of expansion 5 lb. The efficiency of the steam in such an engine, neglecting friction, is about $0·12 = \frac{W}{H}$. Suppose now that one-tenth of the indicated work is lost in friction in the cylinder, and that all the heat of friction is taken up by the steam; that is to say, let F = 0·1 W = 0·012 H. Then the fraction 0·012 expresses the saving of heat through friction, and the efficiency is found by equation A to have the following value: $\frac{W-F}{H-F} = \frac{0·12 - 0·012}{1·000 - 0·012} = \frac{0·108}{0·988} = 0·1093.$
The result of taking into account the loss of work, but neglecting the saving of heat, is $\frac{W-F}{H} = 0·108$.

4. The following is the result of applying the principles of thermodynamics more in detail to the process of expansive working as affected by friction. During any small portion of the process of expansive working let d W be the total work done, including friction, and d F the part of that work which is lost in friction; also let t be the absolute temperature at which the work d W is done, and k the real dynamical specific heat of the substance. Then by the second law of thermodynamics, the expenditure of heat during the given small portion of the process is

$$d\,H = t\,d\,\phi;$$

in which the "thermodynamic function" ϕ has the following value:—

$$\phi = k \text{ hyp. log. } t + \frac{d\,W}{d\,t}.$$

If all the heat due to the friction is taken up by the working substance, let $d\,H^1$ be the diminished expenditure of heat; then the thermodynamic equation of the process becomes

$$d\,H^1 = d\,H - d\,F = t\,d\,\phi - d\,F \quad \cdots \quad (B)$$

And if, as is often sensibly the case, the work done in friction is a constant fraction f of the whole work, so that $d\,F = f\,d\,W$, we have the following equation:

$$d\,H^1 = t\,d\,\phi - f\,d\,W \quad \cdots \quad (C)$$

5. The special mode of operation of friction in saving heat during the working of steam in ordinary steam engines probably consists in a diminution of the additional supply of heat required by the steam while in the cylinder, in order to prevent the accumulation of liquid water there. It is known that during the expansive working of steam heat disappears: that part of such disappearance of heat (viz. from one-fourth to one-fifth of it) takes effect in lowering the temperature of the steam to that corresponding to the diminished pressure; and that the remainder (being from three-fourths to four-fifths) tends to produce liquefaction of part of the steam. Such liquefaction is known to cause indirectly great waste of heat, through the distillation of the liquid water into the condenser, and consequent abstraction from the cylinder of heat, which has to be supplied by means of an increased expenditure of boiler steam. In order to realise, therefore, the economy due to expansive working, it is necessary to keep the steam during the expansion nearly in a state of dryness; and for that purpose it must be supplied with heat to the extent of from three-fourths to four-fifths of the heat which disappears during the expansion. That supply of heat may be conveyed from the boiler either by means of a steam jacket, or of superheating, or by both methods combined; and the heat due to friction in the cylinder, by contributing to that supply, diminishes the part of it which it is necessary to obtain from the boiler.

6. The theoretical formulæ for the indicated work and the expenditure of heat in a steam engine working with dry saturated steam are as follows:—*

Let the initial absolute temperature, absolute pressure, and volume of one pound of steam be denoted, during the admission into the cylinder, by t_1, p_1, and v_1, and at the end of the expansion by t_2, p_2, and v_2; so that $\frac{v_2}{v_1}$ is the rate of expansion.

Let p_3 be the back pressure of the exhaust steam in the cylinder, and t_4 the absolute temperature of the feed-water.

Let $a - b\,t$ be the approximate value, in units of work, of the latent heat of evaporation of one pound of water at the absolute temperature t; the constants being as follows:—

a = 1109550 foot pounds;
b = 540·4 foot pounds per degree of Fahrenheit, or 972·72 foot-pounds per Centigrade degree.

Let J be Joule's equivalent of the specific heat of liquid water = 772 foot-pounds for Fahrenheit's scale, or 1,390 foot-pounds for the Centigrade scale nearly.

Let U denote the work done by a pound of steam, on the supposition that the back pressure is equal to the final pressure ($p_3 = p_2$); and W the whole indicated work done by a pound of steam.

Then $$U = a \text{ hyp. log. } \frac{t_1}{t_2} - b\,(t_1 - t_2) \quad \cdots \quad (D)$$

and $$W = U + (p_2 - p_3)\,v_2 \quad \cdots \quad (E)$$

also the expenditure of heat per pound of steam is

$$H = U + a - b\,t_2 + J\,(t_2 - t_4) \quad \cdots \quad (F)$$

Now the total heat of evaporation of one pound of steam, at the initial temperature t_1, is

$$H_1 = a - b\,t_1 + J\,(t_1 - t_4) \quad \cdots \quad (G)$$

and the difference between this and the total expenditure of heat is the additional heat which must be supplied to each pound of steam in order to prevent liquefaction in the cylinder, that is to say—

$$H - H_1 = U - (J - b)\,(t_1 - t_2)$$
$$= a \text{ hyp. log. } \frac{t_1}{t_2} - J\,(t_1 - t_2) \quad \cdots \quad (H)$$

It appears by calculating numerical results in particular cases that $H - H_1$ = from 0·75 to 0·8 U nearly . . (K)
0·75 being the co-efficient at high temperature, and 0·8 at low.

7. It is out of this latter part of the expenditure of heat $H - H_1$ that the saving is made through the heat produced by the friction in the cylinder. The following are four examples of the theoretical calculation of the work and expenditure of

* Paper read before the British Association, Nottingham, 1866.

* For their demonstration see "Phil. Trans.," 1859, and "A Manual of the Steam Engine and other Prime Movers," p. 396; and for approximate formulæ for practical use, see also "The Engineer," Jan. 5, 1866, p. 1, and "Useful Rules and Tables," p. 282.

heat per pound of steam, and of the efficiency, with and without allowances for friction :—

No. of Example.	I.	II.	III.	IV.
Temperature—Fahrenheit.				
Initial, ordinary	338 deg.	338 deg.	257 deg.	257 deg.
,, absolute; t_1 =	799 ,,	799 ,,	718 ,,	718 ,,
Final, ordinary	248 ,,	203 ,,	176 ,,	221 ,,
,, absolute, t_2 =	709 ,,	664 ,,	637 ,,	612 ,,
Feed-water, ordinary	104 ,,	104 ,,	104 ,,	104 ,,
,, absolute; t_4 =	565 ,,	565 ,,	565 ,,	565 ,,
Pressures—lb. on the square foot—				
Initial, p_1 =	16580	16580	4854	4854
Final, p_2 =	4152	1765	988	2524
Back, p_3 =	649	649	649	649
Volumes—cubic feet to the lb.—				
Initial, v_1 =	3·814	3·814	12·09	12·09
Final, v_2 =	14·00	31·26	53·92	22·34
Rates of expansion $\frac{v_2}{v_1}$ =	3·67	8·2	4·46	1·86
Indicated work in foot-pounds per pound of steam, at pressures above the final pressure, U =	83930	132350	89000	37600
Do. at pressures below the final pressure $(p_2 - p_3) v_2$ =	49042	34700	18140	41900
Total indicated work, foot-pounds, per lb. of steam, W =	132972	167050	107140	79500
Heat expended in foot-pounds per lb. of steam, before admission H_1 =	859175	859175	840139	840139
Additional heat to prevent liquefaction (without deduction) $H - H_1$ =	62778	100623	69964	29139
Total heat expended (without deduction) H =	921953	959798	910103	860278
Efficiency without friction $\frac{W}{H}$ =	0·1442	0·174	0·1176	0·0915
Suppose co-efficient of friction one-tenth, then work lost in friction and heat saved $F = \frac{W}{10}$ =	13297	16705	10714	7950
Available work W — F =	119675	150345	96426	71559
Heat expended to prevent liquefaction, deducting that saved by friction, $H - H_1 - F$ =	49481	83918	59250	2118
Total heat expended, deducting that saved by friction H — F =	908656	943093	899389	861328
Efficiency, allowing for friction $\frac{W - F}{H - F}$ =	0·132	0·1595	0·1073	0·083

8. From the preceding formulæ and calculations it appears that although the heat produced by friction in the cylinder makes but a trifling saving when compared with the whole heat expended, it may become considerable when compared with that part of the expenditure of heat which is employed to prevent liquefaction of steam in the cylinder, and may thus co-operate usefully with the action of jacketing and superheating.

In reply to some observations by Mr. Smith and Mr. Bramwell, the latter of whom pointed out that the heat generated would be carried away in part by the exhaust, Professor Rankine said he was sorry that he should have explained himself so badly in his original paper as to lead Mr. Bramwell and Mr. Smith to suppose that he regarded the heat generated by friction as increasing the motive power. That was not what he had intended to convey. He was far from supposing that the heat generated by friction added in the slightest degree to the amount of the working power of the steam, or even made the diminution of the work less than it would otherwise be. What he meant to convey was that the effect which he had ascribed to the heat produced by friction was not a gain or saving of mechanical work, but simply a saving of a portion of the heat which would otherwise be lost in preventing liquefaction of the steam. Whatever quantity of heat was produced in the cylinder by friction, precisely to that extent would the heat which it was necessary to supply by means of jacketing or superheating be diminished. Steam might be dried or superheated by wire-drawing, or passing through a small aperture without performing work. Most engineers, however, would agree with him that to dry or superheat steam by that method was not economical, and that the same object could be better attained by the direct application of heat.

ON THE DECAY OF MATERIALS IN TROPICAL CLIMATES, AND THE METHODS EMPLOYED FOR ARRESTING AND PREVENTING IT.*

By Godfrey Oates Mann.

The cause of the decay of materials in tropical climates, and the means successfully employed to prevent such decay, must become an increasing matter of interest to the Engineer, as well as to the English capitalist, not only from the rapid increase of public works in India, but also from the connection of Great Britain with the extensive and rising empire of Brazil, with reference to which this Paper is especially written.

The climate of Brazil is the most agreeable of any within the tropics, either in the western or in the eastern hemisphere. This is especially the case in the Province of Pernambuco, where, probably, the temperature varies less than in any other quarter of the globe, as—

The average temperature in the night during the year is 64°.
The average temperature in the shade during the rains is 78°.
The average temperature in the shade during the hot season is 82°.
The highest temperature in the sun during the year is 148°.

The seasons, which, without doubt, influence more than the temperature the decay of materials, cannot be said to be so regular, as regards particular months, as in India, or as to the quantity of rain falling during the year. The annual rainfall varies from 60 inches to 120 inches. Thus, in 1860, 67 inches fell, whilst in 1861, the rainfall amounted to 123 inches. In some years the rains commence unusually early, continue for a month or more, after which there may be a month, or even two months of hot weather; when the rains again set in for a short or a lengthened period. In other years the rains commence late, and last only a short time; or set in early, and continue for a long period, with intervals of days, or perhaps weeks, of sun, causing that peculiarity in the climate, excessive heat combined with much moisture, noticeable, more or less throughout the year, and which must be very trying for the generality of materials, more particularly railway sleepers, about which it is proposed first to treat.

The first lengths of the permanent way of the Pernambuco Railway were laid in February, or March, 1857, with creosoted sleepers of timber from the north of Europe. Fair average samples, taken out on the 1st December, 1863, show that the half round intermediate sleeper is in the most perfect state of preservation, in fact, nearly as good as on the day it was put down; while the square sawn, or joint sleeper has not withstood the effects of the climate so well. Although the square sleeper does not exhibit a very favourable result, there can be no doubt as to the advisability of sending out, in the first instance, to India, Brazil, or any other tropical climate, in which a railway is being made, the whole of the materials required for the permanent way, as the Engineers and the contractors' agents, are, in most cases, unacquainted with the qualities of tropical timber, and the locality is generally unable to supply timber of good quality, in sufficient quantities, for the rapid construction of a line. Even if the required quantity could be obtained, the natives are so well versed in the question of supply and demand, that the native timber quickly assumes the price of imported creosoted sleepers. It is evident, from a sample which had been laid nearly seven years before removal, that creosote will, if properly applied to suitable descriptions of timber, prevent its decay in tropical climates.

The points requiring consideration are, the quality and form of the sleeper, and the kind of ballast in which it will be most advisable to lay it. About 12 miles of the Pernambuco Railway are entirely laid with creosoted sleepers, principally in white sand. In this description of ballast, the half-round sleepers have suffered, since the opening of the first section of the line in 1858, a depreciation of not more than 1 per cent., whilst the square sawn sleepers have experienced a depreciation of not less than 50 per cent. Had the latter been placed in wet cuttings, with ballast retentive of moisture, no doubt the whole of them would have required to be renewed. Hence it is evident, that the smaller and closer grained wood is much more lasting than the larger and more porous description; and that fine open sand ballast, which allows a free drainage during the rains, is best adapted for the preservation of sleepers in the

* Read before the Institution of Civil Engineers.

tropics. This has been satisfactorily proved in 10 miles of road laid with creosoted and with native sleepers, in a mixed description of ballast, in which neither has stood so well as in the fine sand.

As regards the form, the general opinion in Pernambuco is in favour of the half round, as it allows the water, during the wet season, to pass away more freely, than is the case with the square sawn sleeper.

In 1859, whilst the works of the second section of the Pernambuco Railway were in progress, the Government Engineer Fiscal, Signor Manoel de Barras, advised the use of native sleepers; but, beyond giving a list of those timbers he considered suitable, he did not, in any way, assist the Company's Engineer with any facts as to the peculiarities of these timbers. The result was, that the wood was cut at unfavourable seasons, and the progress of the works being rapid, the sleepers had not time to dry, but were used in a perfectly green state, so that shortly after the opening of any section, the renewal of the sleepers had to be commenced. On the fourth and last section, this took place within a month after it was opened.

From this it might be inferred, that there does not exist in Brazil timber, either in quality or quantity, fit for railway purposes; but such is not the case, as there are numerous qualities of the finest wood in the world, and about as inexhaustible as the coal-fields of Great Britain.

The question may be asked, why then has this supply not been made available? In reply, it may be said, that there is an entire want of all statistical or reliable information amongst the people themselves. They continue to employ what their forefathers used, and if it serves their purpose, they have not the least desire to find out anything better, or more available. This seems to obtain in all tropical climates, so that the railway pioneer finds himself without data to guide him, and it is only after a residence of many years in any one of these countries, that personal and gradually acquired experience can guide the Engineer to a judicious use of the resources of the country, and insure his not committing any serious error.

Railway sleepers being a new feature in Brazil, the railway Engineers had to seek for information, as to the durability of the innumerable varieties of timber existing in the country. The result was, that scarcely two opinions were found to agree; ignorance or cupidity in most cases influencing the information given. Consequently most unsuitable descriptions were used, which now (as previously stated), after being laid but a short time, require extensive renewals. Still, some of the samples afford evidence, that there is wood in Brazil that will last for an indefinite period. The opening of the railways into the interior will doubtless bring this superior description of wood to the various sea-ports, as is now the case on the Pernambuco Railway, to the exclusion of all imported timber. The Author, after nearly seven years' experience, is confident that properly selected timber of the country will be found more durable than any description of wood sleeper yet imported; and, as resident Engineer of the Pernambuco Railway, he is now employing these kinds in renewing the sleepers on the line.

In conclusion, upon the subject of native railway sleepers, it is found advisable, in order to prevent decay, to cut the timber during the dry season, to select large and full-grown trees, to remove the whole of the bark and sapwood, leaving the heart only, and not to expose the sleepers in the sun when first cut, but to stack them in open piles under cover, through and about which the air can freely circulate for a few months. These rules being attended to, the result will be satisfactory, as regards Brazilian timber, and it is reasonable to assume, that the same rules will apply, more or less, to timber in India, and other tropical countries.

The cost of sleepers delivered, subject to these conditions, at the various stations on the Pernambuco Railway is at present 2s. 7d. each, the scantling being sometimes 10 inches, by 5 inches, by 9 feet, but more frequently 12 inches, by 6 inches, by 9 feet. Imported creosoted sleepers have invariably cost double that amount.

From what has been said with regard to railway sleepers, it will be evident, that timber in general requires in tropical climates, the greatest consideration in its use for permanent structures. Reliable information may perhaps be obtained, as to the best descriptions for general use: still the Engineer will meet with such a variety of opinions among the natives, that it is only after considerable personal experience, that he feels certain in using any description for particular purposes. Good timber suitable for building abounds in Brazil, in the greatest variety. Many kinds are impervious to the white ant, which insect generally selects the more porous woods, and especially if these are in contact with the earth. In dry places and with a free circulation of air, the white ant does not prefer timber thus situated; and it is found that roofs of buildings, of good and well-seasoned native wood, resist, for an indefinite period both the climate and the white ant.

Creosoted timber, it is well known, resists the attacks of the white ant; but the close grain of the generality of tropical timber renders any attempt to creosote it all but useless. North American pitch-pine also stands exceedingly well the attacks of the white ant, when used in the roofs of buildings, or in any locality not humid; but it is found after a time, when laid upon the earth, to lose its resisting powers, as well as to become subject to rapid decay.

White, or yellow, pine can only be used in the tropics for doors, movable window frames, bodies of railway wagons, or other work intended to be kept in motion. Its use even for these purposes is questionable, as the white ant has such an affinity for it, that a door or a window which has remained shut for a few weeks, will almost invariably be attacked by that insect. Generally it will be best to select suitable native wood for all permanent works. Since the opening of the railway in Pernambuco, timber can be brought 70 miles or 80 miles from the interior, and be delivered of any practical scantling, at the rate of 1s. per cubic foot.

Since the establishment of the gasworks in Pernambuco, the Brazilian Engineers and constructors have adopted the practice of 'paying' over, with coal tar, the ends of all timbers built into the gables of buildings, or in any other position in which it is buried, or excluded from the air, and so far apparently with beneficial results.

The oldest samples of native timber that could be obtained accompany this Paper, and are part of the piles, taken up during the month of November, 1863, of the old Recife wooden bridge, constructed in 1614, and now about to be replaced by an iron bridge, under the direction of Mr. W. Martineau, (M. Inst. C.E.)

It is only necessary to add, as regards this part of the subject, that to insure satisfactory results, it will be essential to select the quality suitable for any particular description of work, to see that the wood is cut at the proper season, and, to prevent its splitting, not to expose it to the sun when first cut; to have all the bark and sapwood removed, and to allow it to dry a certain time before being used. With these precautions no foreign timber will be found able to compete, in the tropics, with that of native growth.

Upon iron bridges, from their increasing adaptation, any information as to the result of their use in tropical climates must be very desirable. The merits of the different forms will not be discussed, as each may be said to be equally liable to decay. There is, however, one great defect in the construction of some of these bridges, that is, suspending the transverse girders by bolts, instead of allowing them to rest on the main longitudinal girder. When the two plans are compared, the most casual observer must give the preference to the latter, particularly where iron is so subject to rust if not properly treated.

Iron bridges in the tropics will, if proper care be taken in the first place, and ordinary attention be bestowed upon them afterwards, last for an indefinite period, whether on the sea-board or in the interior; but in the latter locality they will always show more favourable results. Under either of these conditions, it will be found desirable, wherever practicable, to construct the piers of stone, in preference to using iron piles, as the latter will be found to be the first destroyed. In the province of Pernambuco, there are no examples of old iron bridges; in fact except the St. Isabel, completed in 1863, by Messrs. Horace, Green and Co., there are no other iron bridges than those of the Pernambuco Railway, four of which, when examined, showed the following results:—In these bridges the piers are formed of four cast-iron pipe pile, each 15 inches in diameter, to which were afterwards added two cylinders, each 3 feet in diameter, sunk on each side of the original pier, with columns and side brackets to the girders, an addition that was found necessary after the line had been opened for traffic. The superstructure, in most cases, is composed of Warren's girders.

The first bridge over the Pirapama River, about 16 miles from the city terminus, consists of two spans of 60 feet each. The iron piles below the water level were found to be coated with a thin layer of mud, similar to that of the bed of the river. When this was washed off, the piles appeared to be in a most perfect state, and not in the least rusted, in fact in as good preservation as when first put down. The bolts and nuts connecting the piles, the wrought iron tie-bars for bracing the columns, as well as the whole of the upper structure, were also found to be in the most perfect state. The water in this river, although affected by the rise and fall of the tide, is at all times fresh, both near, and for some distance below the bridge.

The second bridge consists of three spans over the Saboatao, a tidal river, which at the site of the bridge is salt, or more or less brackish, except at the lowest tides, when it is sometimes found to be fresh. Here the piles under high water were covered with small marine shells, not to any great thickness, and easily removed, when the red paint was found to be as perfect as when first applied. The iron itself did not seem to have been in the least affected. The wrought-iron bracing bars, 3 inches by ⅝ inch, were not in such good preservation, rust being observed on them after the shells were removed. The whole of the upper structure was in a good and satisfactory condition.

The next bridge that came under examination was one of five spans, over the mouth of the river Ibura, at the head of Recife Harbour; and the fourth and last of six spans, over the Capibaribe, a few hundred yards from the former, and as the result in both was exactly alike, they may be jointly described. At the time of the examination, the tide was very low, the bed of the river being nearly dry, so that the pipe-piles could be examined down to the sand. The whole of these were densely covered with oysters from 6 inches to 12 inches thick, and the first ones had adhered so firmly to the piles, that on breaking them with a hammer, portions of the backs of the shells remained, requiring a chisel to get them off. When these were all removed, it was satisfactory to find that the piles were perfectly sound. These shells appear to act as preservatives to the metal, by excluding the air and the sea-water. There is no doubt further examinations will prove, that these shells afford probably a better protection than any composition that could be put on, and therefore ought not to be removed. The wrought iron bracing bars in these bridges, do not, as may be expected, show so well as the cast-iron piles. A sample from the end of the bar attached to the pile-joint below the water line accompanies the Paper. It will show to what extent these bars have been affected, after being erected about six years, as well as illustrate how the shells adhere to the piles. The upper structure of these bridges was found to be in the best possible condition, and the result of the examination on the whole was very satisfactory.

It may probably be necessary in a few years to renew some of the wrought-iron bracing bars, as well as some of the bolts and nuts under water. When these require renewing, it will be advisable to use steel in place of wrought iron, as that material will no doubt endure as long as the bridge lasts. The result of six years' experience is certainly but a short time upon which to form a decided opinion; but it would appear, that the cast-iron pipe piles are likely to last for a considerable period, and that the upper structure of wrought iron, with ordinary care and attention, is also likely to stand well. The only parts apparently affected are the wrought-iron bracing bars and the bolts and nuts below high-water mark. These may in future be made of steel with but little additional expense.

No special means appear hitherto to have been employed, or to have been considered necessary, for the preservation of iron bridges sent to the tropics. Red lead, or any other description of paint that came to hand, appears to have been used, and no consideration seems to have been given to the condition, or state of humidity, of the ironwork when painted. In consequence, after the sea voyage, owing to the high temperature and the 'steamy' state of the ship's hold, rust is formed underneath the paint; the latter rises in blisters, then bursts, and falls off in large flakes, exposing the bare iron, highly oxidised, without a vestige of the paint remaining. This not only takes place with bridge-work, but also with locomotive engines and tenders, wrought-iron tanks, &c., when sent out completely painted. No doubt the same care is bestowed upon them as when intended for home use, but it would be better not to go to this expense, as it only entails further outlay in a short time, to scrape the whole off and commence afresh. Care should be taken, in every description of work, that the iron be perfectly dry before the paint, or any other composition, is laid on. After trying a variety of paints, coal-tar was at last resorted to, for the preservation of the iron bridges on the Pernambuco Railway, and so far apparently with good success. From the result of its application in several other descriptions of work, the Author does not hesitate to recommend its use as the most efficient protection for bridges and iron work in general for the tropics. In order to remove the great and first source of mischief, moisture, or incipient oxidation on the surface of the iron, it will be advisable to have the whole of the smaller parts of the bridge-work, &c., before being sent away for shipment, heated to a low temperature, by passing them through a furnace or otherwise, then brushed and dipped in tar. The larger parts, which it would be inconvenient to heat, should be well cleaned, and the tar laid on as hot as possible. Tar of course can only be employed where it is decided to continue its use for the future preservation of the bridge. With public bridges, or in any situation where ornamental painting is considered necessary, linseed oil may be used instead of, and in the same way as, tar. Over this, and for further protection, a thin coat of zinc paint may be laid. This will stand the sea voyage, and when the bridge is erected, it can be cleaned off, when the ironwork will be ready to receive the finishing coat, which should also be of zinc, as all other paints for tropical climates are perfectly useless.

It is to be hoped that tar, linseed oil, and zinc paint, will all shortly be superseded by galvanising the whole of the bridge-work for the tropics, by which process more efficient protection will be afforded than by any other.

With regard to building materials, stone, when obtainable of good quality, is the most desirable, in all respects, for a tropical climate; and with the excellent lime of Brazil, and the still better 'chunam' of India, good stone-work in these climates is the most likely to last, with the least outlay for repairs. Stone ought never to be lost sight of by the Engineer, whenever its use is at all practicable. Abutments for bridges will, of course, be built of this material when it is obtainable, and, as previously stated, when practicable it is also to be preferred for the piers, instead of cast-iron piles. Stone has never been extensively used in or about Recife, owing to its being found only at a considerable distance from the city. It is imported from Portugal, for facing the churches. These, and a few old Dutch works of the seventeenth century, show how well this material stands the decaying influence of the tropics. It need scarcely be said, that no mistake can possibly be made in allowing it to enter freely into the construction of all public works in these climates.

Bricks, when stone cannot be obtained, must of necessity be used for certain descriptions of work. Great caution should be exercised in their selection, as it is found that all bricks made near the sea-board, with brackish water, are exceedingly susceptible to the weather, and moulder rapidly away when exposed. It is, therefore, advisable to make them at some distance from the coast, with fresh water, and above all to have them well and thoroughly burned, which, in these climates, where fuel is generally expensive, is most difficult to insure. Near to the sea-coast, it is found necessary to protect all brickwork with plaster, which certainly serves its purpose exceedingly well. In the interior of the country well-burnt bricks may stand for a few years, but ultimately it will be necessary to plaster them, or to give them a thick coat of whitewash from time to time. Tar, over a coat of whitewash, has been used with considerable success, for the protection of brick buildings, and other works of this material; and in localities where it would not be considered unsightly, it is certainly preferable in buildings on the side from which the prevailing winds and rains set in during the wet season, as it not only throws off the moisture on the outside quicker, but tends to keep the interior of the building freer from moisture than any other outer protection. Of two samples of brick taken from the same wall, built in 1790, in Recife, although not in any way protected by plaster, or lime whitewash, one appears to be quite perfect, while the other is rapidly decaying, and shows the necessity of outward protection, as a general rule, owing to the all but impossibility of obtaining, in large quantities, thoroughly well-burnt bricks.

Tiles, in Brazil, are almost invariably of the form shown in the specimens, and are made of similar material to, though where obtainable of better clay, than the bricks. When well burnt, and of a good shape, with sufficient overlap when laid on the roof, native tiles answer their purpose exceedingly well, and being thin, and invariably burnt in ovens, this process is so effectually performed, that the weather seems scarcely to affect them, either on the sea-board or in the interior. Their chief recommendation is, however, the thorough ventilation afforded by them in all buildings. Should at any time corrugated iron buildings, with roofs of similar material, become largely introduced within the tropics, it will, it is believed, be found desirable to cover these with native tiles, both for the protection of the roof, and for keeping cool the interior of the building, unless a double roof is used, 3 inches or 4 inches apart.

In Brazil, rafters are selected from the young trees of the forest, from 3 inches to 4 inches in diameter, and from 20 feet to 30 feet long; and when of proper quality of timber, these rafters answer their purpose very well and are of considerable duration.

Laths are in nearly all cases made from the sap-wood of one of the hardest and most durable timbers in Brazil, 'Imberiba.' A chisel, or axe, is introduced into the end of the stick of timber, about ⅜ths of an inch from the outer edge: very little force splits it in the direction of its length, allowing the fingers and hand to be introduced, and the lath is reft off, retaining an uniform thickness, with a breadth of from 2 inches to 2½ inches.

Permanent-way keys, cut from native timber, have, since the opening of the Pernambuco Railway in 1858, been used for renewals, and with success. The timber, being of a remarkably close nature, has not shrunk after use, as the imported keys are liable to do. With keys, as with sleepers, there is not the least necessity for creosote. In fact, with some keys kept constantly in creosote for three months, when sawn through the centre, the oil only appeared a little below the surface.

Rails are found to oxidise considerably when left near the sea-coast. It will therefore be advisable, in the construction of a line, to remove them into the interior, as soon as it is convenient to do so. When in use, in whatever locality, the motion of the trains appears to prevent any considerable amount of rust from forming. There is, however, a matter for serious consideration, as regards permanent-way rails in the tropics; and that is their tendency to flatten, or laminate, after being subject to the wear and tear of the engines and trains for a short time. This is no doubt owing to the high temperature during the greater part of the day, and the constant passage of the trains when in that state. The remedy appears to be, the substitution of steel, or steel-faced rails, and engines as light as the traffic of the line will allow. Whilst on the subject of engines, it may be as well to mention the rapid wear of the wheel tires in the tropics, particularly on lines like the Pernambuco, with numerous curves. Where it has been found necessary to adopt steel tires, in addition to an arrangement for keeping the leading wheels wet when going round curves, there is a small pipe from each pump to the front upper side of the leading wheels, made so as to open and close at pleasure from the foot-plate. Although this arrangement answers exceedingly well, in saving the flanges of the wheel tires, as well as in causing the engine to work round any curve much easier, still this can only be looked upon as a desirable expedient in existing engines. The bogle should be used with all engines made for tropical climates, where the rails are so constantly hot and dry. The saving in the rails, as well as in the wheel tires, would be considerable, and there would be greater safety in working, as it is found that the dryness tends to make the leading wheel-flanges grip, and, when a bad joint occurs, mount the rail.

Chairs and spikes do not require any special notice, as, with the exception of the former not being so liable to breakage, owing to the absence of frost, these need not, in any way, differ from those used in England.

About 10 miles of the Pernambuco Railway are laid with Greave's 'pot' sleepers, as to the durability of which in the tropics there is no question, though found to be too rigid even in fine sand ballast. Had these sleepers been used on the deep banks when first formed, the usual subsidence during the rains would have caused considerable breakage, and in any case much more ballast would have been required than generally falls to the share of railways abroad when first opened. A portion of the 10 miles actually laid has, however, been considerably improved, by introducing the ordinary fish plates, with four bolts, and suspending the joints. The easiest method of doing this is by cutting away about 15 inches of the first lengths of rails, knocking out all the keys, and then drawing the rails in succession 15 inches back, by which the joints are brought into the centre betwixt the joint and the next intermediate sleeper, the 'pots' remaining undisturbed. The fish plates are then put on. The 15-inch pieces are always kept at hand to be introduced to allow for the passage of the trains. This work was done by the piece, and cost 1d. per pair of joints.

The carriages of the Pernambuco Railway are made with a strong wrought-iron under frame. The body is of teak, the inside lining is also of this material; the outside panels are of 'papier mâché.' After six years' hard work and exposure to sun and rain, these carriages are in excellent preservation. The material employed for the outside panels has proved in the highest degree suitable for the tropics, and will probably be generally adopted when its good properties are known. But whether 'papier mâché' or timber is used, the panels should be well painted and varnished, or the sun will not fail to destroy them. The first carriages sent out to Bombay for the Great Indian Peninsula Railway, with panels of varnished teak, split after being exposed to the sun for a short time, whereas in the 'papier mâché' panels on the Pernambuco Railway, there is not a crack in any of them after six years' wear and exposure.

The railway wagons for the Pernambuco Railway were constructed in Brazil, the iron work having been sent from England; the under frames are made of native timber, and the body of white or yellow pine. The great heat of the sun is found to dry up and cause the sides, and particularly the roofs, of these wagons to become leakey. Zinc has therefore been used as an outer covering for the roofs, and will no doubt answer. For the tropics, the most serviceable covered goods wagon will be found to be one constructed with an iron underframe and a light galvanised iron body.

In conclusion, there is no doubt that the subject of the Decay of Materials in Tropical Climates, and its prevention, is but little known, though deserving of being thoroughly investigated. It is hardly to be expected, that any one individual will be found to possess the information necessary to treat upon this subject with reference to all tropical countries; but it is to be hoped that some Member will take the trouble to compile the results obtainable from all reliable sources, and produce a work which will not fail to be acceptable to all who take any interest in these countries, and particularly India.

APPENDIX.

A.

List of Brazilian Timbers suitable for and now being used as sleepers on the Parnambuco Railway:—Sicupira; Oiticica; Almesca Brava; Gararoba; Gulandin; Pao Santo; Angelim Amargozo; Sapucaia de Pilao; Amarello Vinhatico; Macaranduba Preta. The present price of the above, for sleepers, 10 inches by 5 inches, by 9 feet, delivered at stations on the line, is 2s. 7d. each.

B.

List of Brazilian Timbers suitable for general purposes in permanent structure:—Sicupira Assú; Sicupira Meirim or Verdadeiro; Sicupira Acari; Oiticica; Gararoba; Paõ Santo; Sapucaia de Pilao; Sapucarana; Massaranduba; Imberiba; Paó Ferro; Paó d'Arco; Barabu. These cost 1s. per cubic foot, and are of great durability, and resist the white and excepting in the sapwood.

The following are as durable as the foregoing, and resist the white and even in the sapwood on account of their bitterness:—Angelim Amargozo; Araroba; Pitia (Gararoba) and Pitia (Marfin). These also cost 1s. per cubic foot. Cocâo, Bordâo de Velha and Arueira do Sertao, are very durable, and resist the white ant; but are not to be found of any great dimensions. These likewise cost 1s. per cubic foot, as do Parahiba and Cedro, which are very suitable for boarding, their strong smell and their great bitternes repelling the white ant. The price of Louro Cheiroso and Louro Ti is the same. These are of a porous description, fit for doors and shutters. The Cheiroso repels the white ant, owing to its smell; the heart of the Ti is very strong and durable, resisting the white ant. For Amarello Vinhatico and Amarello Verdadeiro, the cost is 1s. 1½d. per foot. They are of great durability, and are extensively used in cabinet work.

C.

Table of Specific Gravities of Brazilian Timber for Shipbuilding.

Name.	lbs. per cubic foot.	Uses.
Louro . . .	37	Yards, masts, &c.
Jequitiba . . .	44	Do. Do.
Amarello . . .	46	Planks for above and below water.
Putumugu . . .	48	Do. Do. Do.
Pao d Oleo (Vermelho)	56	Yards, mast, &c.
Olandim . . .	57	Bowsprits, topmasts, gunwales, &c.
Sicupira Meirim. .	59	Useful for every part of a vessel.
Pao Roxo . . .	63	Keels, sternposts, ribs, &c.
Pao d'Arco . .	66	Do. Do. Do.
Peguim . . .	64	Deck beams, &c.
Sapucaia . . .	73	Keels, ribs, &c.
Jetahy (Amarello) .	66	Gunwales, &c.
Massaranduba . .	68	Beams, posts, &c.

PARIS UNIVERSAL EXHIBITION, 1867.

The works in the Champ de Mars are proceeding with great rapidity; the whole of the framework of the iron portions of the building may now be said to be completed, and the outer circle which masks all within, the *grand nef*, as it is called, and which is to form the machinery and processes court, including in the latter manual as well as mechanical labour, presents a very bold and commanding appearance. There is little or no ornamentation connected with this exterior circle, or rather zone of the building, but its huge sides of plate iron, eighty feet high (walls there are scarcely any apparent), look light and elegant, in consequence of the clerestory, or range of windows, in three compartments, with arched tops, which occupy all the upper portion between the great pillars of the inner as well as the outer side. This *grand nef* is nearly a mile round, more than a hundred feet in width, and eighty in height, and will certainly form one of the noblest exhibition galleries ever constructed; the roof being unpierced, and the light coming in from the upper part of both sides, give this noble court an importance, as regards appearance, which a glass roof would be far from producing; there is plenty of light, without the cold or hot glare of a glazed covering. The clerestory, as already stated, occupies the whole of the upper portion of the sides; the corresponding spaces below are filled in with brick and plaster work, and in front is the alimentary court, in which all the cafés, restaurants, and other places of refreshment are to be placed; beyond this again is a jutting roof, forming a covered promenade, twenty feet wide, open to the park all round this outer circle of the exhibition. The grand nave is being rapidly covered in, and a large number of the window frames, the only portions of the zone which are in cast-iron, are in their places; when viewed from the park, beyond the gigantic proportions of this great court, its curved outline, and the fan-like appearance of the *marquise*, or verandah, produce an admirable effect, and show how much may be done without any extraneous ornament, by the mere repitition of simple elements, when good proportions are maintained throughout. The Commission has wisely determined not to mar the symmetry of this outer face of the building by any attempt at architectural effect in the way of porticos; there will probably be an entrance to the park of an ornamental character on the side of the quay, and opposite the main door of the building, and there will be many elegant structures in the grounds themselves, but these will all be at a sufficient distance from the building itself not to produce an unpleasant contrast with its bold, simple features.

The inner zone of the building, divided into two courts, a wide one for the Fine Arts, and one of smaller dimensions for the retrospective museum, or gallery of the *Histoire de Travail*, is, as has before been stated in the *Journal*, formed of solid stone walls, with partly glazed roofs. The whole of the masonry has been finished for some time, many of the sections into which these two courts are divided are roofed in, and some have the glass in its place and the walls plastered. The *salles* of the Fine Art gallery, which occupy the straight sides of the building, are noble rooms, admirably lighted, but those which occupy the circular ends, and which form by far the largest portion of the whole, will give, we hear, great dissatisfaction, the walls presenting curves of small radius, the light falling in the most perplexing manner. In this inner zone of the building the curved form is a sad mistake. Between the great outer portion and the inner zone which we have just described, are the intermediate galleries, to be devoted to raw materials, furniture, clothing, ornaments, hardware, and all the remaining classes of the catalogue; the light cast-iron columns and partially glazed roofs here present a very pleasing effect, and the curvature of this portion, from its larger radius and the absence of division walls, improves its appearance. These intermediate courts are the most advanced of all; the roofs are being glazed, the louvre boards are in place, and in a few weeks they promise to be ready for the exhibitors.

The central garden, like the exterior of the building, will have an iron *marquise*, or verandah, all around it, but in a different style. This is nearly finished, and consists of a light and elegant cast-iron facia, supported by slender columns, whose plinths rest on steps raised above the garden level.

A large number of buildings are rising up in the park. In the first place there is a very large plain building, of three stories, on one side, communicating with the park as well as with the road without; this is to be devoted to the use of the juries, and probably in part to that of the Imperial Commissioners also. This building has been covered in for some time and will shortly be entirely finished. At the opposite end of the park near the Quay d'Orsay, is another large building, not so far advanced, which is for the purpose of a club, to include all the ordinary features of such an establishment as far as they may be required for its temporary purpose, and also a large exchange or hall, for the use of exhibitors and those with whom they have business to transact. In another part, again, is a small ecclesiastical edifice, of which the roof is now nearly completed, and which is intended for the exhibition of all kinds of church furniture and decoration, interior as well as exterior. With this view the model church is provided with a transept, an apsis, a number of small chapels, and a profusion of windows. The admirable idea of thus forming a court in which all objects of ecclesiastical use or decoration may be exhibited in an appropriate setting is said to have originated with M. Leveque, a well known artist in stained glass, of Beauvais, who, with the sanction of the Imperial Commission and the aid of exhibitors and others, has raised this model Gothic church, which covers a thousand square yards of ground, and, which, no doubt will glisten next spring in all the splendour and with all the taste for which French artists, decorators, church jewellers, and others are so conspicuous. It is an excellent idea, likely to be well carried out.

Amongst the auxiliary buildings, erected or in course of erection, is a water tower for the supply of the building, steam engines, cascades and fountains, and two engine houses, pretty constructions in brick, with ornamental tiled roofs.

A kiosque is also being constructed, by order of the Sultan, who, it is said, will visit the Exhibition.

Another building is to be raised by order of the Viceroy of Egypt, to contain a large number of copies of the most celebrated monuments of that country, besides other objects of art and curiosity.

In one corner of the park considerable works are going on for the formation of the horticultural and piscicultural exhibition which will form a large garden, with cascades and aquariums on a large scale.

Outside the precincts of the Exhibition, the railway station of the line which will lead direct to all parts of Paris as well as, bring into communication all the lines starting from the city, is nearly completed, and the railway works in connection with it are under hand; the bridge over the opening made in the Quai d'Orsay, which will afford a direct entrance to the park from the landing place on the bank of the river is constructed, and the ornamental portions are now being completed; and lastly, the large space of ground in the Isle St. Germain, intended for agricultural experiments and other subsidiary purposes, is levelled and arranged. This ground is about a mile distant from the Exhibition.

Amongst the features talked of, but whether decided upon we are not informed, is the formation of a terrace on the top of the *grand nef* of the building, with ascent and descent by means of hydraulic lifts, from which a bird's eye view may be obtained of the park and the surrounding country.

The publication of the catalogue has been ceded to M. Dentu, the well-known bookseller of the Palais Royal, for the sum of £20,320; the catalogue is to consist of twelve parts, the first to contain the plans, tables, and documents relating to the exhibition; the second is to be devoted to the history of labour, or retrospective museum; and the remaining parts to the ten great groups into which the general contents of the exhibition is to be divided. The entire work is to be sold for five francs, and the separate parts at half-a-franc each.

The lists of intending exhibitors in many of the classes are now complete, and some idea may be formed of the show which will be made on the French side of the Exhibition. Classes 14 and 15 unifed, artistic furniture, upholstery, and decoration, numbers 220 exhibitors; class 17, porcelain, faiences, and other artistic pottery, 96 exhibitors; class 18, carpets, tapestry, and other tissues for furnishing purposes, 62 exhibitors; class 21, goldsmiths' work, 30 exhibitors; class 22, bronzes, fine iron castings, and repoussé work, 101 exhibitors; class 26, objects in fine leather and basket-work, and other small wares, 90 exhibitors; class 27, cotton fabrics and threads, 241 exhibitors; class 32, shawls, 28 exhibitors; class 34, hosiery, linen, and small articles of dress, 170 exhibitors; class 35, clothing, 215 exhibitors; class 36, jewellery and other ornaments, 153 exhibitors; class 39, toys and other small wares (*bimbeloterie*), 16 exhibitors; and class 46, leather, skins, and furs, 84 exhibitors; class 52, prime movers, generators, and machinery specially adapted to the purposes of the exhibition, 12 exhibitors; class 54, tool-making machines, 111 exhibitors; class 58, materials for and processes connected with furnishing and fitting, 41 exhibitors; class 59, paper making, dyeing, and printing of fabrics and tissues, 80 exhibitors; class 60, machines, instruments, and processes of ordinary trades, 52 exhibitors; and class 62, saddlery and harness, 41 exhibitors. The classification differs so much from that of the former Universal Exhibition held in Paris, that of 1855, that it is impossible to make a comparison of the numbers; in the former there were only 27 classes, not including the fine arts; in the latter there are 96 classes, or, excluding the fine arts, 91. If we take the twenty classes of which the number of exhibitors are given above, as a fifth of the whole, we shall arrive at nine or ten thousand, which is little short of the total of 1855, which was 10,950, without Algeria and the colonies; there is no doubt, however, that the exhibition will be far in advance of its predecessor; and if, as is understood, the admission juries have, in accordance with the principles laid down by the Imperial Commission, set up a much higher standard of admission than formerly, a diminution of the number of exhibitors will be an immense advantage in every respect. It may be taken for granted that there will be no space to spare on the French side of the exhibition, and that the quality will be in keeping with the quantity. In looking over the lists many important names are not missing, and certainly the trades for which Paris and its neighbourhood are celebrated will be well represented. The same remark applies to those great industries such as the cotton and hosiery trades; and there is no doubt that, whatever may be the number of exhibitors, the productions will show not only a considerable advance since 1855, but even since 1862. Since the preceding was written the list of admitted exhibitors in the class of manufacturing machinery has been inspected, and it appears that they amount to very nearly four hundred, and include the first firms in the empire.

The Imperial Commission attaches great importance to the tenth and last group in the classification adopted, namely, that which has for its object the improvement of the physical and moral condition of the population. The group is divided into seven classes, devoted to:—Materials and methods of infant education; books and materials for adult education; furniture, clothing, and food, distinguished by utility combined with cheapness; popular costumes of various countries; specimens of cheap, convenient, and healthy houses; productions of all kinds, manufactured by working men, having their own shop, and only assisted by their own family or one apprentice; and tools and methods employed by these little masters; forming together a complete economical exhibition.

As regards the products of master workmen, the Imperial Commission desires to see represented an important phase in the life of working men—that in which a man has arrived by his talent to the position of small master, and may hope at some future day to be at the head of a large establishment.

The class will include all kinds of productions, the only general characteristic being the conditions of their productions. Working men in visiting exhibitions have often seen the admiration of the public excited by the productions of their own hands, but which bore no trace of their name, and regretted that they could not exhibit objects conceived and executed at their own homes,; or, rather, perhaps, it should be said, that special facilities were not afforded them for that purpose; the Commission has therefore created a class in which every object shall be the production of an artizan, with or without the aid of his family and an apprentice, either for regular trade or sale.

In other classes of the exhibition the articles will be showed under the name of the manufacturer who has arranged for their production and assured their execution, but in the class under notice every article will reveal the hand of the actual producer.

Many small masters, who work at home for manufacturers, have feared to give offence to their employers by exhibiting on their own account, but the new classes introduced into the programme of the coming exhibition have been sanctioned by the manufacturers who take part in the management, so that it is hoped all jealousy will be done away with; and the object in view has been made known by various means of publicity in all parts of the empire, and special committees have been formed in the Departments, as well as in the capital, to carry out the project.

The productions in question are to be submitted to five committees of admission, and the whole of the articles accepted for exhibition will be exhibited previously, and privately, in the *Palais de l'Industrie* in the Champs Elysées, the Imperial Commission bearing the expense of their display in the preparatory exhibition, but the exhibitors paying for their own fittings in the Universal Exhibition itself. In order to make place for this preliminary exhibition, and for other operations connected with the exhibition, the collection of Algerian and colonial products, and all the fittings used for the exhibition of cattle, are now being removed from the building in the Champs Elysées. The Offices of the Imperial Commission are at present in this building, and some departments will be retained there during the whole time of the exhibition, and this, with what we have stated above, shows how valuable it is to have such an edifice always ready for exhibitions of moderate extent, or for the preliminary and supplemental service of a great exhibition like that of the coming year. It should be mentioned, too, that in order to assist working exhibitors as much as possible, it is arranged that, in case of large articles, a deputation from the committees of admission will examine them in the workshop of the producer.

The works of fine art intended for the exhibition of 1867, limited to such as have been produced since 1855, are also to be collected in the Champs Elysées building, by or before the 15th of October; the jury of admission will commence its examination on the 10th of November, and announce its decisions by the end of the year. Great dissatisfaction has been caused by the very early dates fixed for this examination, as the works received for exhibition will thus be lost to their owners for twelve months, and it is feared that these regulations will have a damaging effect on the art portion of the exhibition; certainly five months seems a long period for selection and arrangement.

As regards foreign countries, much of the anxiety that was felt a short time since has passed away. It is certainly to be feared that the manufacturers of Bohemia, Moravia, and other countries, will not make such a show as they would have done had not the war interfered with all their operations, but both Austria and Prussia have supplied the Imperial Commissions with the plans of their space and the list of their exhibitors.

As regards Spain, the government has formally announced its intention to take part in the exhibition, and has supplied its plan and a list of exhibitors, and intends to erect in the park some structures of considerable extent and importance. The Spanish Commission has issued pressing circulars to the local representatives on the subject.

The war in Italy will probably have an unfortunate effect on her manufacturers, but the Italian Commission has furnished the designed for the façade of its portion of the building, and is about to commence its constructions in the park.

Switzerland is expected to be very well represented. Its section will be characteristically decorated with a façade in ornamental work, composed of pine wood, and bearing the escutcheons of the twenty-two cantons. She will have, amongst other things, curious archæological and ethnographical collections, and a comple te series of the picturesque costumes of the country.

Egypt will present a very remarkable exhibition; a quadrangular building, with a colonnade all round, about 85 feet long by 60 broad, is being raised in the park, and will contain some of the most curious objects of art and antiquity in the country. This building will be a reproduction of the Ptolemaic temple dedicated to Hothor, with the greatest possible exactitude in all the details, and the execution of it has been entrusted to the learned Mariette Bey. Amongst the most interesting monuments and representations to be exhibited are—Ceremony of offerings to the gods, by Ptolemy; an authentic likeness of the famous Cleopatra, found by Meriette Bey last winter in a cavern at Denderah; bas-reliefs of various handicrafts, classed according to date; artistic representations of the epoch of the pyramids; the bas-reliefs from the tomb of Phtah hotép (Saqquarah), representing the deceased surrounded by his people, hunting scenes, combats of lions and buffaloes, fétes and dances; bas-reliefs from the tomb of Ti, with scenes of rural life and labour; representation of various trades and arts, the navigation of the Nile, and other subjects, under the various dynasties; reproductions of the famous bas-reliefs and paintings of the Temple of Abydos, with a number of original statues and works of art, coffers and other objects. In addition to this large building, there will be two others illustrative of modern Egyptian life—one representing the habitation of a fellah of Upper Egypt, with a small establishment for artificial hatching, a stable of dromedaries armed and caparisoned for war, and other animals, and an ethnographical collection; the other a horeshoe-shaped kiosk, in the purest Arab style, surrounded with plants and flowers of the country.

Outside of the kiosk native Egyptians will be seen practising the trades of the present day. In the interior of the kiosk will be a divan for the Viceroy of Egypt, who is expected to visit the exhibition, and an Oriental café, furnished with all its accessories. In the court will be a large plan, in relief, of the whole of Egypt, executed by order of the Viceroy, and under the direction of Colonel Mircher, the chief of the French mission in Egypt, and in the centre a fountain, composed of the alabaster of the country.

It will not be out of place to conclude this notice of the coming exhibition with the results of an inquiry into the sanitary condition of the mass of workmen employed on the works on the Champ de Mars. It appears that there has been no great agglomeration of population in the neighbourhood. Down to the 1st of April the number of persons employed did not exceed 800, but since that period it has increased to 1,477. Of these 472 live in distant quarters of the town, 300 belong to the establishment of Mar, Cail and Co., and make part of the resident population of the quarter in which the works are situated, and that of the whole number only 438 form an addition to the neighbourhood. The lodgings of these last, have been frequently visited, and found to be in a satisfactory condition as regards health; and as the greater portions of these men are masons, whose work is finished, 300 of them have already been discharged. The result is, that the accumulation of this large number of men on one spot has not given rise to any notable change in the condition of the quarter. This enlightened watchfulness for the well-being of the labouring classes reflects great credit on the authorities, and offers a valuable hint to those other places where large undertakings interfere with the temporary or permanent condition of the district.—*Journal of the Society of Arts.*

ROUTES OF COMMUNICATION WITH INDIA.

By Captain H. W. Tyler, R.E.

The development of science and of steam-power has already done much to improve the communication between this country and India. The Duke of Wellington, when he was first ordered with the 33rd Regiment to the East Indies, being unable to proceed with them from ill-health, followed them in a fast sailing frigate, and overtook them at the Cape of Good Hope, and then went on with them to India. Again, on his return from India, he embarked at Madras in the year 1805 for England, and was five months on the voyage, one month of which he spent at what he called "the beautiful and salubrious island of St. Helena," destined afterwards to be the prison and the burial-place of his great rival. He almost lived long enough to see troops sent out in as many weeks by what is called the Overland route to quell the great mutiny in India.

But this route from England to India is not only a way for the thirty millions of the United Kingdom, and the two hundred millions of India, to pass from one to the other, but it is a highway between Europe and Asia—between all the nations of Europe, except perhaps Russia, and all the countries of Asia. And whatever amount of traffic may exist upon that highway at present, there can be no doubt that as greater facilities of communication are afforded, an increase will occur which at the present time we can hardly contemplate.

It is my task now to show how those facilities can be afforded. In the first place, I will quote a few statistics. The figures have been taken out by Mr. H. R. Lack, of the Board of Trade, from Board of Trade Returns, and are a summary of imports and exports between the United Kingdom and France, on the one hand, and India, Ceylon, Singapore, China, and Japan, on the other.

In the year 1860 the value of the total imports from India to the United Kingdom was £15,000,000; but it rose in 1864 to £52,000,000. In 1860 the exports were £17,000,000; in 1864, £20,000,000. The former were carried in 527,000 tons of shipping in 1860, as against 731,000 tons in 1864. From Ceylon our imports increased from £2,274,000 in 1860 to £3,173,000 in 1864, while the exports to Ceylon from the United Kingdom increased from £711,000 in 1860 to £822,000 in 1864. From Singapore and the Eastern Strait settlements the imports have increased from £1,000,000 in 1860 to £2,000,000 in 1864; while the exports to those settlements decreased from £1,718,000 in 1860 to £1,230,000 in 1864. The imports into the United Kingdom from China increased from £9,323,000 in 1860 to £15,548,000 in 1864; but the exports decreased from £5,000,000 in 1860 to nearly £5,000,000 in 1864. There was very little traffic from Japan in 1860, the imports from that country amounting to only £127,000; but they rose to £1,500,000 in 1864. The imports from Egypt have nearly doubled themselves, having increased from £10,347,000 in 1860 up to £19,602,000 in 1864. The increase of imports from the East and from Egypt during those years has been owing, in a great measure, to the importation of raw cotton, in consequence of the American War, while the decrease above referred to, occurred from diminished manufacture of cotton goods. To give an idea of the trade of France with those regions, I may state that the imports into France from the British East Indies rose from 57,000,000f. in 1860, to 117,000,000f. in 1864; while the exports from France to the British East Indies fell from 10,000,000f. in 1860 to 9,000,000f. in 1864. The imports into France from China rose from 2,800,000f. in 1860 to 21,000,000f. in 1864; while those from Egypt rose from 23,000,000f. in 1860 to 101,000,000f. in 1864.

The principal, or almost the only, articles brought from India, and through Egypt, by the overland route, up to the end of 1864, were precious stones, bullion, raw silk, and silk goods; the raw silk being worth about £2,240 a ton, and elephant's teeth about £600 per ton. But great quantities of raw cotton have since been carried. along that route, and it cannot be doubted that both the number of articles and the quantity transported will, as already stated, very much increase as greater facilities for communication are afforded.

All this merchandize, between the East and the West is carried by two main routes—the nine-thousand-mile route round the Cape of Good Hope, and the six-thousand-mile route by the Mediterranean, a large proportion of that by the shorter route, being conveyed in the vessels of the celebrated Peninsular and Oriental Company. To show the magnitude of the operations of that company, which has been established for a quarter of a century, I may remark that it has a total capital of £3,248,000, with a surplus, which is its Reserve Fund, of £458,000. The gross receipts for the twelve months ending the 30th September, 1865, amounted to £2,136,000. The insurance, wear and tear, and depreciation, for the same period, amounted, in round numbers, to £1,976,000 leaving a net profit of £159,000; and the chairman stated at the last half-yearly meeting of the Company, that which gives a very good notion of the extent of their operations, viz., that the rise in the price of food had affected them very materially, because they had no less than "ten thousand stomachs to fill every day." The navigation of the Company for the twelve months extended over 1,500,000 miles, and they possess altogether a magnificent fleet of 63 vessels, with a Customs' measurement of 92,353 tons, and 18,270 horse-power. Some idea also may be formed of the increase of traffic which we may expect from Eastern countries if I state what is now occurring on the railways in India. There are as yet in India less than 3,500 miles of railway. The two principal lines are the East Indian Railway, running from Calcutta to Delhi, with a branch under construction to Jubbulpore; and the Great Indian Peninsula Railway running from Bombay to Jubbulpore in the north-east and from Bombay to Madras in the south-east. Of the East Indian Railway, from Calcutta to Delhi, which has cost about £20,000 a mile, 1,200 miles are completed, and the traffic has reached from £38,000 to £40,000 a-week. The Great Indian Peninsula Railway from Bombay to Jubbulpore and Madras has only been half completed, about 624 miles being open for traffic; but that line is being constructed at the lower figure of £13,000 a-mile, while the weekly traffic upon it has amounted to as much as, and in one case has even exceeded, that on the East Indian Railway. In fact, the traffic on the Great Indian Peninsula Railway has nearly trebled itself as between some of the first few weeks of last year and the corresponding weeks of this year; and if the receipts go on at the present rate, it promises to be not only one of the best paying railways in India, but one of the best paying railways in the world.

When this line is completed to Jubbulpore on the north-east, and to the Madras Railway in the south-east, and when the East-Indian portion is completed to Jubbulpore also, there will be complete railway communication between Bombay and Calcutta and between Bombay and Madras, and these lines being main routes, Bombay will necessarily become *the* port of India. In dealing with my subject, therefore, I shall consider the two ends of my grand route as being England and Bombay. That route naturally divides itself into two parts, the one part being from England to the east of the Mediterranean, and the other part from the east of the Mediterranean to Bombay.

Of the different routes between England and the east of the Mediterranean, the first which claims our attention is that by sea from Southampton to Alexandria, which is 3,000 miles long, and which occupies about thirteen or fourteen days. There can of course be no shorter sea passage than this to Egypt. The only question is, whether the ports of Plymouth or Falmouth might not be used with advantage instead of Southampton. There are strong opinions in the minds of many upon that point. Another question to which I shall have hereafter to refer, is that of the Suez Canal. When the Isthmus of Suez is once cut through by a navigable ship canal, there can be no doubt that it will complete an excellent sea-route between Bombay and England, by which merchandise may be carried in steamers without transhipment, and with a saving, as compared with the route round the Cape, of 3,000 miles.

The next route is that by Marseilles. The distance from London to Marseilles is 853 English miles, and from Marseilles to Alexandria 1,460 nautical miles, in all about seven days and 18½ hours. Whatever route we take we can hardly take one which has a much shorter mileage, though we might take one, as I shall presently point out, which will be more advantageous in point of time.

The first question on that route is how we can get over, or under, the straits of Dover. One scheme has been brought forward, even this year, for a tunnel under the Channel—from Dungeness to Cape Grisnez. Extravagant as the idea may now appear, I have no doubt that a tunnel will some day be carried out. There are eminent engineers now working upon it. It is believed that the whole of the ground under the sea is composed, if not of chalk, of materials, at all events, which will not be anything like so tedious or so expensive to bore through, as the tunnel which is now being constructed through the Alps, though the length is 20 miles against 7⅓, and there might be difficulties as to water, which in the Alps have not hitherto been encountered. Another scheme was brought forward this year, of employing very large boats for crossing the channel. The trains were to run from the pier to those boats, and to be ferried across in a complete state. I applaud the idea of larger boats than we have at present, for having made the passage frequently in rough weather, I can speak from experience as to the disagreeables of it; but if I am to have a big boat at all, I should prefer to walk about it, rather than to sit in a railway carriage during the passage. At the same time these large boats may be very useful, in transporting waggon-loads of merchandise for saving transhipment.

On this route occurs, also, the very disagreeable passage across the Gulf of Lyons, between Marseilles and Malta, and it is now proposed to avoid that passage by the route *viâ* Brindisi or some other Italian port. Three years ago the Government of Italy entered into a convention for the employment of steamers from Ancona * *viâ* Brindisi to Alexandria; in May last the railway was opened to Brindisi; and Brindisi has thus become the nearest accessible port to Egypt. If you look at the map, you will see that 638 nautical (or 734 English) miles of sea may thus be saved, by substituting for it 651 miles additional of land-journey; and, inasmuch as we may travel more than twice as fast by railway as by steamer, it is obvious that an important saving of time may thus be effected. But it is as yet undecided whether Brindisi, which is out of the line of steamers from Marseilles to Egypt, would be upon the whole the most convenient port from which to embark, and there is a break in this journey at present, where the Alps lie across the railway. The diligence takes in summer eight or nine hours, and in winter 10½ hours, when the weather is good, for crossing the Mont Cenis; but at times, during bad weather, the diligence is not able to go at all, and at other times, as many present are no doubt aware, the journey is made in sledges. To obviate this delay in the means of communication between France and Italy, the "grand tunnel of the Alps" is now being constructed. This tunnel, which was commenced in 1857, is 7⅓ miles long, of which distance headings have been driven through less than 3½ miles, while upwards of four miles remained at the latest accounts to be pierced. The whole line from St. Michel, on this side, to Susa, on the other side, will be about forty-two miles long. It is from beginning to end a difficult line, in an engineering point of view. There are many other tunnels on it besides the "Grand Tunnel," which it has not yet been thought worth while to commence. The gradients are as steep as 1 in 28 in places; and even half through the "Grand Tunnel" the gradients is 1 in 45½. The summit of this tunnel will be at an elevation of 4,500 feet above the sea, and the total cost of these 42 miles of railway will be £5,376,000.

The excavation in the tunnel is carried on by machinery, worked by means of compressed air. Outside the tunnel, and a short distance from it, there are half-a-dozen large water-wheels, by the action of which the air is compressed to a pressure of five atmospheres; and the compressed air being taken into the tunnel through a pipe, is used at the face of the excavation to work a most ingenious machine, which was originally contrived by Messrs. Sommellier, Grattis, and Grattoni, and which has now been working there for some years. There are nine jumpers working against the rock, kept in motion each by two cylinders, the one cylinder causing the jumper to twist round, and the other propelling it forward. They thus imitate the action of jumpers worked by hand, and bore holes ten, or twenty, or thirty inches deep, according to the nature of the rock. Then other holes are bored; and when a sufficient number have been made, the machine is run back 200 or 300 yards, and powder is inserted, tamped and exploded in the usual way. As soon as the explosion has occurred, the material is thrown into waggons, and run back as rapidly as possible; and the machine is brought up again, and set to work as before.

But there are some difficulties with regard to ventilation. About 200 yards behind the machine there is constantly a dense column of smoke and the products of combustion; and in walking into and out of the tunnel you find practical experience on this point by the way in which your clothes, face, and hair are blackened. It takes as much as two days to clear the tunnel out, and purify the air, when no work is going on. It did so, at least, when I was in the tunnel last spring. They were then progressing at the Modane end at the rate of as much as one mètre and a-half per day; but since that time they have come, as was then expected, to very hard, solid, quartz rock, and they find great difficulty in getting through that rock. Their progress lately has been at the rate of half a mètre a-day. There is believed to be about 500 mètres of this quartz rock, followed by compact limestone, which will, it is expected, be more easy

* These steamers of the *Adriatico-Orientale* Company now run between Brindisi and Alexandria only.—H. W. T.

to deal with. Looking to the quantity and quality of rock to be bored through, and to the rate at which the work will probably progress, it may be estimated that this tunnel will not be completed, perhaps, for six or seven years.

In consequence of the time which it will take to complete this tunnel, the idea has been conceived of constructing a temporary railway over the top of the Mont Cenis. There is a very good road over the mountain, along which it is proposed to lay this railway. The total elevation of the pass is 7,000 and of the mountain 11,000 feet. When Mr. Fell went three or four years ago to examine it, with the view of taking a railway over it, he found it too steep for any ordinary railway worked in the usual way, and he was therefore obliged to adopt a new system, the principle of which I will now explain. In ordinary railway working we trust, as you are aware, to the adhesion between the vertical driving wheels of the engine and the bearing rails of the permanent way, as the means by which the steam-power is applied to propel a train. And in order to get extra adhesion to take heavy loads up steep gradients, we are obliged to increase the weights of our engines, and the number of their driving wheels, in proportion to what we require. But in mounting a gradient of 1 in 12, with bad adhesion, such as you are liable to on the Mont Cenis, sometimes not more than one-tenth, or even one fifteenth, an engine, ever so heavy, would only be able to take itself up, with perhaps a very light train. So Mr. Fell has thrown off extra weight, and made an engine partly of steel; and he has employed for extra adhesion, a central rail, laid in the centre between the other two, with horizontal wheels on the engine to bite upon it, and so pinch their way up the incline. His second engine weighs 17 tons, which, added to 24 tons of pressure between his horizontal wheels and middle rail, affords a total adhesion of 41 tons; and it will do the work, therefore, on steep gradients and slippery rails, of an ordinary engine weighing 36 or 40 tons, without being killed—so to speak—by its own weight.

Mr. Fell first tried this system,—which was patented so far back as 1830, but had never been reduced to practice,—at Whaleybridge, with the assistance of Mr. Brassey, in this country, and the experiments there were so successful, that he then constructed an experimental railway on the Mont Cenis, which has been worked now for many months with great success. About 20 minutes' walk above Lanslebourg, where the ascent of the Mont Cenis commences, he has constructed a mile and a quarter of railway, on the zig-zags of the steepest part of the mountain. The steepest gradient on it, is 1 in 12, the average gradient 1 in 13. The curves are very sharp, with a radius of only 40 mètres, or 131 feet, round the corner of the zig-zag. On this experimental line, with his second engine, he has taken up a weight of 16 tons, which is equal to 50 passengers with their luggage, at the rate of 8 miles an hour; and there is no doubt he will be able to run without any difficulty for the 48 miles which he has to traverse with his railway, in four hours; whereas it takes twelve by the diligence in bad weather, and eight hours in the best of weather.

There will be nine miles and a half of covered way on the mountain, to avoid any risk from the action of snow and avalanches, and that the traffic may be worked punctually and with safety in the worst of weather. One very important element in the system, is the greatly increased degree of safety that may be obtained. The central rail, properly applied, will prevent the possibility of a train running off the line; and you may easily conceive that it is most important to have this extra means of safety round very sharp curves, and at the edges of precipices, on the slopes of the Mont Cenis. In fact, the engine wheels have on more than one occasion mounted the bearing rails on the experimental line when the permanent way was not in good order; but the action of the middle rail was sufficient to bring them on to the rails again. In running down this railway at first, it feels—so to speak—rather like sliding down the roof of a house; but the breaks acting upon the middle rail afford a powerful means, in addition to the ordinary breaks, of stopping the train; and I have seen the experimental train, travelling at the speed proposed to be employed, brought to a stand within a dozen yards on the steepest part of the slope.

Another advantage of the system is its great economy. This summit railway will be constructed at a cost of only £8,000 a-mile, in the place of £128,000 a-mile, which the tunnel line will cost; and it will be constructed in two years instead of—say fourteen or fifteen years, which will probably have been expended altogether before the tunnel line can be finished. But even if a permanent line were constructed over the mountain at a cost of £20,000 a-mile, or twice and a-half as much as this temporary line will cost, and if you add an extra amount to cover the working expenses, which will, of course be additional in carrying the traffic of the summit railway over a super-elevation of 2,500 feet above the highest point of the tunnel line if you capitalise that extra cost of working at the rate of 6 per cent.—you will even then save as much as £4,000,000 out of the £5,376,000 which, as I have already stated, the tunnel line will cost. But the economy is still better shown in this way—that summit railways might be constructed over all the Alpine passes—over the Mont Cenis, over the Simplon, over the Saint Gothard, and Luckmanier or the Splugen, for the same money as this one tunnel line will cost.

Many other systems have been advocated for taking trains up steep inclines, amongst which I may mention the screw system of Signor Grassi. He proposed to place under his engine, connected with the crank-axle, an Archimedean screw, which was, as it twisted round, to work upon rollers fixed between the rails of the permanent way; and the adhesion of the screw upon the rollers was intended to take the place of that between the wheels and the rails as the engine screwed itself up the incline. I may mention also the pneumatic system, which has many advocates, both in England and on the Continent, who suppose it to be suited for very steep gradients. This system may probably be used with advantage for underground lines, of more moderate gradients, where you are obliged to have tunnels, but it is not so well adapted for very steep gradients on account of the loss of power, and therefore greater expense of working, under increased pressure.

Then again, there is the system of Signor Agudio, which is in great favour with the Italians, and is entirely a system of ropes. He places a stationary engine at the top of his incline, and a second stationary engine at the bottom. He has one double endless rope passing between them, which is continually worked, the ascending portion by the upper, the descending portion by the lower engine; and a second rope between the two portions of the endless rope, called the cable of adhesion, which is fixed at the top and weighted at the bottom of the incline. He employs, also, a machine which he designates as the "*locomotive funiculaire*" at the head of his train. The endless rope works upon this "locomotive," and turns certain wheels upon it, the rope running about two and a half times as fast as the "locomotive" goes with its train up the incline. The wheels turn certain drums upon the "locomotive," which have two and a half turns round them from the cable of adhesion; and by the rotation of these drums in the cable of adhesion, the "locomotive" machine winds itself and draws its train up the incline.

There would be serious difficulties in the application of this system to very high mountain passes, in consequence of the difficulty of working them when the ropes are enveloped by snow and ice; and you have not the safety in such a rope system that may be derived from the central rail. Another important point is that under the system of Signor Agudio and very sharp curves which are necessary on the railway over the Mount Cenis are impossible.

Another route which we must now consider is the Trieste route. This is 260 miles shorter by sea, but 369 miles longer by land than the route by Marseilles; and, therefore, it may be rather a quicker route. But now that railways have been constructed down to Brindisi, few people will be inclined to embark at Trieste or even at Ancona.

Two other routes have been proposed which are, perhaps at present, hardly worth considering. The one is from Belgrade to Constantinople, which will be a difficult railway route to construct, and the other is by Avlona, oppposite Brindisi, and so by land to Constantinople. Another difficulty about both of those routes at present is, that even when you reach Constantinople, you have a very difficult country again to cross through Asia Minor; and it will probably be some time before railways are made through those countries.

The route, then, by Italy is the quickest route which we have any immediate chance of using. The railway over the Mont Cenis will probably be brought into use in the course of next year; and I may say that it is under the consideration of Government to send the Indian mails by Italy if they can make proper arrangements for it, as regards the railways and harbours.

I now turn to the other side of the map, to the route from the east of the Mediterranean to Bombay.

The sea route from Suez to Aden and Bombay is about three thousand miles long. The navigation is difficult, and at times very disagreeable. By way of improvement to this route, the Suez Canal is, as every one knows, now being constructed. M. Lesseps proposes to make across that isthmus a ship-canal seventy-two miles long. He neglects the routes taken by the Pharoahs of old, which were connected with different branches of the Nile, and goes straight across from Port Said in the Mediterranean, to Lake Timseh (which was dried up until very lately) half way, and so on to Suez. The channel of this grand ship-canal is to be twenty-six feet deep, one hundred and ninety feet wide at the top, and one hundred feet wide at the bottom. He has already constructed a *rigole*, or small canal, about six feet deep from Port Said to Lake Timseh. The part from Lake Timseh to the Red Sea has hardly been commenced, or at all events very little has been done upon it. But a sweet water canal has been constructed from a place called Zagazig, from a branch of the Nile towards Lake Timseh and near it, and from thence nearly parallel to the line of the permanent canal to Suez. This sweet water canal is nearly finished, sixty feet wide and six feet deep; but it is about nineteen feet higher than the Salt water Canal; and he has by means of locks connected the two together. He is able thus to convey boats, by using the rigole to Lake Timseh, and the sweet water canal to Suez, all the way from the Mediterranean to the Red Sea. There is little doubt, I think, that the great energy of M. Lesseps, and the credit of the French Government, who are backing him up, will lead to the completion at *some* time of this canal. But there are still great difficulties to be encountered on parts of it. The foundations are in some places very bad, and as fast as he digs out the mud and sand, so fast does the excavation fill up again. He proposes to make walls all along the sides; but to get foundations for those walls will be exceedingly troublesome, and they will take a great deal of time and money. He has also, which are less difficulties, very high hills of sand to excavate. He is evidently going about this in a very energetic way, for I heard not long ago of a hundred steam-dredges having been ordered to Egypt for the excavations. With these he intends, no doubt, to compensate as well as he can for the want of the forced labour, of which at first he had the advantage, but which he has since been deprived of. Twenty of these steam-dredges were recently landed from a ship that was obliged to put back into Falmouth in distress. They were constructed to work to a depth of about twenty feet, with portable engines, so that when the dredges had done their work the engines might be employed for other purposes.

There has been much political feeling on the subject of this canal, which has been supposed to be hostile to British interests. But it will certainly, if it is completed, be of much more use to us than to any other nation; and I think that we ought to feel very much obliged to M. Lesseps and the French Government, for expending so much money in the hope of making it for us. As long as we have command of the sea it will be entirely at our mercy at both ends; and it will, if it is completed, give us a most excellent ship route to the East, by connecting our Southampton and Mediterannean route with our Suez and Bombay route. But it is a question whether it will ever be of much use to sailing vessels in consequence of the difficult navigation of the Red Sea.

The Egyptian Government also have an idea of making a railway 1,700 miles long, from Suez to Cape Guardafui. Such a railway may be important for Egypt, but I doubt whether it would ever be of much avail for British traffic, because it is a long line, about twice as long as another and a better, to which I shall have directly to point; and because it would bring us out at the wrong side of the Arabian sea.

The next and last, but by no means least important route which I have to consider, is that by the Euphrates Valley. The first discoverer of that route may fairly be said to have been Alexander the Great, who marched from Egypt to the Valley of the Euphrates, and so on to Bagdad, wintered at Bokhara, conquered Persia, took possession of India, sighed for more worlds to conquer, and returned with the remnant of his sickened army, after a march of nearly 20,000 miles, to die in the Lamlum marshes. Many others have since followed or attempted to follow his example, and it is well known that the Great Napoleon, when he went to Egypt, had an idea of doing the same—of wresting India from us, and conquering the East; and he would, no doubt, have endeavoured to carry out the project, if we had not nipped it in the bud in Egypt.

This route was reconnoitred by General Chesney in 1830, when he made a most enterprising and interesting voyage of 700 miles, with an interpreter and a servant down the Euphrates. £20,000 was afterwards voted by Parliament for a regular survey of this route, which was made, under General Chesney's command, by Sir John Macneil and others. I have been glad to learn recently from General Chesney, that the Treasury have authorised the publication of another volume of his proceedings. The result was a proposal to make a harbour about three miles to the south of the Orontes river, and they chose, as the best route for a railway that by Antioch and Aleppo, down the Euphrates, on to Bagdad, and so the Persian Gulf. The harbour was to cost £350,000, and the railway about £6,000,000. They found that the route would be an easy one. There were a couple of bridges required over the Orontes river, and some cuttings between the Orontes and Aleppo; but the line from Aleppo down to the Persian Gulf was stated to be principally over flat, dry, level ground, that would present every facility for a railway. There is a steamer already running between Basrah and Bagdad. The navigation through and from the Persian Gulf would be far superior to that from Suez by the Red Sea; and there remains the possibility of ultimately completing the communication by railway from Bagdad *viâ* Kurrachee to Bombay.

By the adoption of this route we should save about 800 miles of distance, and several days of time. There can be no doubt that it is a most important route, in a strategical as well as in a commercial point of view, for ourselves as a nation. We should have the command by sea of the two ends of it, in the Mediterranean and in the Persian Gulf, and we should be able by its aid to connect our forces in Europe more intimately with our armies in Asia—to unite them for any operation intermediately between Great Britain and India, and to reinforce Great Britain from India, or India from Great Britain, within a fortnight, whenever we required to do so.

Mr. Bancroft, in a speech that did not exhibit much delicacy the other day in America, accused us of having constructed a chain of forts from Madras to Ceylon. But what we really want, in a military point of view, is a chain of forts along the route of the Euphrates Valley from England to India. There is an idea that we should meet with great difficulty from the inhabitants in making such a line; but it is said by others, on the contrary, that as Englishmen we should on the whole, be well received, while if the Turks attempted themselves to construct the railway they would meet with great opposition—that it would be looked upon in the one case as an undoubted advantage; in the other as another instrument of oppression.

The ultimate route, then, that we should look forward to, practically, at the present time, is that through Italy and by the Euphrates Valley. By this route we may hope to go some day about 5,000 miles in a fortnight.

In concluding, there is another most interesting feature to which I would direct attention. Every reader of prophesy must regard a map of this sort with great interest, when he remembers the predictions that are not yet fulfilled. One can hardly look at it, indeed, without observing that it points in both directions, from the east and from the west, towards the Holy Land. We see and know that the Jews have been and are now scattered from that promised land among all nations; and judging from the completeness with which the prophecies with regard to their banishment have been fulfilled, we may be quite sure of the punctuality with which those prophecies will also be literally fulfilled which speak so plainly of their reinstatement. May we not, therefore, indulge the hope that in laying out and establishing these routes between England and India, we are really doing something more—that we are contributing in an important degree to fulfil the designs of Providence. Who can read the passage in Isaiah, "Every mountain shall be a highway for my people," without thinking of all the summit railways and grand tunnels that are in contemplation? We are surely in some measure assisting to pave the way for the return of that people to the land to which they will "fly ere long as a cloud, and as the doves to their windows," bringing their silver and their gold with them, and which land they are destined on their conversion to inhabit and to enjoy in future generations.

ON TREATMENT OF MELTED CAST IRON AND ITS CONVERSION INTO IRON AND STEEL BY THE PNEUMATIC PROCESS.*

By Mr. Robert Mushet.

In the year 1815, my father, Mr. David Mushet, took out a patent for the manufacture of refined iron direct from the blast furnace.

For this purpose he erected a small blast furnace, 30ft. high, blown by means of three tuyeres, with a pressure of blast of about three pounds and a-half per square inch. These tuyeres were arranged so as to dip down upon the surface of the melted iron in the hearth of the furnace, and when the hearth was full, or nearly full, the tuyeres were partially below the surface level of the melted iron. There was no difficulty experienced in keeping the melted iron in a liquid state in the middle of the hearth, but round the sides the refined iron chilled, and formed what is technically termed "scull," and this rendered it very difficult, and sometimes impossible, to tap the furnace and run off the portion of the metal which retained its fluidity. When the tapping took place, the metal flowed from the furnace intensely heated, and throwing off the most brilliant scintillations. The temperature of the metal, like that of ordinary refined metal, was far higher than that of pig iron produced under the regular working of a blast furnace. The pigs of metal obtained were perfectly solid, showing, when broken, a dense white steely grain. They were so strong as to bend before they broke, and occasionally they could not be broken at all, though struck by the heaviest sledges wielded by the most powerful men; the metal was, in fact, crude cast steel, and could be chipped with a cold chisel, and, when annealed, was susceptible of being forged at a low heat to some extent. The defect in this process was that, as in the refinery, the waste of metal was excessive, owing to the surface action of the blast upon the melted iron for a prolonged period. The difficulty of keeping the hearth open, and of tapping, arose merely from the small size of the furnace and hearth, and the weakness of the blast. The iron was, however, decarbonised, so as to be in the condition of crude cast steel, too highly oxygenated, however, to be forged into bars of commercial value.

The experiment I have described was, I believe, the first practical step taken in the development of the pneumatic process, though it was certainly not undertaken with any idea of producing either malleable iron or steel by that process, but simply a highly decarbonised refined metal. About the year 1850, I made experiments with some very highly-blown refined iron from the Parkend Ironworks, in the Forest of Dean, and found that, when alloyed with manganese, this refined metal could be forged into sound bars of very hard steel, too hard, indeed, for any practical purpose, but, nevertheless, solid, and free from seams or flaws, indicating that if the iron could be sufficiently decarbonised whilst in the melted state, steel of marketable quality might be obtained by simply adding some metallic manganese to the decarbonised metal.

In the autumn of 1856, Mr. Henry Bessemer read a paper at the meeting of the British Association in Cheltenham, which, whilst it filled the scientific as well as the practical world with astonishment, did not in the least surprise me, except in the one circumstance of its being possible to maintain a tuyere beneath a heavy column of melted cast iron. That, indeed, appeared to me most surprising, as I was well aware of the highly destructive action of the iron slag which is generated by the action of atmospheric air upon melted cast iron. However, what I considered impossible had actually been accomplished by Mr. Bessemer, and the first great advance towards rendering steel as cheap as iron had been inaugurated by that gentleman.

Mr. Bessemer's process consisted in forcing air through melted cast iron by means of tuyeres situated beneath the surface of the melted iron. When melted cast iron is subjected to this process, the silicon contained in the iron is first combined with the oxygen of the blast, and thrown to the surface as a light, frothy, grey slag. Next, the carbon of the melted iron enters into combustion, and, lastly, the iron itself is attacked and consumed with the development of an intense temperature, sufficient to keep the iron, though freed from carbon, in a perfectly liquid state.

When the silicon and the carbon have been nearly or wholly eliminated from the cast iron operated upon, the product obtained is either crude cast steel or iron, according to the degree of decarbonisation arrived at. Ingots cast from this metal are more or less unsound, and, when forged, they frequently crack or break off, owing to their redshortness, and are wholly unfit for the requirements of commerce. Moreover, whenever the melted cast iron operated upon contains sulphur and phosphorus to any notable extent, the decarbonised iron is found to be so crude and brittle that it cannot be forged at all, and is, in fact, less valuable than the pig iron it has been made from. Hence, only the purest coke pig irons of Great Britain are at present suited for Mr. Bessemer's process, and these are comprised in the hematite pig irons, the Forest of Dean pig irons, the Weardale spathose irons, and the Blanavon and Pontypool Welsh brands; these latter two being, however, far inferior to the other brands for the pneumatic process.

Mr. Bessemer naturally inferred that he should be able to produce both cast steel and iron by his process alone, and it by no means detracts from his merits that he happened to overlook the fact that iron exposed in the melted state to the action of oxygen becomes as it were debased. Some persons term it "burnt iron," but I call it "oxygenated iron;" and oxygenated iron can never of itself constitute a commercially valuable article. This oxygenation can be prevented when a metal is present whose affinity for oxygen is greater than the affinity of iron for oxygen, and it can be remedied when such a metal is subsequently added to the oxygenated iron. When Mr. Bessemer read his paper, I foresaw all the difficulties he would have to encounter from oxygenation of his iron, and I knew that the remedy was simple and attainable, provided a suitable metal could be found at such a cost and in such quantities as would render its use practicable on the large scale. Out of several metals possessed of the required properties, I selected the metal manganese as found abundantly in the spiegeleisen or spathose pig iron of Rhenish Prussia, and combined therein with carbon and iron, the iron forming a convenient vehicle by means of which I could introduce the metallic manganese into melted decarbonised iron treated by Mr. Bessemer's process. My first experiment was with some Bessemer metal prepared at the Victoria Ironworks from hematite pig iron. The experiment was made in small crucibles containing only a few ounces, the Bessemer metal being melted in one crucible, and the spiegeleisen in another; the melted contents of the crucibles were then mixed, and a small ingot cast. This ingot was forged into a bar of excellent cast steel, which was doubled, welded, and made into a chisel, and was found for all practical purposes to be cast steel of fair average quality.

I then extended the scale of my experiments, and operated with steel melting pots, containing from 40lb. to 50lb. of Bessemer metal each, and melting the spiegeleisen in smaller crucibles. The most complete success resulted from these experiments, and Mr. S. H. Blackwell having subsequently supplied me with a small blowing engine, capable of maintaining a blast of 10lb. pressure per square inch, I operated upon quantities of melted cast iron of from 500lb. to 800lb., and with similar success, the Bessemer metal being wholly freed from unsoundness, red-shortedness, and other defects which had precluded its being forged or rolled into a marketable product. The British pig irons that I found best suited for the joint processes of Mr. Bessemer aud myself were the Lancashire and Cumberland hematite iron, the Weardale spathose iron, and the Forest of Dean pig iron. Of foreign brands, the Indian charcoal pig, and some manganese pig iron from Sweden gave the best results, though not so satisfactory as those obtained when hematite coke pig irons were employed. I had, meanwhile, secured my invention by means of letters patent, dated 22nd September, 1856. This patent lapsed in 1859, through nonpayment of the stamp-duty of £50, owing to some unaccountable oversight of the trustees to whom I had been advised to entrust my patent rights. My invention thus became public property, and I was deprived by this accident of all remuneration for an invention which every person, practically acquainted with the manufacture of Bessemer metal, will admit to be of immense value.

I speak, no doubt, as an interested party, and my opinion is, therefore, open to criticism; but I venture to submit than an invention such as that described in my last patent, places all

* Read before the British Association, Nottingham, 1866.

who have benefitted by its use under a moral obligation to recognise my claims to remuneration; for although by the accident of the non-payment of the stamp duty my invention became public property, I still think that that accident ought not to debar me from the reward that I am morally entitled to, and could have commanded to so large an extent, but for the oversight of those on whom I relied.

Much remains to be done to extend the use of the pneumatic or Bessemer process to the ordinary brands of pig iron at present considered to be unfit for this purpose. I am, I believe, in possession of the requisite knowledge to accomplish all this, and I am only waiting the opportunity to do so, whenever the Titanic Company, with whom I am associated, shall consider that the proper time has arrived for them to erect a suitable Bessemer apparatus at their works.

The means are, I believe, as simple and efficacious as is the addition of spiegeleisen, now invariably employed by all Mr. Bessemer's licenses in England, and the resulting advantages will be proportionally great.

In Sweden, the Bessemer process has been carried out by operating upon certain brands of Swedish pig iron containing a considerable alloy of metallic manganese; the result is, that with the subsequent addition of a little of the same manganesic pig iron in lieu of spiegeleisen, a workable steel is produced of moderate quality, but too seamy and unsound to be of much value for tools, and not nearly so tough and strong as the Bessemer steel made in this country from our own coke pig irons, and it can never enter into competition with our English Bessemer steel. In treating melted cast iron by the pneumatic or Bessemer process, the simplest plan is to deprive the iron of the whole of its silicon and carbon. In this case, the addition of a given weight of spiegeleisen, or of any similar metallic compound of iron and manganese containing carbon to a given weight of decarbonised cast iron, will ensure results of tolerable uniformity as to the hardness or temper of the steel produced. The effect of adding spiegeleisen to Bessemer metal is as follows :—

The metallic manganese, by its superior affinity for oxygen, de-oxygenates the decarbonised metal, and renders it sound and free from redshortness.

The carbon of the spiegeleisen steelifies the mixture, and improves it when stiff or hard metal is required.

The iron of the spiegeleisen adds to the weight of the charge, and may, therefore, be considered as a gain to nearly the amount of its weight.

The silicon which is found in spiegeleisen has the effect of reducing the boiling or agitation of the pneumatised metal when poured into moulds, and is therefore beneficial, and it is not present to any injurious extent in spiegeleisen.

The hardness or temper of the Bessemer steel may be increased at pleasure by increasing the dose of spiegeleisen.

When spiegeleisen is added to Bessemer metal containing sulphur, and the pneumatic blast is turned on so as to eliminate the carbon and manganese of the spiegeleisen, a portion of the sulphur of the pneumatised iron is carried off by the manganese, and thus, by repeated additions of spiegeleisen and subsequent eliminations of its manganese, pneumatised cast iron may be wholly desulphurised.

In a similar manner, Bessemer metal containing phosphorus may be dephosphorised by employing titanic pig iron in repeated doses to eliminate the phosphorus, and when both sulphur and phosphorus are present, both may be eliminated by sepeated additions of spiegeleisen and titanic pig iron, the pneumatic blast being turned on after each such addition made to the pneumatised cast iron.

The pneumatic process of Mr. Bessemer, in conjunction with my spiegeleisen process, is producing a revolution in the engineering world, and in all the departments of art dependent upon engineering, to an extent almost incredible, and the magnitude of its ultimate effects it is impossible fully to foresee. Mr. Bessemer's name will be remembered in connection with this, the greatest metallurgical invention the world has ever seen; and I venture to hope that I may not be wholly forgotten as having supplied the link which was wanting to render Mr. Bessemer's process what it now is. As I have had much experience in matters relating to the steel manufacture, it was not surprising that I should at once have been able to devise the remedy for the one solitary defect which marred the success of the pneumatic process at its outset.

RAILWAYS AND COMMUNICATIONS IN RUSSIA.

Railways have been for some years the object of special attention to the Russian government. The surveys of projected lines, as well as the works of those in execution, are receiving at the present time a fresh impulse. St. Petersburg, Moscow, and Warsaw are already in communication with each other; and Eastern Prussia and Berlin may be reached by Gumbinnen and Thorn. More towards the south, the Russian line join those of Cracovia, leading to the two Prussian Silesias; and before long the southern line, which at present is opened from Odessa to Balta, will communicate with Bessarabia, a province bordering on the Roumanian principalities, and communicating with the Lemberg railway in Galicia. Another central line, running from north to south, is intended to unite the capital, Moscow, Ozel, Koursk, Kharkov, Nicolaeif, Sebastopol, and Taganrog, and to put the Gulf of Finland into communication with the Crimea. The southern part of this line is intended in the east to fulfil the same purpose as that of the Odessa-Balta in the west, viz., that of bringing to the two ports of exportation, Taganrog and Odessa, the wheat of Ukraine, of Pultava, of Ekaterinoslav, of Knerson, and of Podolia. A branch from the Balta line would no doubt run north-east towards the central part of the Ural. In a few weeks the trunk lying between Moscow and Serpoukhoff will be opened for traffic, and as far as Koursk next year. Supposing she could not, without solution of continuity, carry her products from the Baltic to the Black Sea, she has railways that lead, or will lead within a little, to the frontiers of all her neighbours, from the Pruth to Niemen. Other interior and transversal lines, such as those of Riazan, of Nijni Novogorod, are of great utility, but none more worthy of interest than the two following, intended to form a double communication between the Caspian and the Black Seas. The first of these lines, which is but twenty leagues in length, is in full work. It begins at Tzaritzin, an important town situated on the right bank of the Volga, which falls into the Caspian, and finishes at Kalatcheff, a town on the left bank of the Don, which falls into the Sea of Azof. The second of these lines is due to the energy of the Grand Duke Michael, Governor-General of the Caucasus. A line of railway is likewise intended to unite the port of Poti, on the Black Sea, with that of Bakon, on the Caspian Sea, passing by Koutaïs and Tiflis; the line follows principally the valleys of the Rion and the Kour. For the last two years six thousand soldiers have been employed under the direction of Mr. Bailly, an English engineer. The port of Poti is now the site of important works, which will make it the principal port of the Black Sea in these parts. Besides this, the organisation of a direct service of steamboats with Constantinople, and the establishment of a good carriage-road between Tiflis and Tauris, is in contemplation. Merchandise from Persia and Central Asia will probably follow the Russian lines, and it may be foreseen that the Transcaucasian line will almost completely absorb in these parts the traffic between Europe and Asia.

Reviews.

English Mansions, Lodges, Villas, etc.; being a Series of Original Designs, with Plans, Specifications, and Estimates illustrating the Requirements of Modern Architecture. By Frederick Rogers, Architect. London: Atchley and Co. 1866.

The work before us consists of sketch plans and views of a considerable number of small and large residences, together with memoranda descriptive of the proposed kind of construction, and intended to aid in the preparation of complete specifications. The work, however, does not aim at so complete an illustration of the subject as to enable the building to be carried out without professional assistance. The sketches are executed in a clever and effective manner, and several of them are highly picturesque, while others are broadly and simply treated. The style generally used is more or less mediæval in character; such as combines well with the irregular levels of sites and the varied outlines of country scenery. The materials intended to be used are chiefly those which may be best available in localities where such buildings are likely to be erected. The plans contain several useful combinations of rooms, and are such as the architect may advantageously study. The views being in perspective, give that clear and ready idea of the grouping of parts which is valuable to architect and amateur alike.

This is a useful addition to the many works on the not easily exhausted subject of English residences, rural and suburban.

BURLINGTON HOUSE.

The space of ground at the back of Burlington-house is apportioned between the London University and the Royal Academy, and the former has commenced operations. Trees are felled, and the ground is levelled for the foundations. The moiety of Burlington-gardens which falls to the University will give a spacious, and yet quiet and secluded frontage towards Cork-street and Burlington-street. Mr. Penethorne's designs for the building, with the exception of some final details, are now prepared. He had, in the first instance, presented to Lord John Manners' a classic façade, but, at the request of the First Commissioner of Public Works, the design ultimately adopted was made. The style is transitional. The elevation consists of a centre and two wings; in the latter are two spacious lecture-theatres; the examination-rooms, &c., occupy the main body; the entire ground plan covers an area of about 220 feet by 150 feet. The treatment, though allied to Italian Gothic, is yet independent and individual: no one model in Venice or Lombardy has been implicitly followed; on the contrary, the whole design has been adapted to exigencies of climate, demands of utility, and the resources of local materials. For the marble architecture of Italy will be substituted a stone architecture, which may be more in keeping with immediate surroundings, and the cheaper and ruder material will be so employed as to secure polychromatic display. The adopted Gothic, too, admits of varied sky outline: a steep roof, and a couple of lofty campanile will present a bold profile. The parliamentary estimate is £65,000, of which £20,000 was voted last session as a first instalment. The remaining moiety of the gardens, that adjoining Burlington-house, has not yet undergone any marked change under the hands of its present owners, the Royal Academicians. It is understood that the Academy will avail itself of the advantages offered by the Government. One of the body, Mr. Sydney Smirke, is entrusted with the making of plans for new galleries. Under present arrangements, the façade of Burlington-house, which the Institute of Architects and their President, Mr. Beresford Hope, made efforts to save, will remain intact. The effective Doric or Palladian colonnade, however, that rounds off the area on the side next Piccadilly, and which some deem the best part of the architectural composition of the celebrated amateur, the Earl of Burlington, appears still in danger. The works are committed to the care of Mr. Pennethorne, Mr. Sidney Smirkes, and Messrs. Banks and Barry.

ST. JOHN'S CHURCH, WOLVERHAMPTON.

The church of St. John, Wolverhampton, is a noble specimen of the style of architecture which prevailed in England a century or so ago, after the Wren revival, which is about the date of its erection. A font of beautiful proportions has just been erected at the west end of the centre aisle, and has been so designed as to harmonise with the character of the building, without strictly following the rules of orthodox classic detail. The main form of the font is circular, flanked by four columns of rich Devonshire marble, having capitals of the Corinthian type, conventionally carved. In the leafage of these are introduced the rose, lily, passion flower, &c.; while a corresponding enrichment encircles the stem of the bowl itself, and serves with the base mouldings to give variety to the effect. Above each of the four capitals is a circular sunk panel, containing a Maltese cross and other devices, executed in different coloured marbles; and around the rim, in the spaces between these panels is inscribed the following text, in incised letters—"One Lord, one Faith, one Baptism—Amen." Below this text, a belt of inlay marbles, composed of griotte and Irish green, in patterns, with jewelled centres of spar, crystal, and malachite, surrounds the bowl, and adds greatly to the blending of colours and richness of the effect. The general material of the font is Caen stone; and it stands upon a red Mansfield-stone step, round which plain, coloured, and glazed paving tiles are laid down geometrically in the aisle, which has been widened at this spot for the purpose, so as to form a suitable platform for the whole.

The work throughout, with the exception of the carving, which is by Farmer, of London, has been very carefully executed by Messrs. G. and F. Higham, of Wolverhampton, from the designs of Mr. J. Drayton Wyatt, Architect, London.

ON THE HEIGHT OF ROOMS.

TO THE EDITOR OF "THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL."

Sir,—Permit me to offer a few remarks upon Mr. Crellin's very inconsequent formula in your last number. I fear we owe it to his unbounded admiration for the cube, and that it is this which has misled him into stating that the height of a room should in all cases be the square root of its area; for this is what the wisdom about B, LB, &c., amounts to. He commences by saying, "If therefore the four sides together with the top and bottom of a room be made equal each to each, the proportions thereof will *of course* be perfect." I am convinced that such a room, as is here given us as a model of perfection, is really of the worst form possible; and as I deny the advantage of the cube, I deny also the argument by which this form is made to affect all other cases. Indeed as far as the plan is concerned, I consider no room should be less in length than four-thirds of its width. But allowing the rule to pass, let us assume the area of a room to be 4,900 square feet, then by the given formula we have the height $= \sqrt{4900} = 70$ feet. Now let us take some dimensions which will accord with our given area—

$$\left.\begin{array}{r} 70' \times 70' \\ 98' \times 50' \\ 196' \times 25' \end{array}\right\} = 4900 \text{ square feet.}$$

Surely Mr. Crellin would not have us believe that all these rooms, whose areas are equal to 4900 square feet. should be of equal height. I think that he must admit that a picture-gallery, 25 feet wide by 200 feet long, such as was the water-colour gallery at the 1862 Exhibition, would have been unnecessarily high at 70 feet.

Lastly, why does Mr. Crellin after so carefully embodying his theory, make such an unfortunate choice of examples?

Does he consider that Sir Charles Barry would have improved the House of Lords had he made the height 63·63 feet; and does he think that the fact of raising the roof 32·17 feet would amend the proportions of Guildhall? or does he perhaps intend to show that an average difference of only 47 per cent. between the works of these distinguished men and the results by his formula proves that they unconsciously adopted it? I am, &c.,

18, Hyde Park Gate South. Gilbert R. Redgrave.
September, 1866.

Waste of Coal.—Welch mining engineers estimate that over thirty per cent. of coal is lost in mining. Much of it is in fine dust. There are patent processes to make it into blocks; but their costs is so great that they are little used. In Scranton, Pa., the coal-dust is a great nuisance; and there is much dust in all coal yards. Being baffled in attempt to work up coal dust into lumps, the question is whether we cannot adapt furnaces to burn the dust. We have seen it burned by blowers, in a rude way, which is of little use; but this is not the question mooted. What we want is a process that burns it well, and with a moderate draught. This, we think, can be done by sifting the coal into the upper part of the furnace, mixed with air. The coarser particles will fall upon a fine grate, through which there will be a regulated draught; but the dust will burn as it falls, and never touch the grate. We have seen carbonaceous powders burned while suspended in air, and they flashed like gas; an intense fire may be made in this way if skill be exercised, and the problem is to proportion the furnace, the draught, and the feed of dust, so as to produce perfect combustion of all the fine particles before they fall to the bottom. The conceivable saving is not limited to that of thirty per cent. of the weight of the coal in the mines. There are cases in which the flaming combustion attainable by mixing air through the fuel, instead of merely bringing it in contact with the surfaces of lumps, will save room in furnaces, and thus be of great advantage. In steam boiler furnaces, where the grate-room is limited, it may be advantageous. We think inventors may find piles of money in the piles of coal-dust that need to be carted off.—*American Artizan.*

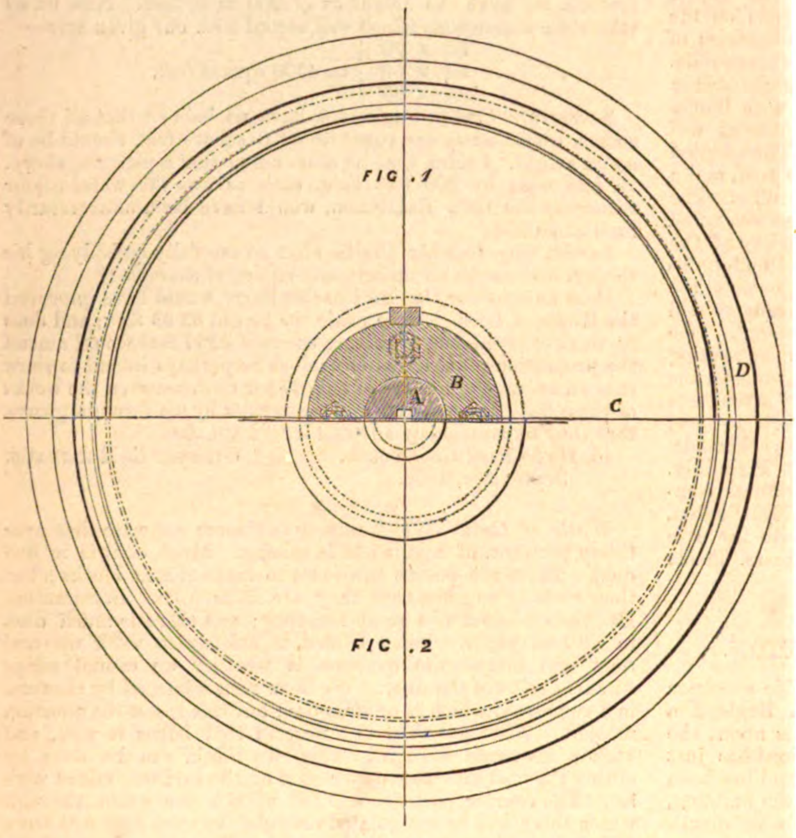
Competition.—The authorities of the town of Charleroi, Belgium, invite foreign as well as Belgian architects to submit plans for the enlargement of the town, the demolition of its fortifications, and the reconstruction of its railway station. The first premium is £200; it is not stated whether the successful competitor will be entrusted to carry out his design; the second premium is £80. The premiated plans to remain the property of the municipality, which, moreover, reserves fo itself the right of purchasing any of the others for the sum of £20.

SMITH'S SELF-ADJUSTING ELASTIC RAILWAY WHEEL.

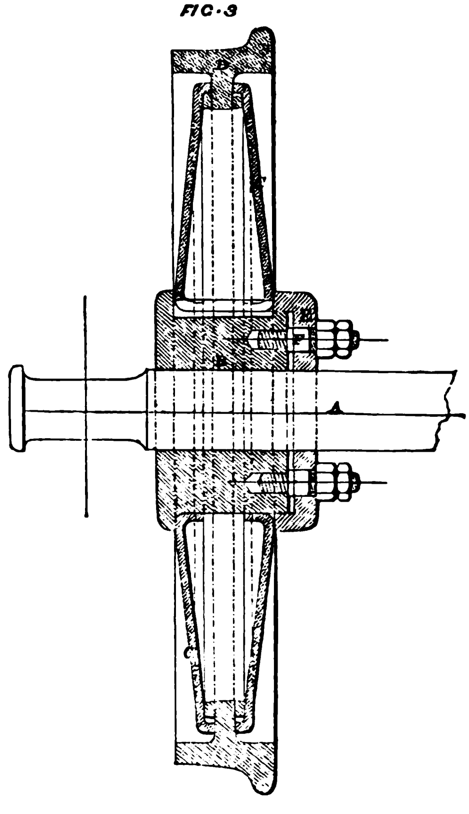
THE defects of most railway wheels now in use, arise partly from their being fixed to the axles resulting in loss of power in traction, by the unequal wear and tear of the tyres, sliding, skidding, oscillation of the train, unequal shrinkage of the tyres, and these disadvantages are increased, should the frames of the engines or carriages get out of the square by twisting or straining, leaving out of the question bad road, unequal lengths of the rails at the curves, the harsh and grating sound while passing over the bridges, as well as the enlargement of the engine tyres, when they have to be taken off and reset, all of which have to be taken into consideration.

The object of Smith's Railway Wheel is to obviate the disadvantage of the fixed wheels now in use.

The novelty consists in the body, spokes, or disc-plates being suspended to the tyres. By such an arrangement, the tyres are in compression, while the body, spokes, or disc-plates are in tension, the reverse of the principle now adopted. The advantages, as stated by the patentee, are cheapness, lightness, durability, greater safety to the trains, especially at high speeds, as the tyres cannot separate or break from the body, spokes, or disc plates of the wheels, nor can they mount the rails; the jolting is less, and also the wear and tear to engines, carriages, and permanent way; no skidding, or sliding, or lateral concussion, nor any necessity for double rails at sharp curves, as the tyres regulate themselves; neither is the vibration of the bridges so harsh, on account of the elasticity of the wheels.



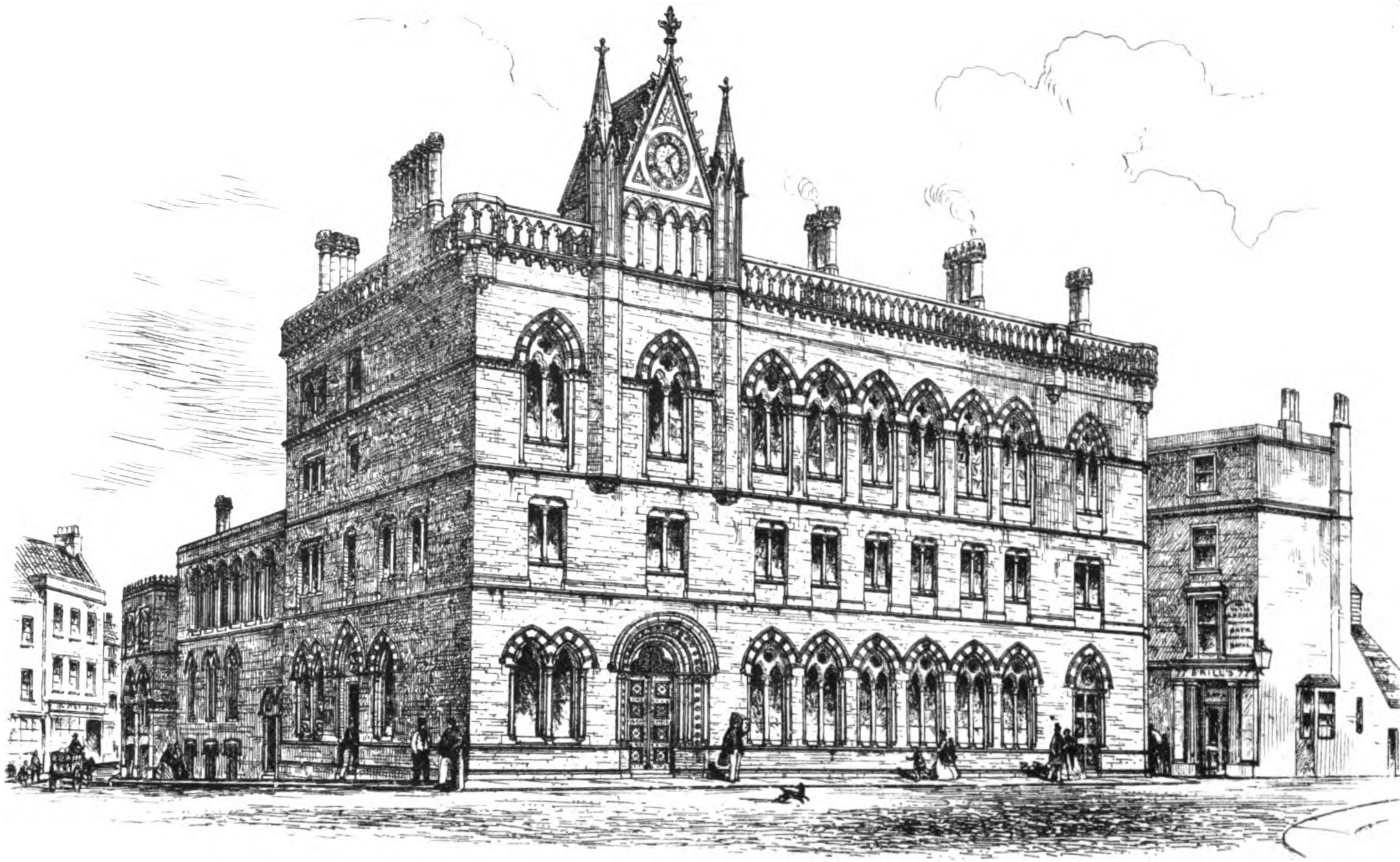
FIG·3



The construction of this wheel will be understood from the accompanying diagrams.—Fig. 1 is an elevation of the upper half of a suspended wheel with the disc plate C removed. In this case the tyre D is grooved and the edges or flanges of the disc plates C, C, are turned inwards and inserted in the groove of the tyre, such groove being of sufficient depth to allow of easy play, with elasticity of action and means of adjustment to the tyre; Fig. 2 is an elevation of the lower half of the same wheel; and Fig. 3 is a transverse section of the whole wheel. When the wheels are fixed to the axles, the tyres must be worn unequally, and there is great oscillation should the frames of the carriages be out of square. To avoid this inconvenience, hollow axles are keyed into the bosses or naves of the wheels, and the solid axles pass through these. The bearings, which may be of any kind, rest on the hollow axles. A spring may be inserted at the back of the boss or nave, being confined by a plate, so as to allow the wheels to yield laterally, and lessen the effect of concussion in that direction. To keep the wheels in their places, and, at the same time, to allow of self-adjustment when travelling over curves or defective roads, plates are bolted to the backs of the bosses, naves, or collars. The wheel is formed separately, and connected to the back of the tyre, which is grooved, by means of either disc or ring plates, rivetted or bolted to the spokes or arms of the boss or nave, and having turned-in edges or flanges, which are inserted in the grooves of the tyre, and are of sufficient depth to allow of easy play, and to afford elasticity of action, and means of adjusting to the tyre.

A set of these wheels have been in use for some time past on the North London Railway, and it is stated that they have given satisfaction. Another set will shortly be employed upon the Great Western Railway, to test their capabilities.

The inventor and patentee is Mr. George Smith, Jun., M. Inst., C.E.

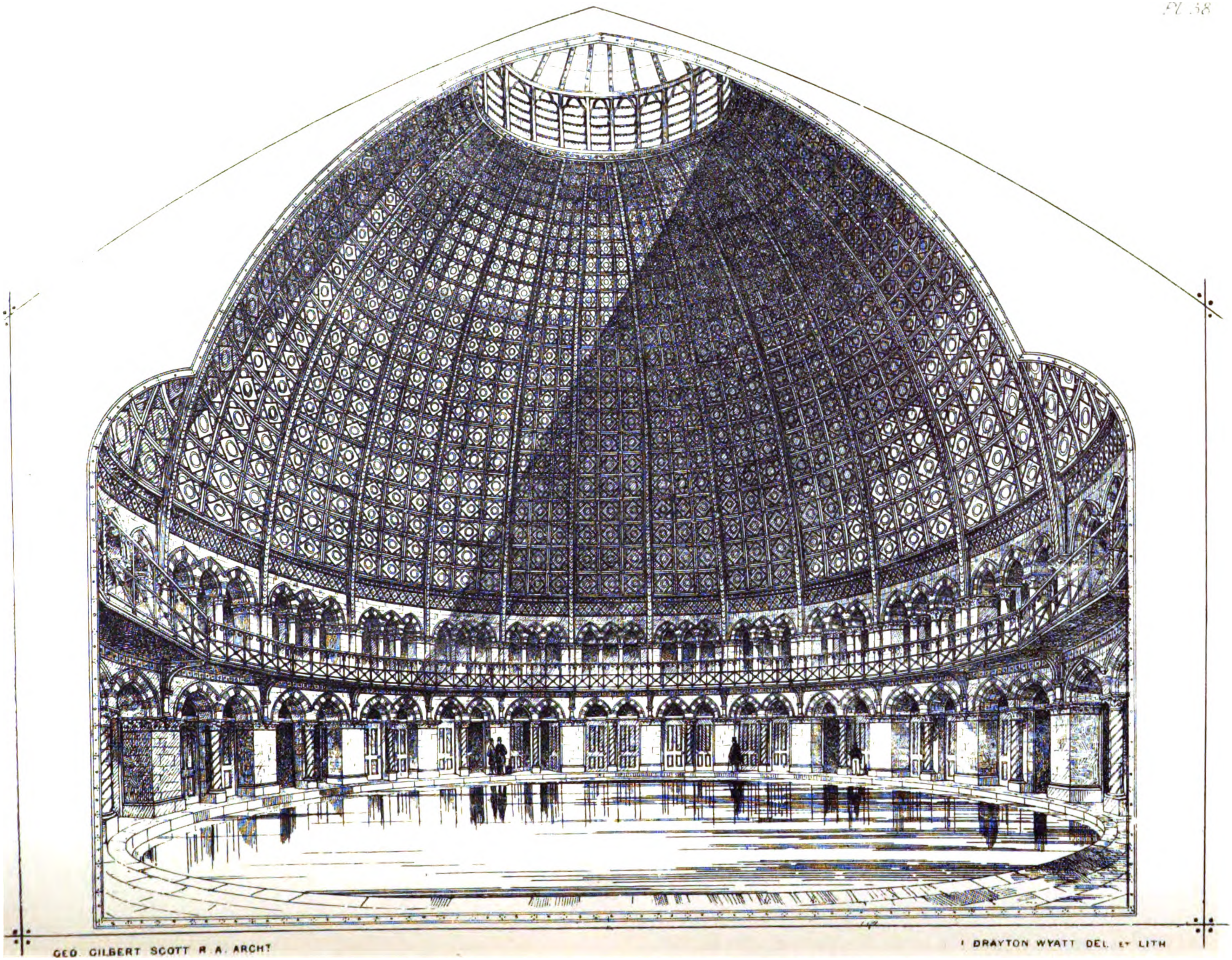


GEO. GILBERT SCOTT R. A. ARCHT

J. DRAYTON WYATT DEL. ET LITH.

BRILL'S BATHS, BRIGHTON;—VIEW OF EXTERIOR FROM EAST STREET.

Pl. 38



GEO. GILBERT SCOTT R.A. ARCHT

J. DRAYTON WYATT DEL. ET LITH.

BRILL'S BATHS, BRIGHTON;—INTERIOR OF SWIMMING BATH.

BRILL'S BATHS, BRIGHTON.

(With Engravings.)

THIS building, of which we give exterior and interior views, is now in course of erection on the site of the structure so long well known as Brill's Brighton Baths, and will form an important addition to the architectural features of the town. The new building will greatly exceed the former in size, and in the completeness of its arrangements.

The general arrangements consist of a plunging bath on ground floor 52 feet long by 30 feet wide, the ends being semi-circular, and the interior paved with white glazed tiles, on a Portland cement ground. There are eighteen dressing-rooms on this floor, the divisions between which are of a light green enamelled slate; their ceilings, and that of the passage, being white enamelled slate, of which material the floors, too, are constructed. The doors of communication between passage and dressing-rooms, and from dressing-rooms to plunging bath, have glass in the upper panels. The whole of the woodwork is stained and varnished. All the walls on this floor not faced with brick will be in parian cement, tinted to agree with the light green divisions. The whole of caps, string, and cornice are of Devon limestone. The columns are of granite. Hood moulds to arches, Portland stone. There will be an encaustic-tile band under cornice, and two between the first and ground floors. The brick facing is the Budham pressed bricks, pointed in fine mortar; the arches Suffolk reds. The whole of the brickwork is of stock bricks in cement. The first floor is furnished with twelve white porcelain baths and fittings. This floor is also of slate, and has a space of 2 feet, for pipes, between it and the ceiling below. The roof is of iron, and filled with red and yellow bricks; the interior ironwork will be faced with oak mouldings, and the exterior will be covered with plain tiles. The lantern over is of wood, and the roof of glass. The Pool Valley front is faced with Budham facings and red Suffolk bricks. The caps, cornice, and strings are of Portland stone; there is an encaustic-tile band between the caps of piers.

The architect is Mr. Geo. Gilbert Scott, R.A., and Messrs. Jackson and Shaw, of London, are the builders.

ON RIVETTED JOINTS.*

BY THOMAS BALDWIN.

ASK a boiler-maker why he places the rivets in a boiler 2 in. apart, and he answers, because "it's the practice—" that is because it is customary to do so.

Ask the inspector of a boiler association the same question, and he, "with his extensive experience and close observation of many hundreds of boilers," tells you that 2 in. is the best distance, since the boiler-makers use it, and, further, if the rivets be placed at a greater distance apart, the joints cannot be made tight, and, if placed nearer together the metal left between the rivet holes will be too weak to bear the strain upon it.

If, then, you say to these gentlemen it has been found by experiment that a bar of iron 1 in. square used as a rivet will be sheared across by a force of 50,000 lb., and that a piece of boiler plate having a section equal to 1 square inch will be torn asunder by 51,000 lb., and that you conclude from these experimental facts that the area of the rivets and the area of the cross section of the metal left between the rivet holes should be nearly equal to make the strongest boiler, you are at once told that "*in theory* it may be so, but it has been found that the plates are so much weakened by the use of the punch that nothing short of 2 in. will do for the pitch of the rivets." If you ask to be referred to experimental data showing that this pitch under all circumstances is the best, you are simply told that experience teaches it, and this even by men placed in a position to advise the users of steam boilers as to the best method of construction.

The writer is, therefore, desirous of placing this matter fairly before those who spend large sums of money on steam boilers, and yet get only 75 per cent. of the strength that correct principles of construction will give, and, therefore, pay 25 per cent. more for a boiler than is required if these principles be attended to, or get a boiler that is 25 per cent. weaker than it ought to be. However strange it may seem, a boiler made of ⅜ in. plates and put together with ¾ in. rivets and 2 in. pitch, is just as strong as a boiler made of ½ in. plates, with the rivets and pitch the same as used for the ⅜ in. plates, for both would give way by the rivets being sheared across, which causes the user of a boiler to pay 25 per cent. more for his boiler than he ought to pay.

We will now try to ascertain and confirm by mathematical demonstration what ought to be the proper pitch to get the strongest rivetted joints for steam boilers from the least material when the thickness of plates and the diameter of the rivets are given.

As mathematical demonstration is by far the shortest and simplest way of arriving at the required result,

Let P = pitch of the rivets in inches.
d = diameter of the rivets in inches.
a = area of one rivet in inches.
t = thickness of plates in inches.
s = number of pounds required to shear one square inch of wrought iron in the form of rivets.
n = number of pounds required to tear asunder one square inch of the boiler plate, left between the rivet holes after punching.

Then the sectional area of the plate between any two rivet holes is

$$= (P - d)\,t,$$

and the force required to tear that section asunder is

$$= (P - d)\,tn \quad . \quad . \quad . \quad . \quad (1)$$

The force required to shear one rivet across is

$$= as \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Now, to economise material, and make the strongest single rivetted joint, we must make the rivets just on the point of shearing across when the plates are just on the point of being torn asunder; thus (1) and (2) must be equal, or

$$(P - d)\,tn = as \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

from which we get

$$P = \frac{as}{tn} + d \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and

$$n = \frac{as}{(P - d)\,t} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Now Mr. Fairbairn has given a table for practical use, in which the thickness of the plates, the diameter of the rivets, and the pitch of the rivets are stated.

Making s = 50,000 lb., which has been arrived at by experiment, and given on the authority of Professor Rankine, and making P, d, and t agreeable to Mr. Fairbairn's table, we find by equation (5) the values of n in table 1, column 5;

Given in Mr. Fairbairn's table.				By equation. (5)
Plate t	Rivet d	Pitch P	a	n
$\frac{3}{16}$	·375	1·25	·11044	33670
$\frac{1}{4}$	·500	1·50	·19635	39270
$\frac{5}{16}$	·625	1·625	·3068	46088
$\frac{3}{8}$	·75	1·75	·4417	58893
$\frac{1}{2}$	·8125	2·00	·51849	43666
$\frac{5}{8}$	·9375	2·50	·6903	35346
$\frac{3}{4}$	1·125	3·00	·994	35343

The values of n, shown in the last column, are very variable indeed, attaining a maximum in the case of ⅜in. plates amounting to 58,893 lb., while the experiments made by Mr. Fairbairn on the tensile strength of boiler plates, and given in his paper read before the Society of Arts in November, 1864, gives the mean value of n = 52,486 lb., and yet we find the values of n as deduced for ½in. plates from Mr. Fairbairn's table, amounting only to 43,666 lb, and for $\frac{5}{16}$in. plates as low as 39,270 lb., a discrepancy quite unaccountable,

The common practice of making the distance between the rivets 2in. for ⅜in. plates with ¾in. rivets, given by equation (5) the value n = 51,041 lb., which is a close approximation to the strongest form of joint for single-rivetted plates.

If n be taken of the same value as Mr. Fairbairn recommends for ⅜in. plates, we have by equation (4)

$$P = \frac{as}{tn} + d = \frac{\cdot4417 \times 50000}{\cdot5 \times 58893} + \cdot75 = 1\cdot5\text{in. (A)}$$

* Read before the Society of Engineers.

But if the pitch of the rivets for $\frac{3}{4}$in. plates be 2in., then n = 51,041 lb., with $\frac{3}{4}$in. rivets and $\frac{1}{2}$in. plates we get:—

$$P=\frac{\cdot4417\times50000}{\cdot5\times51041}+\cdot75=1\cdot616\text{ in.} \qquad (B)$$

Mr. Fairbairn gives a number of experiments on single-rivetted joints in the "Philosophical Transactions for the year 1850," and in his "Useful Information for Engineers," the thickness of the plates used being ·22in. and 3in. broad, put together with $\frac{1}{2}$in. rivets.

The mean breaking weight of all the experiments is given at 18,590 lb.

The area of the two rivets being 2 × ·19635 = ·3927. and the sectional area of the plates after punching = (3 — 1) ·22 = ·44, from which we get:—

$$n=\frac{18590}{\cdot44}=42250\text{ lb.},$$

which being used for $\frac{1}{2}$in. plates with $\frac{3}{4}$-in. rivets, we have by (4)

$$P=\frac{\cdot4417\times50000}{\cdot5\times42250}+\cdot75=1\cdot795\text{ in.} \qquad (C)$$

Mr. Fairbairn's experiments with plates ·22 in. thick, $3\frac{1}{2}$ in. broad, fastened together with three rivets $\frac{1}{2}$ in. in diameter, gives—

Area of the three rivets . . . . . . = ·589 in.
Area of plates, deducting rivet holes . = ·44 in.,

which broke through the line of rivets by 19,675 lb., giving

$$n=\frac{19675}{\cdot44}=44534\text{ lb.}$$

Had these plates been 4·178 in. broad, instead of 3·5 in., the section of the plate after punching would have been 2·678 × ·22 = ·589, equal to the area of the three rivets, and the rivetted joint much stronger, the ratio of strength being nearly as 100 to 84.

But experiments made on only two or three rivets is no fair criterion, as Mr. Fairbairn has suggested, for he concludes that the strength of a single-rivetted joint, including the rivet holes in the measurement of the section of the plate, is fairly represented by a breaking strain of 34,000 lb. on the square inch of such section.

Now, the entire section of the plate used in the experimental inquiry with two rivets, was 3 × ·22 = ·66 in., and the section of the plate, after deducting the rivet holes, will be (3—1) ·22 = ·44 in.; we then have $n=\frac{34000\times\cdot66}{\cdot44}=51000$ lb. as the power of the rivetted plates to resist a tensile strain.

Applying this value of n as before, we find for $\frac{1}{2}$-in. plates and $\frac{3}{4}$-in. rivets—

$$P=\frac{\cdot4417\times50000}{\cdot5\times51000}+\cdot75=1\cdot616 \qquad (D)$$

The mean of these results for $\frac{1}{2}$-in. plates will be found to give P = 1·63 in.

We therefore find that the shearing force and the tensile force are so nearly equal that for practical purposes they may be considered so; we can then dispense with s and n in equation (4), which becomes

$$P=\frac{a}{t}+d \qquad (6)$$

which gives for $\frac{1}{2}$-in. plates and $\frac{3}{4}$-in. rivets

$$P=\frac{\cdot4417}{\cdot5}+\cdot75=1\cdot6334\text{ in.} \qquad (E)$$

nearly the same value as the mean of all the other deductions.

After Mr. Fairbairn has analysed his experiments, he says:—"If we take the mean of the experiments as respects the area of the rivets to that of the plates, we find one-half in rivets about the proportion, or the area of the rivets in the last experiments should have been 4 in., which is nearly equal to the area of the plates through the rivet holes."

The following note is also attached:—"Subsequent experimade for ascertaining the strength of rivets (*vide* experiments on the strength of rivets for the Britannia and Conway tubular bridges) fully corroborate these views, namely that rivetted joints exposed to a tensile strain are directly, or nearly so, as their respective areas, or, in other words, the collective areas of the rivets are equal to the sectional area of the plate taken through the line of rivets."

Agrin, in his paper read before the Society of Arts (November, 1864), he says:—"In this estimate we must however, take into consideration the circumstances under which the results were obtained, as only two or three rivets came within the reach of experiment; and, again, looking at the increase of strength which might be gained by having a greater number of rivets in combination, and the adhesion of the two surfaces in contact, which in the rivet-joints compressed by machine is considerable, we may fairly assume the following relative strengths as the the value of plates with their rivetted joints:—

Taking the strength of the plate at 100
The strength of the single rivetted joint will be 56."

Now we find, by equation (6), for all practical purposes, s and n are so nearly equal that they may be neglected, and that

$$P-d=\frac{a}{t} \qquad (7)$$

Then we have 100:56::P:P—d. But it has been shown that the area (a) of the rivet must enter into the calculation, and if we substitute the equivalent of P—d from (7) we get—

$$100:56::P:\frac{a}{t}$$

$$\therefore P=1\cdot7857\ \frac{a}{t} \qquad (8)$$

which for $\frac{1}{2}$ in. plates and $\frac{3}{4}$ in, rivets gives—

$$P=1\cdot7857\frac{\cdot4417}{\cdot5}=1\cdot5774\text{ in.} \qquad (F)$$

Or substituting the value ·7854 d^2 for a in (8), we have—

$$P=1\cdot4\frac{d^2}{t} \qquad (9)$$

This expression for the distance of the rivets is therefore deduced from Mr. Fairbairn's estimate of the whole of his experiments, and gives values differing from Mr. Fairbairn's table, given in his paper, and before quoted.

Now Mr. Fairbairn gives distances for rivets which, he states, he finds the best in practice, yet at the same time they do not agree with his deductions from experiments.

No one will doubt the importance of having the shells of boilers made of the strongest possible construction.

When the single-rivetted joint is used, and the thickness of the plates and diameter of rivets given, we have seen that the true pitch of the rivets is given sufficiently near for practical purposes by equation (6), and also again as deduced from Mr. Fairbairn's estimate of his own experiments by equation (9).

A table, giving the pitch and diameter of the rivets, and the thickness of plates, will be found below, containing the results of both these investigations.

II.

Thickness of the plates in inches.	Diameter of the rivets in inches.	Area of the rivets in inches.	Pitch of the rivets in inches. Equation (6)	Pitch of the rivets in inches Equation (9)
t	d	a	$P=\frac{a}{t}+d$	$P=1\cdot4\frac{d^2}{t}$
$\frac{1}{4}$ = ·25	$\frac{1}{2}$ = ·5	·1963	1·2854	1·4025
$\frac{5}{16}$ = ·3125	$\frac{5}{8}$ = ·625	·3068	1·6067	1·7528
$\frac{3}{8}$ = ·375	$\frac{3}{4}$ = ·75	·4417	1·9278	2·1033
$\frac{7}{16}$ = ·4375	$\frac{3}{4}$ = ·75	·4417	1·7596	1·8031
$\frac{7}{16}$ = ·4375	$\frac{13}{16}$ = ·8125	·5185	1·9976	2·1159
$\frac{1}{2}$ = ·5	$\frac{3}{4}$ = ·75	·4417	1·6334	1·5774
$\frac{1}{2}$ = ·5	$\frac{13}{16}$ = ·8125	·5185	1·8496	1·8513
$\frac{1}{2}$ = ·5	$\frac{7}{8}$ = ·875	·6013	2·0776	2·1471
$\frac{9}{16}$ = ·5625	$\frac{13}{16}$ = ·8125	·5185	1·7343	1·6465
$\frac{9}{16}$ = ·5625	$\frac{7}{8}$ = ·875	·6013	1·9439	1·9086
$\frac{9}{16}$ = ·5625	$\frac{15}{16}$ = ·9375	·6903	2·1647	2·1910
$\frac{5}{8}$ = ·625	$\frac{15}{16}$ = ·9375	·6903	2·0420	1·9729
$\frac{5}{8}$ = ·625	$\frac{1}{1}$ = ·1	·7854	2·2566	2·2436

The fourth column of the last table seems to be entirely trustworthy as to the pitch of the rivets, since the relations of the strains are more uniform than would be the case if the formula of the last column was used. Where the holes are punched their mean diameter should be taken in fixing the pitch, as the taper of the hole, reduces the area of the metal between the rivet holes, and it is only necessary to increase the pitch by the amount the mean diameter exceeds the diameter of the punch.

As double-rivetted joints are made up of two parallel rows of rivets, we have to determine first the distance from centre to centre of rivets measured along the rows, and secondly, the distance between the centres of the two parallel rows of rivets.

Mr. Fairbairn gives the pitch or distance between the centres of the rivets for double-rivetted joints the same as for single-rivetted joints, but that distance, the writer presumes, is measured diagonally from one row of rivets to the other, so as to form two rivets in one row and one in the other into an isosceles triangle, and the distance apart of the two rows of rivets can only be determined by knowing that the lap for double-rivetted joints is to be one and three-quarter times the lap of a single-rivetted joint, and placing the two rows of rivets at the same distance from the edge of the plate as for single-rivetted joints.

Now, if we so place the two rows of rivets that they shall form a number of isosceles triangles, they will, when measured diagonally, and having equal distances apart, have the following values.

Make P equal the hitch of the rivets in each row as before, and D the distance they are apart, measured diagonally, and D the distance between the two rows of rivets; and all the other values the same as before, then

$$(P - d)\ t$$

represents the sectional area of the plate between the rivet holes in each row of rivets, and

$$(P - d)\ tn \quad \ldots \quad (10)$$

the force required to tear that section asunder.

The rivets to be sheared across by the force that would tear the last-named section asunder are two in number, and this force is represented by

$$2\ as \quad \ldots \quad (11)$$

and as before, in the case of single-rivetted joints, the values indicated by (10) and (11) must be equal; that is,

$$(P - d)\ t\ n = 2\ a\ s \quad \ldots \quad (12)$$

But it has since been shown before that s and n are equal; hence

$$P = \frac{2a}{t} + d \quad \ldots \quad (13)$$

the distance the rivets ought to be apart to ensure the strongest and most economical structure.

The sectional area of the plates between the rivet holes, taken diagonally, according to the principles of *stress*, need not be greater than half that of the plate between the rivets of each row; that is,

$$D - d = \frac{P - d}{2}$$

Therefore,

$$D = \frac{P + d}{2} \quad \ldots \quad (14)$$

and by substituting the value of P from (13) into that of (14) we get—

$$D = \frac{a}{t} + d \quad \ldots \quad (15)$$

If we make the distance between the two rows of rivets one half the distance of the pitch of the rivets measured longitudinally, we shall get D rather in excess of the above value (15), and approximate very closely to the experimental form with double-rivetted joint made by Mr. Fairbairn.

The Table I. applies equally to double and single-rivetted joints, since Mr. Fairbairn gives the pitch of the rivets the same for one as the other, although it is difficult to see why, since the strength of the double-rivetted joint depends entirely on the proper proportion of the pitch of the rivets in each row to the diameter of the rivets and the thickness of the plates, and not on the distance between the two rows of rivets, or the diagonal distance of those rivets, so long as the last two distances are not so small as to cause the plates to be torn or sheared asunder diagonally. Any excess above these distances only adds to the cost and weight of the structure, without increasing its efficiency.

In Table II. the fourth column gives the pitch of the rivets for double-rivetted joints, and by comparing equation (6), from which that column is computed, with equation (13) for double rivetted joints, we find that it is only necessary to add $\frac{a}{t}$ to the values of P in the table, in order to obtain the correct pitch of the rivets for double-rivetted joints.

Taking experiments Nos. 38 and 39, Table X. of Mr. Fairbairn's experiments on double-rivetting, as the most conclusive, we find that the thickness of the plates are ·22, the diameter of the rivets three-eighths = ·375, the breadth of the plates 3·125 in., the mean breaking weight 23,707 lb., fracture taking place across the rivet holes A, B.

In these experiments there are five rivets to shear across, and the sectional area of the plate, deducting the rivet holes across A, B, should equal the area of the five rivets, that is,

$$\cdot 11044 \times 5 = \cdot 5522,$$

and $\cdot 5522 \div \cdot 22 + 3\ d =$ the width of the plate to be of the strongest form, d being the diameter of the rivets, from which we get 3·635 in. as the width of the plate, whereas the experimental plate was only 3·125 in.

Now, to have been in accordance with double-rivetted joints as used in practice, the experiment should have been on six or any other even number of rivets, if the object be to determine the distance or pitch of the rivets. As an example, take the shell of a steam boiler, the direction of the rivets passing round the shells is shown at $a\ b$, and the double or longitudinal rivets at $c\ d$. The distance of the rivets in each row of the double-rivetted joint will then be given by the equation (13) as before stated.

In circular steam boilers with two flues, the strain on the rivetted joints is very variable, for whilst the joints that run parallel to the axis of the shell have a strain upon them of three units, the joints that pass around the circumference of the shell have only a strain of one unit upon them; hence this class of boilers should have the longitudinal joints double rivetted, and the other single rivetted, when, owing to the ring of rivets passing round the boiler on each edge of every set of plates, and the double-rivetted longitudinal joints, the boiler would be as strong with this combination as if the whole were made of solid rings of plates, providing the plates are not made too wide.

The common practice of boiler makers in Lancashire and Yorkshire is to use two inch pitch and three-quarter rivets, whether the plates be three-eighths, seven-sixteenths, or one-half inch, which cannot be too much condemned; yet we find chief-engineers of boiler associations stating that this is the correct method of constructing steam boiler rivetted joints, although experiments decide to the contrary.

THE ARCHITECTURAL ASSOCIATION.

This Society commenced its 25th session on the 26th ult., under the Presidency of Mr. Robert W. Edis, A.R.I.B.A., who also filled the Presidential chair during last year. The meeting was numerously attended, a *conversazione* forming a part of the evening's engagements, but the principal business of the evening was the delivery of the President's valuable inaugural address, which will be found reported in another part of this month's number of this Journal.

We are glad to draw attention to the very excellent syllabus of papers to be read during the Session 1866-7, which the Council has been enabled to issue, containing as it does, many subjects of the greatest practical value to the architectural student, and which will be treated by men, several of whom have long been well known for their distinguished attainments in connection with architectural art.

The committee express their great satisfaction in observing the continued increase in the number of members of the Society, which affords proof of its utility, and supplies the means of increased usefulness. The list of members now numbers 333, against 280 and 245 in the last and preceding years respectively. The number of architects in practice who belong to the association and take part in its business is considerable, but the members generally are students, and it is from this class chiefly that new members are expected to be obtained. For their information, therefore, the committee set forth some of the advantages of membership, and express their wish for a still larger addition of that class for whose benefit the association was founded and now exists. The ordinary meetings of members are held on alternate Friday evenings, when papers upon architectural questions are read. In the discussions which follow, all members are encouraged to join, and it is to be desired that this favourable opportunity of acquiring the power of public speaking were more generally used.

The Vice-Presidents are Messrs. R. Phené Spiers, and Edward J. Tarver, and the Committee for the session now commencing are Messrs. G. H. Birch; J. S. Edmeston; E. B. Ferry; H. L. Florence; E. Lee; C. H. F. Lewis; W. Longsdale; J. T. Perry; L. C. Riddett; and L. W. Ridge; Hon. Treasurer, Mr. J. D. Mathews; Hon. Secretaries, Messrs. J. D. Mathews and Rowland Plumbe.

Students of architecture in the metropolis would do well to avail themselves of the opportunities for improvement which are placed within their reach by this Society, which has proved of great benefit to those who have become members.

NEUMEYER'S NEW POWDER FOR GUNS AND BLASTING.

The new powder discovered by Herr G. A, Neumeyer, a manager of stone quarries at Taucha, near Leipzig, is said (Berg- und hüttenmännische Zeitung, No 36, 1866, p. 309) to possess the following properties:—

1. The powder burns, but does not explode if the air has access.

To prove this the following experiments were made last year at Altenburg, in presence of the Town Council:

(*a.*) An earthenware drain pipe, about 11 inches long and 4½ inches internal diameter, was placed upon a brick and buried in the ground for two-thirds of its length; it was then filled with about 4½lbs of Neumeyer's powder, and this lighted. The powder burnt quietly, merely sending up a long flame. After the experiment the drain pipe was found to be quite uninjured.

(*b.*) A conical earthenware tube, 15½ inches high and 4½ inches in diameter at the bottom, and rather more than 1 inch at the top, was buried in the ground for two-thirds of its height, and filled up to the mouth with about 1 lb. 6 oz. of Neumeyer's powder. On being lighted, the powder burnt somewhat quicker than in experiment (*a*), but the vessel was uninjured.

(*c.*) An earthenware bottle, with a large body and very small neck, was filled with 1 lb. 10 oz. of Neumeyer's powder. It burns very quickly, giving a long flame; the upper part of the vessel broke off in consequence of the great heat, and fell down by the lower part.

As counterproof, a similar but smaller vessel was filled with about 9oz. of ordinary powder; it exploded with a loud report, and the vessel was broken into numberless fragments, which were scattered about for a great distance.

(*d.*) A very instructive experiment was performed with an iron gun-barrel 2 feet long and ¾ inch in diameter. The barrel was filled up to the muzzle with Neumeyer's powder, and this was lighted through the touch-hole. The powder burnt, sending out a curved flame through the touch-hole, and it was only the last portions that were projected in a small flame from the muzzle.

On the 27th November, 1865, the following experiment was made in a quarry at Taucha, and shortly afterwards it was repeated before a large assembly at Altenburg. A small house was built, 4 feet 8 inches high, 2 feet 6 inches long, and 2 feet 6 inches deep, the walls being 5½ inches thick. In front an opening for a door was left, 11 inches square, and at each gable end there was a window 3¾ inches square, closed with thin boards. A wooden box with 33 lbs. of Neumeyer's powder was put in through the opening for the door, which was then closed with a piece of sheet iron. The powder was ignited by a fuse; it burnt without making any impression on the house, and even the wooden box retained its shape, being merely charred. To show the contrast with ordinary gunpowder, a pound of this, loose, as in the previous case, was put in the little house. On its being ignited, the house was shivered into pieces.

2. Neither pressure nor percussion will cause it to ignite.

3. Its explosive force is equal to that of ordinary powder or even greater.

4. It leaves behind less residue than ordinary powder.

5. It does not attract more moisture from the atmosphere than ordinary powder.

6. It leaves behind less powder-smoke than ordinary powder. Its smoke, however, is light, disappears quickly, and has no injurious effect on the health of the workmen.

7. It is cheaper than ordinary powder in the proportion of 30 to 31. The prices by weight are the same, but as it has been found that 76½ grains of Neumeyer's have the same explosive force as 79½ grains of ordinary powder; the above proportion may easily be deduced.

It appears that Neumeyer's powder is as strong as ordinary gunpowder in spaces that are made as far as possible air-tight, but that when the air has access it burns without exploding. Herr Wohlfahrt, inspector of mines in the Duchy of Saxe Altenburg, adds the following concluding words to Herr Neumeyer's pamphlet:—I must really call Herr Neumeyer's discovery a blessing for mankind when I look at the frightful accidents caused by explosions, which recur year after year in all quarters of the globe. I need only recall the great explosions at Mayence and Erith, and that which happened lately in the laboratory of M. Aubin in Paris. All imaginable precautions, the strictest regulations, and the most expensive arrangements for transport and storing, do not strengthen the thread by which the life of those who have to do with gunpowder must always hang. How many soldiers are killed in battle when an ammunition waggon explodes, and how much greater is the disaster when the powder magazine explodes on board a man-of-war! All these disasters in war and in peace will be avoided by the use of Reumeyer's powder. Accidentally ignited it will burn out quietly, whether in a massive tower, in ammunition waggons, or on board ship, but will not explode. It will at most lift up the valves which should be fixed to the cases, and probably will not cause the fire to extend to other combustible materials, for I expect it will have a similar effect to Bucher's fire extinguishers. Just as the spectators stood only five paces from the little house when 33 lbs. were burning, so one will be in perfect safety at a short distance when several tons are lighted."

ARCHITECTURAL ASSOCIATION.—OPENING ADDRESS SESSION 1866-67.

By Robert Wm. Edis, A.R.I.B.A., President.

Another year has brought us again together, and once more I have the honour of coming before you, as your President, to address you at the commencement of the new session. When I addressed you last year, I did not expect so soon again to have the pleasure of doing so; and, highly as I estimate the honour of re-election as your President, it is, at the same time, a source of much gratification to me, as a proof of your esteem and approval during my last year of office.

In starting upon our twenty-fifth year, I must again congratulate this Association upon its continued and increased success. I believe that each year we have been making ourselves more useful to each other, and gaining increased influence abroad, and I think there can be no doubt that, if properly managed, our Association should become one of the most important societies of the kind in London; for, remember, we clash with none; we hold with all proper respect the Royal Institute, of which very many of us are members; but we have belonging to us a variety of essentially useful classes, which, I believe, are peculiar to our society, and I cannot attach too much importance to their usefulness, for, without doubt, they encourage and foster a spirit of work and friendly competition, give room for the interchange of friendly opinions, and are the means to many of us of forming acquaintances which, depend upon it, we shall none of us regret in afterlife; for, as I have always urged, the more young architects know of each other, and the more they work together in unity, especially in those things pertaining to their art, the better it will be for them, and the more pleasant will be their after business intercourse; and remember, too, that the Architectural Association, as the younger society, becomes the nucleus of what must needs be the future generation of architects. I can only hope that our members will yearly increase, as they have done during the last few years, our numbers being now nearly 350, for I believe, in these days of societies, unions, and amalgamations, the more we as a body cling together, the stronger and the more able shall we be to assert our own, and to raise the profession to which we have the privilege of belonging. Our funds are in a prosperous state, and the attendances at the usual fortnightly meetings, as well as at the various classes, with one exception, have been good and increasing. The class of design has been most satisfactorily attended, and to judge by the sketches, the progress therein in the designing portion of the work has been equal to the numerical increase. We owe our best thanks to several of the senior members of the profession and of various art trades, who have come forward to help us, by giving us valuable papers, embodying the results of their more matured experience in the practical working of our profession. I am glad that we are able to lay before you an equally good programme for this session. One great benefit to members of such an association as ours lies in the classes belonging to it, and that it gives them also the opportunity of forming separate classes for various subjects if they please: as an instance of this I may mention the water-colour class, which has been in every way successful. The figure-drawing class I consider as one of the most important classes of this society, and I cannot but regret that it is not more numerously attended, for the man who wishes to understand, and to work in, the art accessories of our profession, such as sculpture, painting, and stained glass, cannot do so without he himself has a good and thorough knowledge of the human figure. Our best thanks are due to Mr. Poynter, our late teacher—who, I am sorry to say, has resigned, from press of other work—and also to Mr. Tarver and Mr. Ferry, the honorary secretaries. This year the class has made a new start, under the secretaryship of Mr. Lewes, whose name I have only to mention to make the Association feel that under the care of one of its most energetic and constant members, the class will not suffer. It has been decided to continue the class at the same rooms—those of the School of Art, in the Portland-road—and I urge you, gentlemen, not to lose the opportunity of joining this really valuable class, for, to quote Mr. Scott, "The human figure is the most delicate and subtle, in an artistic point of view, of all natural objects; and its study is consequently the best training for the eye to a delicate appreciation of beauty. It is the highest of the works of creation, and its introduction in artistic works of whatever kind must necessarily give them a tone which no other object can impart, and I am quite convinced that the general training of our architectural students to figure-drawing would alone work a reformation in our architecture." One class in our Association has been given up, unwisely, as I think, for even if the express object of it be more or less a failure, yet it is eminently a most useful one, and I hope to see it ere long revived, even if it have to be re-christened. The class I refer to is the "Voluntary Examination Class." The subject of architectural examination seems to me a most serious one, and, although the Institute has considerably modified its rules to meet the wishes of the Association, yet, practically speaking, I believe the scheme, as it now stands, is essentially a failure, and is likely to continue so, unless some very radical alteration be made therein.

There is a continual outcry by newspaper critics at the want of character and the want of design, and ofttimes worse than this, of many of the new buildings of the present day, but how a good design is to be got without a proper art education, any more than good sound law, or good medical advice, without proper legal or medical educations, I am at a loss to understand. Before entering into an architect's office the embryo pupil should, I think, have gone through a course of preliminary study, so as to give him some foundation for office work, instead of, as now, being often drafted direct from school, ignorant probably of the very rudiments of the history and learning of architecture, and understanding nothing about the use of T squares, or set squares, or instruments of any kind. Mr. Scott says "The architect of the future must be himself the leader and director of the artists he employs, and if he desire to remedy their defects, he must take the lead by making himself master of the subject," and nothing but a sound artistic training independent of the necessary practical as well as art work of an office can effect this; for how is it possible to base anything on ignorance, and how can you expect good work from men who have never had a good art education. The sooner we can have *a compulsory*, not a voluntary examination, the better will it be for us, and the better for the public. We shall not then have the great number of quacks and speculative builders, usurping the title of architects, and setting up buildings here, there, and everywhere, to the detriment of educated professional men, and public taste. Carpenters, joiners, auctioneers, and builders will no longer be able to add "Architect" to their sign boards and card plates, and the status of the profession would be raised in every way, and I hope that this Association will not let this matter of education and compulsory examination fall to the ground, but will earnestly consider what steps can with propriety and advantage be taken towards accomplishing this important object. To the *Builder* and other professional journals we owe our best thanks for the continual exposure of the present quack and sham systems, and I hope we shall have their assistance in mooting this important matter.

I can only regret that the competition for the prizes offered by the Association and by the friends of the Society has been, particularly with regard to the essays, exceedingly limited. Perhaps the members of the Association wish to show, by their not going in very much for these matters, that they disbelieve in the whole system of competition. Certainly I should not at all wonder if they did so, for without doubt the present system is as bad as it possibly can be, and herein there needs some very great reform. The pages of the *Builder* are continually teeming with letters and articles about the unfairness of these competitions, and making all due allowance for the rejected addresses, there can be no doubt that most competitions in England are managed in a very unfair manner. I make no exception, for no greater slight can be cast on a very large majority of our profession than has been done in the selection of competitors for the new Palace of Justice, and the new National Gallery competitions. The work should have been given to any one architect that the powers that be might have selected, or both the competitions should have been thrown open to all English architects. When the Government thus slights the profession, we can hardly expect other people to think very well of us. In most cases, the remedy lies in your hands, for, so long as architects will be found ready to send in drawings to people, who offer perhaps half the proper commission, and to merge the premium into that (even supposing you are allowed to carry out the works), or else offer premiums barely sufficient to pay for the paper and strainers on which the designs are made and mounted, so long will the present degrading system prevail; until architects let the public know that they are not tradesmen, and refuse to send in designs, under the too often unfair, unjust, and insulting instructions and conditions, not till then shall we be able to hope for any reform in this matter, and while under the present *régime*, some architects are tradesmen, and some tradesmen architects, at least according to their self-adopted titles, I cannot see that we can hope to effect any material change. I do not think we can look back to the late competitions for the Foreign and War Offices, and for the late Prince Consort's Memorial, although the former was an open one, with any great amount of satisfaction, for, as regards the first, the matter became after all a question of Ministry, and those to whom the first prizes were awarded, became the happy possessors of a sum of money about sufficient to cover the expenses of making the designs, but as to carrying out the work, it was not given to them, and they were left to muse on the vanity of all earthly things, and more especially of Governmental competitions.

One of the fairest competitions that I have heard of lately, and one from which our Government and committees of all kinds may take a lesson; was that for the French Opera House at Paris. The competition was thrown open to all the world, at least certainly to all Frenchmen, and after the drawings were sent in (mind not before), a committee was appointed, consisting of well-known architects, scientific men, and others, who were learned especially in the requirements necessary for such a building: firstly, the members were reduced to about thirty, by carefully eliminating all those drawings which did not essentially and carefully adhere to the conditions made out for the competing architects: then again the number was reduced to the number of the prizes offered, namely, *five*, and the order in which these prizes were awarded was determined by the vote of the committee; then these five prize holders were asked to furnish new designs, embodying various alterations and improvements, which the committee suggested, and they were allowed to alter and improve their old plans in any way they thought fit, or to make new ones; a certain sum being awarded to each man for this second competition: after this, one design was chosen, again by vote, out of the *five*, and to the author of this was entrusted the carrying out of the work; and the proof that the best man was chosen, is that the selected architect was a comparatively young man, M. Garnier, and that his design had *both* times been voted the best; and it is moreover worthy of notice, as an instance of the great superiority of the French art educational system over our own, that all the five prizemen in this great competition were "Grand Prix" men. If only the Government and the public could be brought to see the immense advantage to them of having open competitions such as this, and of awarding fairly and honestly the prizes to the best men, then might we see nobler and better buildings, but while everything is as now, more or less managed by interest and favoritism in great things as well as in small ones, we cannot wonder that the result is ofttimes anything but satisfactory. To Mr. Beresford Hope, and Mr. Tite, the thanks of the profession are especially due for their late endeavours in the House to awaken Parliament to a sense of the great unfairness of their proceedings as regards the two large competitions in hand, and we can only regret that their exertions did not meet with more success; although to them, I think, may be attributed the enlargement of the list for both competitions.

I think there is much nonsense talked about Gothic and Classic, a vast amount of pedantry of learning put forth, when people talk of modern buildings being 13th or 14th century Gothic, or composite, or Ionic, or Greek, or Roman, generally rendered under the terms Gothic and Classic. Why are we to design nothing but 13th century churches or houses, or classic temples and mansions? Shall future generations speak of our art century, as one of imitation Gothic palaces or Classic temples, with just such an amount of individuality as shall have ruined the 13th centuryness or Greek templeness of them. For long years our art has been impelled more by fashion than aught else, and just so much as the knowledge of that fashion has been good or bad, so have the buildings been good or bad. From the time when, at the end of the 16th century, real Gothic work declined in England, and when, consequent in part on the diffusion of learning by means of printing, and the encouragement given to Italian architects by Henry the Eighth classic designs became the fashion of the court; but even then our early prejudices cropped up, and clung to the old rather than the new style, and so forced on in great measure, that confounding of Classic and Gothic which gave birth to Tudor, Elizabethan, and Renaissance. But the architects of that time were like the people of two faiths, not quite certain which to follow, and so compromised the matter by believing a little in each, and in the piebald language of Hudibras,

"'Twas English cut on Greek and Latin
Like fustian heretofore on satin."

And classic forms were plastered over with Gothic, and became at once a diseased fashion, and barbarous mixture. Regular columns were embroidered all over with ornaments and foliage, neither Greek nor Gothic, and frontispieces, façades and chimneys gloried in the attributes of two faiths, and lost all grace, by wanting simplicity; and so, while the pedigree and cognizance of each happy founder of a mansion were worked about the building in all the flimsy variety of painted plaster, the grandeur and simplicity of either original was lost. Then came Inigo Jones, that marvellous designer of classic barns, and mountebank mosques, who wandered, and drew through Italy, until nought but rigid Italian and classic would suit him; and good honest cockney and citizen as he was, he left his country's art, to bring into fashion by a single stride, the Greek and Italian palaces and mansions; and the age which had honoured Holbein, who only ventured upon a sort of classic inoculation, in great measure succumbed to the Greek and Roman lore of Inigo Jones. But, alas, for Jones, the purse strings of the nation did not open to the splendid ideas of King James and his architect, and Whitehall remains to us now as an instance of architectural failure in those days, and also as a lasting monument of one of the cleverest architects England has ever produced. But soon a spirit was waxing strong, which set its strength against pomps of all kinds, and alike incensed against Church and State, resolved to reform the land from the palace to the hut, and the learning and inventions of the architect, alike with the art of the sculptor and the painter, and the mummery of the mosques were considered superfluous and profane, and the Puritans regarded Jones with anything but favor. These good people preferred, theoretically, the dust and ashes of humility in building, as in all else, rather than the splendour of architectural magnificence, and Jones' glory departed.

Then came Christopher Wren, that marvellous gentleman learned in most things besides his art, who has shown us what love for his work could do, and who has left to England one of her most magnificent buildings, St. Paul's, which, however, much we may regret that it should be based on foreign learning, never fails to impress the minds of each and all with admiration at its charming unity and magnificent proportion; and the man who, while confessedly working out in all his works the principles of Roman and Greek architecture, has left us St. Paul's and Greenwich Hospital, besides the host of churches scattered everywhere in this great city, was no common man, and to him in a measure we owe the fashion of pillars and columns, vast porticos, and domes.

Then came Vanburgh, Gibbs, Kent, Burlington, Stewart, and Chambers, all more or less following in the footsteps of Jones and Wren, but none equal to them. Then that wonderful age of mawkish uncertainty, and Batty Langley Gothic, that age of plainness and ugliness, which Gower-street, Wimpole-street, and other streets so well exemplify; until last came in a grand revival upon this, and gaudiness and vulgarity, in the shape of hosts of plastered abominations, recoco ornaments, and sham enrichments, succeeded upon what was at least, if plain, unobtrusive; and in our day and generation we have to look upon street after street of plaster commonplace, and line after line of sham cornices and sham decoration, until our city has become a city of sham and unreality, a city that one year seems prematurely black with age, until suddenly it bursts out one fine morning into all the glory of triennial whitewash, and shines for a time in borrowed plumes and unreal misery.

Briefly such has been the history of architecture for the last two centuries and a half, and gradually this learned pedantry, puerile in its very absurdity, inasmuch as it has sought to teach us that the art of the Romans was to be the art of a nation whose views, thoughts, and feelings, independent of the lapse of some 14 or 15 centuries, were totally different; and although no one can deny the great genius of the masters, such as Scasnozzi, Jones, Wren, and Chambers, who have left noble and magnificent works behind them, yet it would be insulting to all taste to assert that the style which has given to London the miserable monotony and boldness of Gower-street and Harley-street, or the pale unreality and commonplace of Belgravia, Pimlico, and Bayswater, and on the continent has been the father of such feeble monotonies as the Rue de Rivoli, and has in so many places substituted all that is vulgar, unreal, and frivolous, for true and good materials, and given the squareness and feebleness of successive rows of pilasters, square holes, and bracketted cornices, for the clustered doorway and traceried window, is aught but a vain and foolish pedantry, chimera-like in its very falsities, and hideous in its very monotony of design, if design it be at all. Classic, Italian, Renaissance, Palladian, or any other title you please to give it, it is still but the feeble and bad copy of a copied architecture, and can have no hold upon our hearts, and leaves us with nothing but the flimsy spectres of other mens' works, and to muse why that fair and lovely work of our forefathers should be forsaken; knowing as we do, that we have now only to follow it up, and with greater means and more appliances to adapt it; as it may be adapted either for the town or the country, for the cottage equally with the church, for the factory equally with the mansion; for man's requirements have varied but little, and are amongst the things that have been and will be again.

But in the midst of our regrets for the beauty that has been profaned, there is no need to despond, as if the fountains of beauty were reserved in heaven, and flowed no more to us on earth; no need to be always looking back till our heads are well nigh twisted off our shoulders; why all our reverence, all our faith, for the past, as if the night were already come, in which no man can work, as if there were not a long day before us for effort in the cause of humanity, for progress in the cause of good? But there has been, and is still much shaking amongst the bones, and our nineteenth century may yet retrieve itself, and leave at its fall something for future generations to be proud of.

Notably amongst house architecture are the new buildings now being erected in Pimlico and Belgravia, on the Marquis of Westminster's estate, and their good honest stone and colored brick, and terra cotta decoration, are a vast improvement on the buildings they have replaced. Then again, wander through the city wherever you will, and you will everywhere see good buildings of all kinds gradually taking the place of the old commonplace structures that have preceded them. Amongst these are the new auction mart, and the Venetian Gothic buildings adjoining the same, both by the same architect; Messrs. Cunliff's and other new banks in Lombard-street; the immense piles of offices now being erected for the City Offices Company, and innumerable warehouses springing up in all directions, most of them at least worthy of attention for some individuality and improvement in architectural design. One more especially, that lately erected by Mr. Burges, in Lower Thames-street, I would name, as exemplifying how much can be done, at a small expense, in good Gothic work. The new streets now being made by the Board of Works are opening up or destroying much that was old and ugly, and already in one of these are rising up large and magnificent buildings that bid fair to make it one of the finest streets in London. Whether it would be better for us if we were tied down in a manner, like our neighbours across the channel, to a certain uniformity of design in our new streets and public places, is a question that has more sides than one. Certainly I think we must admit that the magnificence of some of the modern boulevards and streets in Paris, and other large towns on the continent, is much enhanced by the comparative oneness and uniformity of the buildings, which may, perhaps, be somewhat monotonous, but which never lack, in my opinion, either refinement or grace in much of their design and proportion, and which will give to France of our day and time an individuality in its architecture, which, I fear, we shall not, or, at all events, have not yet attained to.

Then again, there is the late Prince Consort's Memorial in Hyde Park, the new Foreign and India offices, now fast approaching completion, the new theatre in Holborn, and many other public and private buildings too numerous to mention here. Whether in these great days of public companies, and public smashes, we are always to be liable to such hideous sights as that which is presented by the ruins of the commenced, but never finished Strand Hotel, or the hideous monstrosity of Leicester-square, is a question I suppose that time only will answer. One work especially we shall some day be proud of, I mean the Thames Embankment, and those who live to see it and its accessories completed, will see the realization of one of the most important conceptions of modern times.

It is somewhat curious to find that Wren, than whom no more grand conceiver of grand things ever lived, had in his mind the idea of something of the kind of work that is now going on; for to quote Allan Cunningham, who says in his life of this great man, that "he had planned a long and broad wharf or quay by the waterside from old London Bridge to the Temple, where he designed to have arranged all the halls belonging to the several companies of the city, with proper warehouses for merchants between, to vary the edifices, and to make it at "once one of the most beautiful and useful ranges of structure in the world;" and now, after the lapse of more than 150 years, we are seeing this magnificent work actually in progress, on a scale more grand and more important than Wren could have thought of, even in his days of greatest royal favour.

I am glad to say that a great stride is being taken in the improvement of the dwellings for the poor, and thanks to Mr. Peabody's noble gift, and the indefatigable exertions of such men as Mr. Alderman Waterlow, Mr. Torrens, Mr. George Godwin, and others, large blocks of buildings are being erected in various parts of London, replete with every comfort and improvement; and too much importance cannot be attached to such a step as this, which, by effecting the external comforts of the poor, by giving them better and more healthy homes, is likely to improve them morally, socially, and intellectually, and if manhood suffrage is to be the order of the day, then pray God this improvement may be entirely effected first. The works of the Holborn viaduct are proceeding rapidly under the energetic superintendence of Mr. Heywood, and when this great work and its attendant improvements are completed, I doubt not it will prove of immense convenience to the toiling wayfarers in this great city.

The new stations and hotels at Charing Cross and Cannon street are all steps in the right direction, though perhaps a little *less* plaster, and a little *more* reality, might have been good, and ere long, I hope, we shall be able to compare favourably the gigantic terminal stations of our city with those of Paris.

The new Freemasons' Hall, in Great Queen street, by Mr. Cockerell, is certainly one of the most noteworthy of the buildings of the year, and exemplifies how much can be done by an educated and refined taste in classic work, without making it a mere copyism; the symbolic figure carving, and the statuesque work, which are as good as can be produced, exemplify how much a building is improved by figure subjects.

New bridges are spanning the Thames and our streets in all the glory of their practical straightliness. I suppose railway bridges must be ugly, the lines of wrought and cast iron are probably fallen on bad places, for certainly lattice girders and cast iron fronts are not the pleasantest things to look upon, and straight bridges rushing out of high houses, and interlacing bands of colored iron, and telegraph posts perched on the top of high roofs, like clothes props with their attendant lines, are not pleasant features in the city landscape, and it seems to me that one of the greatest things that the architects of the present day can do, is to throw into their works something of the æsthetic and artistic as well as the practical element, and he who shall have designed a straight railway bridge with some art taste will have achieved a great art success, for it is the difficult things of design that call forth the genius and skill of the designer. May we hope that the day is yet to come, when useful things shall not be ugly things, and when even to railway bridges and telegraph posts something like artistic treatment shall be given; and let us hope that, ere long, our city may cease to be overrun and cut up by monstrous incongruities of design, and gigantic monuments of ugliness, such as many of our great engineering works now are. But remember, you must have a thorough knowledge of the designs of those who have gone before you before you can hope to design well yourself; you must be able to understand the faults and beauties of all work, and to appreciate in all styles that unity and harmony of parts which they essentially possess; for even as until you thoroughly understand the idioms and roots of a language you cannot write or speak it well, so must you study in architecture,

"Twining memories of old time,
With new virtues more sublime,"

for knowledge, not ignorance, must be the foundation of good work, and there is no better way of obtaining this knowledge than by continually and perseveringly sketching old work; steam and rail now-a-days enable you to wander where you will, and to make short or long holidays as you please in the midst of all that is beautiful and good in architectural work; you need not leave our own country to sketch, but sketch, sketch, everywhere, and continually, and by doing so, you will acquire a knowledge of the principles that guided the old architects, and a direct training and culture of the eye to appreciate and understand the grace and beautiful proportion of their works, and a knowledge of what is right or wrong in architectural form and outline; always keep a note book in your pocket, and never lose an opportunity of sketching ancient examples. Be sure you will find this a pleasant occupation, as well as a useful one: not to mention the having a collection of interesting mementos of the places and things you have seen.

I can but ask you to look around our walls here to-night, to see one of the most beautiful and interesting series of sketches that I have ever beheld, and to take a lesson from them of what may be done in sketching. Few, if any of us, can hope to excel in it, as our Vice-President, Mr. Spiers, to whose sketches I am referring, does; yet we may learn from him and from his sketches what may be done by talent, perseverance, and hard work.

In practice you will have to contend with many difficulties, to soothe and manage perverse and parsimonious clients, who probably are wanting barns when you are dreaming of palaces; opposing taste and obstinacy of a variety of forms and fashions will meet you at every step, but you must not give way, for remember that you are called in to advise as to taste, and ofttimes to correct and educate it, in fact; and that you will be a hundredfold more looked up to and respected afterwards, even by previously adverse clients, if you carry out your own carefully formed opinions; and although I wish not here to raise any battle of the styles, still I would urge upon you to study well our old English work before you go away from it to follow in the ways of ancient classic examples, remembering always that it is endeared to us by the memory of a thousand years, and that the many magnificent cathedrals and churches, and the great variety of domestic examples, from the cottage to the mansion, all help to show that we are admirable Goths; while, with a few notable exceptions—St. Paul's, Whitehall, and Somerset House, to wit—the endless excesses of rococo and plaster abominations, in all the miserableness of their monotonous unreality and meaningless vulgarity, help to teach us that we can never become good Greeks or Romans. Study well all works of all styles if you will; but be sure that what was adapted in either style to the requirements of centuries ago, will no more be suitable in these days than the primitive garb of the Britons, or the fantastic costume of the mediævalists, for the dress of nineteenth century men and women.

Learn well your art, think no labour too severe, and no knowledge worthless, but remember that if you imitate the ancient examples that you have studied, it should be, as Lord Aberdeen said, "Not with the timid and servile hand of the copyist, but with a due regard to the changes of customs and manners, to the difference of climate, and the conditions of modern society."

It is not the details, or even the form of the edifice itself, however perfect, which ought to influence us, "But we should rather strive to possess ourselves of the spirit and genius by which the old buildings were originally planned and directed, and to acquire those just principles of taste which are capable of general application." You will require to have an intimate knowledge of the necessities and requirements of the buildings you design, whether it be for the large and costly mansion, the suburban villa of the city merchant, or the frugal cottage or farm homestead. In the restoration of either ecclesiastical or domestic work, you will find a knowledge of archæology of much service, and your study of ancient examples most valuable and useful, for your knowledge of the detail of old work will tell you what to keep and what to alter, what to avoid and what to restore; and it behoves you to bear in mind that the true and honest lover of his art will seek diligently in all cases to preserve, and not to destroy; to restore the old rather than to make the new; and, when called upon to add to ancient work, I believe that you should be fettered by no servile ideas of imitating it, but rather seek to individualize your own work, and, while so designing it that it shall not seem incongruous with the general building, but harmonize with it in its lines and proportions, yet shall you make it evident and apparent, both for the present as well as the future, that it is a building and addition of your own day and time.

It is no merely fine figure to say that architecture, like poetry, lives for ever; for how cold and lifeless is all history, in comparison with that which generation after generation writes in its buildings, and how many pages of doubtful story might well be often spared for a few stones piled one upon another.

Work hard and honestly, carefully seek for the opinions of your fellow labourers, and respect them though they differ with yours; remember that they are probably arrived at by an equal amount of study as that which you yourselves have had, perhaps more, but each man will probably take a different view. So sure as you work with all your might and with all your power in small things equally as in large ones, you will succeed, and gain the goodwill and esteem of the great majority of your fellow men. Steer clear of cliquism, believe not the false prophets who seek to fetter design and to keep it in one groove; for so sure as you enter into the narrow circle of any particular clique, you will become not only artistically but socially contracted—artificial and false in your views of men and things. You will hear, also, some absurd nonsense about art-architects, as compared with architects who understand the surveying portion of their work. Any more absurd pedantry or fallacy than this can hardly be imagined, for it behoves an architect to understand not only how to design an art work, but also how to carry through all the essentially practical and business parts of it. You must understand not only how to design, but also how to build; you must be able to write a specification carefully and well, so that it shall explain exactly all that is wanted for the construction of any building. In these days, when, particularly in large towns, stringent laws of light and air and building acts hold sway, you will have carefully to protect and watch over your client's interests, as regards any damage that is likely to accrue to him through the erection of neighbouring buildings, and to know what liability he will incur by erecting his own; for, be assured, if you know nothing of this, and only call yourself an art-architect, you will get very little work, for no client will employ you unless you are able to guard him against pecuniary or other damage in such matters; and it is not to be supposed that he will care to pay any one else to do what I hold is as essentially a part of an architect's practice as the mere designing of the building. You will require to have the Building Act at your finger's end, to know the laws and rights of light and air, and all the other *minutiæ*, which you will find, as you get into practice, are daily coming before you.

Nowadays the light and air question is becoming a most important one, and I think demands the serious consideration of the legislature, to make some alteration in the law thereof; for directly you attempt to raise even in a very small degree any old building, or to re-erect it to any greater height, you are probably met on all sides by threats of injunctions, or actions for damages, or demands for compensation; and although I admit that it would not be at all fair to seriously damage any of your neighbours by really detrimentally obstructing their light and air, yet the absurdly frivolous grounds on which buildings are stopped, and injunctions gained, cannot but seriously affect the chances of any improvements in large towns, and I therefore hope that, ere long, Government will step in with some new Act to lessen what is now becoming a very serious and damaging evil; and, indeed, if something be not done to alter, not only the law of light and air, but also to revise and modify the Building Act, the improvement and rebuilding of London will have to come to a standstill.

You will find also a knowledge of landscape gardening most useful, for every architect should at least be able to select the site which nature has made most appropriate for his building, and often he will be able to help nature by a judicious knowledge of what views should be opened up, what trees should be felled, where to add water, where to add foliage. You must adapt your building in a measure so as to be in harmony with the surrounding accessories of site, and remember that a good building is too often ruined by injudicious selection of position, and its inappropriateness to the scenery which surrounds it.

In commencing practice, be sure always of one thing, that "a soft answer turneth away wrath," be civil, be courteous to all you have to meet, and whether in discussing the merits or demerits of your own or other men's works, let all criticism be given with fairness and judgment; honesty and straightforwardness in everything will gain the esteem of all, opponents as well as friends—whatever you put your hand to, do it with thy might, make up your mind what is right and fair, and best for your client's interests, and swerve not from it, be honest on both sides, and you will find those under you respect you, and be content to abide always by your decision, knowing that they can rely upon your fairness, and those above you will trust you, knowing that you will do them justice.

A young architect has especial need to be careful in all that he does, and it is better to be known as a just man amongst the many, than a sharp man with the few; we are all liable to mistakes, particularly in early practice, therefore be especially careful to ask and take the advice, if necessary, of those who have had more experience, but if you make a mistake, seek not to hide it under the stringency of a contract, but honestly confess it, and meet it in an equitable manner.

Learn diligently, and study earnestly, but avoid all superstitious reverence for old times and opinions, or pedantic adherence to routine, which is only too liable to lead you into opposing all new discoveries and increased appliances, and to lose the respect of all thinking people. Remember that you must always be students, learning always, studying always, looking always still further for new knowledge, for no profession demands more ready command of all knowledge, or clearness of conception, than your own work; and work will be changed to interest, and interest to love, and love will lessen the difficulties and enhance the pleasures of your daily professional life, and enable you to overcome all the difficulties that may beset your path.

"*Nihil difficile amanti.*"

Let your work, then, be associative as well as earnest, to you will come the honour and the glory of guiding the hands that work with you, and of "leading forth mind after mind into fellowship with your fancy, and association with your fame," and beyond all this, seek always that it may be said of your work by the generations yet to come, as it has been said of the work of the generations of the past, that it has a "distinct and indisputable glory, that the mighty walls were never raised but by men who loved and aided each other in their weakness; and that all the interlacing strength of vaulted stone had its foundation upon the stronger arches of manly fellowship, and all the changing grace of depressed or lifted pinnacle owed its cadence and completeness to sweeter symmetries of human soul."

THE HYDRAULIC LIFT GRAVING DOCK.*

By Edwin Clark, M. Inst., C.E.

(Concluded from page 293.)

Mr. G. P. Bidder, Past President, said, it seemed that this discussion had arisen to a great extent from an expression in the Paper which was hardly consistent with the context. He did not regret that expression, because it had given rise to an interesting discussion. The expression in the Paper was, that the system described was capable of universal application. The more proper expression, perhaps, might have been extensive application. It was not a system, beautiful and perfect in its machinery as it was, which could be applied in every possible case. He was designing a dock for the Indus upon a different plan, and there were various conditions which ought to influence any engineer before he recommended its adoption.

Some suspicion had been expressed that the expenditure on this dock, as stated in the Paper, was not altogether *bona fide*. That misapprehension had evidently arisen from the fact that whereas the cost of the lift was stated in the Paper to have been £88,000, somehow or other the capital of the company was very nearly approaching to £200,000. Now both these statements he took to be correct. It was undoubtedly the fact that this lift, with seven pontoons, could have been erected in the Victoria Docks for the sum stated; it was also undoubtedly the fact that the Company had been involved in an expenditure of about £195,000. That expenditure had arisen from the circumstance that the Company had to pay for the land; they had also to pay royalties; and there was also the profit and loss. He did not think he ought to be called upon to give the details of the figures, because in this Institution it had been held that engineers should restrict themselves to the mechanical department, leaving those who had to apply the machinery to do it in the most advantageous and economical way they could. Taking, therefore, the construction of ten acres of dock for the reception of the pontoons, the cost of the land, and the erection of stores, together with profit and loss, the expenditure would have exceeded the £88,000 stated, by somewhere about £100,000.

Now, then, he thought it had been explained why there had been such a heavy profit and loss account; and yet, he was sorry to say, at this very hour there seemed to be still some disposition to give credence to every idle rumour in respect of these works. It was suggested that to almost any ship that entered the dock some misadventure happened—either she was twisted out of shape, or her copper was damaged. But he confessed he was surprised to find it stated, at this late hour, that a vessel in the dock was cambered or hogged to the extent of 8 inches or 9 inches, and that the vessel afterwards became depressed to a corresponding extent in the opposite direction. He had asked the name of the vessel. No name was given, but this remarkable circumstance was said to have taken place upon one of four days. Those four days had been investigated, and it was proved that during two of those days no vessel was lifted; on one day a little vessel of 120 tons was lifted, and on the other a ship of 870 tons was lifted, and he could state on behalf of the Dock Company that no complaint had ever been received by them in respect of any damage which those ships had sustained in the dock, nor, in fact, any others; on the contrary, vessel after vessel that had been there before came again to the dock.

There appeared to have been an impression that the Victoria Dock Company had established this system. They declined it, and it was done entirely by a private company. What would have been the cost of this system if the Dock Company had adopted it? The origin of this dock was owing to the fact that when the Victoria Docks were being made, he felt very strongly that a graving dock added to those docks would be found to be a useful auxiliary, and would tend to attract business. He accordingly set to work to design a graving dock in the ordinary way. He tried wrought iron and cast iron, with brickwork, and every other possible material he could conceive to make a durable work; and he could not get any one design to work out at less than £50,000 for a dock capable of taking in a vessel 320 ft. or 330 ft. long. It was obvious that would not pay. The Dock Company would not undertake it. Then he tried all manner of contrivances for floating vessels, and he hit upon that plan of close pontoons which accomplished the disaster mentioned in connection with the London Docks. He saw it had no stability, and he confessed himself defeated. It was then Mr. Clarke took up the subject and designed this lift.

Now, if the Victoria Dock Company had established it, there would have been no occasion to have bought the 24 acres of land; there would have been no occasion to have made the dock in the manner in which it was made. All they would have had to do would have been to establish the dock during the progress of the works. That lift cost, with the machinery, £30,000 at the most. But it was to be borne in mind that this was the first application of a new invention; and he did say that the fact of its being so successful, so that there had been no failure originating from the scheme itself from that time to this, was most remarkable. The late Mr. Robert Stephenson, who took a great interest in this work, pecuniary as well as personal, when discussing it with him, said, "Depend upon it, there will be some serious disaster at starting."

In the discussion, this new experiment had been compared with docks built on established data and on the experience of years past; a new invention was compared with old and tried works. That was an element to be taken in favour of this scheme. If the London or Victoria Dock Company had applied it, they would have had the lift, with all the appliances and machinery, for £30,000, and £12,000 more would have given them a pontoon capable of supporting a vessel of 3,000 tons. They would have had a graving dock for £40,000, or thereabouts, and more available than a graving dock of the ordinary form. They need not have had the pontoon to have gone off the lift; but they would have had a perfect graving dock for £40,000, occupying no more space than the vessel itself lying in dock. It had been stated that docks had been made in the beautiful stone at Birkenhead for £16,000 or £17,000 each, and that similar ones had been made at Falmouth. The cost of other kinds of docks at Sunderland and the Tyne had also been given. The three docks at Southampton were not made quite so cheaply, having cost, including land, £150,000. But, at all events, for a sum of £40,000 the Victoria Docks might have had a perfect graving dock; for £12,000 more there might have been two; and for a total outlay of £76,000, three; and nothing applied to the Victoria Docks could have been so useful or economical as the lift. But there were situations where there was a higher lift of tide, where the soil was more favourable, and where the trade was not of the enormous character of the Thames, in which he thought this system should not be applied. All that was contended for in the Paper, and all that he contended for, was the perfection of the the invention as applied in the present instance, and that it was capable of extensive, though certainly not universal application. It had been stated that four and a half hours were occupied in the entire operation of lifting, though the lifting itself was effected in twenty-five minutes. He must be excused for saying there was a fallacy in that statement, because all the time the blocks were being put in the lift need not be occupied. The moment the ship was lifted, the pontoon was floated off, and another pontoon could be brought on if necessary. The lift would raise about twelve vessels a day. The last time he was there, the lifting of a vessel was just commenced. About two hours after he could see neither pontoon nor ship. It appeared that the ship was required to be examined by the surveyors of Lloyd's after sustaining an accident, and she was lifted, lowered again, and taken away; and the pontoon was ready for another ship in two hours, and the ship gone. In the establishment of this lift, many of his friends had a pecuniary interest, as well as himself. But one thing they stipulated for, that they would have no share whatever in the patent-right of the invention, because, in the first place, the principle of the thing was objectionable, and, in the next place, being engineers, it was not consistent with their position to recommend a thing in which they had a personal interest.

He had only one further remark to add: that he looked upon this as one of the greatest engineering feats of the last twenty years. That the system should have been brought so nearly to perfection—worked with so much safety on a first experiment—was, to his mind, something marvellous; and when it was said it required judicious management to ensure the safety of vessels on the lift, he need only state that upwards of a thousand ships had already been lifted with perfect safety, which showed, he thought, that the amount of judicious management required was not beyond what could be practically relied on.

Mr. Giles explained that when he stated it took four and a half hours to get a vessel on the pontoon, he did not intend to imply that it required that time to lift the vessel. He should be glad to hear what was the greatest number of vessels lifted in one day.

Mr. J. Scott Russell said he thought it was the general opinion that the Author's invention was a very admirable one; that all the mechanical arrangements were excellent; that the idea was remarkably original, and that it had been carried out in a most successful manner; but he thought the Author did it somewhat of injustice when he brought it before them, if he considered it was better than any other description of graving dock or floating dock, and that it was bettter than those inclined slips which were also used for repairing ships. They were left to draw the inference that all other plans were either very dear or very bad, and that the Author's plan was the best for repairing ships. He was of opinion that graving docks were in certain circumstances better and more economical than the Hydraulic Lift Graving Dock, that floating docks, not of this description, were in some circumstances more economical and more applicable, and that what are called inclined slips were superior to the arrangement adopted by the Author. He should be sorry to say that the hydraulic lift was not the best thing that could have been invented under the special circumstances of the case.

He would enumerate circumstances in which it appeared to him that the plan under discussion did not possess so great merit as it might be inferred was attributed to it.

He submitted that where there was a good rise and fall of tide, a shore with deep water close inshore, a soil able to carry the weight of a ship, and not hard to work, good hydraulic lime, and building material cheap and ready at hand, an ordinary graving dock was cheaper in first cost and cheaper in working than this hydraulic lift. Engineers should consider well all such circumstances before they abandoned the graving dock. In discussing graving docks as graving docks, they should not compare a costly granite graving dock with an economical arrangement,

* Read before the Institution of Civil Engineers.

such as they would make for a private builder. In a tideway, a dock could be easily made. He recollected having a dock made for the repair of small ships, designed by the owners, to be done at small expense. In the yard, alongside the Thames, a space was excavated large enough for the size of ship to be repaired. The bottom of that dock was gravel; it was not even lined with timber, and a simple pontoon floated in kept out the tide, and that was a graving dock of the simplest character, but of the most perfect possible description. Then they had the timber graving dock common amongst shipbuilders, and, finally, the dock lined with brick and granite.

Where they had a gently sloping bank of good solid material shelving down continuously into deep water at an angle between 1 in 24 or 1 in 50, or 1 in 60, the patent slip, as it was called, appeared to him better and cheaper than the hydraulic pontoon dock. In such a place they had nothing to do but lay down the ways and haul up the ship. If they chose simply to haul a ship up a wooden way, well greased, one twenty-fourth part of the weight of the ship would overcome the friction of the ways. If they put the vessel upon rails, he need not say that one-fiftieth of the weight of the ship would overcome the resistance of the ways; and if the slope was up to 1 in 12, which was not the usual form of slip, a system of slips and carriages had been used, by which the ship was raised broadside out of the water. All these were arrangements of which they had had ample experience, and when he told them that each of these plans of slips might be constructed to bring up a vessel of 3,000 tons at an expense in the way of capital of £2 per ton of the ship, it would be seen that that also was a very economical arrangement. With regard to a graving dock, it would cost a great deal more: it might cost £5 per ton of the ship which it took in.

The last arrangement of which they had the choice, independently of the Author, was the ordinary floating dock, and the question was raised, in what circumstances was the ordinary floating dock better than that under discussion? There was one point in common with the Hydraulic Lift Graving Dock and the ordinary floating dock, and it consisted in the comparatively small depth and great breadth of the pontoon; in the Author's he believed it was 6 ft. deep by 60 ft. wide and 300 ft. long. The difference between this and some other floating docks, consisted not in this apparatus by which the ship was carried, but in the machinery which raised and lowered her. The Author sank a series of cylinders, each containing a hydraulic ram, and the presses were connected with a platform, and by a steam engine and hydraulic apparatus, the platform was gradually lowered down into the water. After the platform was sunk under the water, no more force was necessary to lower and raise it, and therefore the machinery was simple, and had the least possible friction; but the moment he placed a vessel on the top of the pontoons, the cost and labour of raising up the ship out of the water was incurred, and for this purpose it was supported in various ingenious ways, which had been explained. In the ordinary floating dock, instead of the hydraulic apparatus being fastened to the ground, it was put on the top of the pontoon in the shape of a long parallel caisson of the same nature as that on which the ship floated. Then by admitting water into the longitudinal caissons, the pontoon was sunk below the vessel; the water was again pumped out of the longitudinal caissons, and the vessel was gradually raised. All that was necessary beyond this was to pump as much water out of the pontoon as was equal to the weight of the ship raised above the water. In a plan previously explained, instead of these pontoons being filled with water, the platform had been lowered by screws, and a variety of inventions had been used for lowering the platform and for raising it.

As regarded the Hydraulic Lift Graving Dock and the ordinary floating dock, the circumstances of position were, in his opinion, of more importance than the mechanical arrangement. For example, where shallow water was abundant, where an extensive area of sheltered water existed, where there were no tides, and where foundations were met with at no great depth under the water, the Author's invention was most applicable. But where a rocky coral shore existed, as at Bermuda, or a bad foundation and great depth of water, then the ordinary floating dock was the best arrangement, and for such a position the Author's was not a good arrangement. The former condition, favourable to the Author's arrangement, existed in the Victoria Docks. He urged that by far the most valuable part of the hydraulic lift, on which he placed great weight, even more than the Author himself did, consisted in the multitude of ships which could be floated in shallow water at comparatively small expense. The Author took, as it were, a single dock with its apparatus, and by this single dock and apparatus he had incurred the greater part of the expense and outlay; for, by a simple method of detaching from this fixed apparatus the floating pontoon, he was able to multiply its usefulness, and to employ the same area for a great many ships, all of which had been lifted by the same apparatus. Therefore, the following were the special circumstances under which the invention might be exclusively and profitably used—where there was protected and deep water to form the dock, where there was not much rise and fall of tide, and where it was required occasionally to put into repair at the same time a large number of vessels in comparatively shallow water. There it would be most useful, and better than any other mode he had described or with which he was acquainted.

Mr. Edwin Clarke said, before he replied to the various questions, he begged to thank the Institution for the time which had been devoted to the discussion, and for the kind manner in which his Paper had been treated by all who had taken part in it. He was glad to find that, although he had pointed out no less than nine features in which this kind of dock possessed advantages over others, yet the principal point which had excited discussion had been the question of cost.

With respect to the cost of these docks, some confusion had arisen, from the manner in which the subject had been treated. Throughout the discussion a dock had been spoken of as costing so much money, without regarding the dimensions of the dock. It would be as definite to speak of a ship costing a certain sum, without regard to her size, &c. It had been assumed that the dock he had made at the Victoria Docks was of a standard size, and that its cost was to be taken as the price of such docks in general, and the whole discussion had been based on this assumption. It was stated that several docks at Birkenhead had been constructed at extremely low prices, in which respect those docks appeared to contrast very favourably with the lift. In other examples, such as those at Southampton and Bow Creek, the advantage of the lift with respect to economy was frankly admitted. Now, Birkenhead was a locality purely exceptional. The site possessed all those natural advantages which had been described as peculiarly favourable for an ordinary dock. The sandstone was easy to cut and work; it was free from fissures, and the stone itself, when cut out, was a valuable building material; and in the excavation of a dock in such a situation, it was so valuable that he could scarcely understand why the dock should cost so much as was stated, because the quarrying ought to be sufficient to pay for it. Such a dock was not a fair subject for comparison with this lift. It had, indeed, been stated that this lift had been erected in the Victoria Docks under circumstances offering some peculiar facilities. He was anxious to disabuse the minds of the Members from any idea of the kind. He had had the pleasure of designing eighteen or twenty docks in various situations, and he might say, of all the number there was no situation which presented the difficulties which he encountered at the Victoria Docks. He could hardly conceive a situation of greater difficulty. In the first place, it adjoined a deep dock full of shipping, where it was of the utmost importance that the water should be kept from running away. Nevertheless, he had to make an entrance into that dock, and for that purpose to construct a costly cofferdam. Then an excavation was required for the lift-pit, and that in a bad soil expensive to work. The whole of the land was, besides, of a costly character, and the surrounding competition of more than eighty other docks had to be contended with. Amongst all the other docks he had designed, he had not met with a situation where the facilities were not much greater than at the Victoria Docks. Hydraulic Lift Docks, as a rule, ought to require little or no excavation. The principal feature was, that wherever he could fix a cast-iron column, there he could make his dock. In many situations, as at Vancouver, Barcelona, and Marseilles, there was no excavation. Having obtained a spot with sufficient depth of water, the sinking of the columns was the only works to be done. He wished, therefore, to correct the impression as to there being any advantages in the site at the Victoria Docks, and if this dock could compete with others in the Thames, he was quite sure it could do so elsewhere.

Two or three questions had been asked, to which he wished now to reply. First, as to how ships could be lengthened on the pontoons in this dock, and how other works of that class could be carried out. Also, what was the cost of the manipulation of such docks; and, further, whether the vessels were not inaccessible on account of their being on a level with the floor of the workshop? With regard to the last point, he apprehended the object of lifting a vessel out of the water was to get access not to the inside but to the outside, and for that purpose he could not conceive anything better than bringing the vessel on the level of the floor of the workshop, instead of having to go down stone steps to it. On the other hand, when ships were built, it was done on a level with the building yard; and as to the lifting of iron plates and other weights, his experience showed that no great amount of that kind of work was required in dock, the work to be done being generally painting, coppering, or partial repairs to the hull or keel, &c. As to putting in boilers, no one would think of doing that while a vessel was either in a stone dry dock or in this dock, as a crane could scarcely reach over 60 feet of dock; but it was effected with shears alongside the wharf in a deep-water dock. On the second point, as to the cost of manipulation, he had stated that the average had been £3 per ton upon the 1,030 ships that had been lifted, as against £13 at the docks at Southampton with 700 ships, although, doubtless, a larger class of vessels was docked at Southampton than in this dock. He had no means of knowing what the cost was at Birkenhead Docks. With respect to how far it was possible to effect on a pontoon such an operation as that of lengthening a ship, the way in which it was done was this. The shallow dock had a level bottom, and by running the water out of the shallow dock, the pontoon was brought down and grounded upon the floor of the dock. Then there was a platform of timber 350 ft. long, or more, and 60 ft. wide, perfectly true, to enable a shipbuilder to judge of his lines; and no better situation could be conceived, either for cutting a ship in two and lengthening her in the middle, or for building a ship outright; and he believed the system would come into general use for shipbuilding. The accident that had just occurred to the "Northumberland" could not have happened if she had beed lowered on a pontoon instead of by the ordinary way of launching; and the American Government attached so much importance to that plan that they adopted it for launching their vessels; and he was sure the interest upon the cost of the pontoon would be far less than the expenditure incurred in the preparation of the present launching ways, with so much timber cut to waste, not to speak of the risk that must attend the launching of vessels of such great weight. Then, again, by the use of pontoons, the number of places where ships could be built was multiplied. Any of the Surrey timber ponds in which the pontoons would float, might be used for the building of the largest ships, and in the launching a small lift only would be required. To launch the "Northumberland," a 1000-ton lift would be sufficient.

With respect to the general request that he would point out the difference between the system of raising with hydraulic power and that of simply emptying the pontoon of water, he would occupy a few minutes in explaining clearly, he hoped, the difference between the two. With any floating body, such as an ordinary pontoon, the stability depended upon the fact that some portion was out of water, and any change of position produced extra immersion or emersion in that part; but when a body was entirely submerged, no change of position could produce any difference in that respect, and a submerged body had consequently no stability; walking from one side to the other would tilt a submerged pontoon, unless it was forcibly maintained in a horizontal position. One of the plans suggested was the paralled motion, which had been tried at the London Docks, the rods being attached to the pontoon and to the bottom of the dock by cast-iron piles driven into the ground, the object of which was to maintain the horizontality of the ship. This plan failed; the strain on those rods, which varied as the tangent of the angle made with the vertical, becoming very great as the water closed, and ultimately infinite. Hence the cause of the accident: the rods broke and went through the bottom of the vessel; the water could not be pumped out; and in subsequently trying to force in air, the deck was blown out. The other system usually adopted for rendering the position stable was to make the sides hollow, and of sufficient height to remain partly out of water. The sides were towers, 40 feet high. In these towers were placed hollow boxes, which by means of screws, or chains, or some other contrivance, could be raised or lowered. The consequence was, as these boxes were always on the surface of the water, this pontoon could be lowered, and the stability maintained, so long as both chains were lengthened to the same amount and at the same time. In that way the stability was maintained in the American Canal Dock. Sometimes this was done in the form of a large chamber, which had to be filled with water. In all these cases, a great difference would be observed between this pontoon and his own. The pontoon he used was perfectly open: it was never subjected to a greater strain than a pressure equal to the draught of water which it drew; and, drawing 6 ft. of water, the greatest pressure was a column of water 6 ft. in depth. The pontoon was consequently light and inexpensive; but in lifting with a submerged pontoon, it must be sunk 26 ft. or 30 ft. deep in the water, and, therefore, being subjected to a proportionate pressure, the quantity of iron required to strengthen it and to form the deck, made it a more costly thing than the whole of the presses and pumps put together. Then, in addition, the manipulation of a large number of these boxes required a large staff of assistants. If a vessel were 300 ft. long, with eighteen boxes, about forty men would be required to work them uniformly. It was a difficult engineering operation, requiring much skill and management, and, after all, it was only one dock; but with his plan, twenty pontoons might be worked by a single lift, with six men.

He did not say that his dock was of universal application; he agreed that there were many circumstances in which docks of another description were better. There were many cases in which a slip would be better than his dock, or any other dock, and there were other cases where a stone dock would be better than this lift; but still it was capable of very general application. The principal difficulty was in respect of the cost of the iron columns, where the water was too deep; and to meet such cases, Mr. Walker had suggested the plan of putting the presses themselves in pontoons. But where the water was of proper depth, there were few cases in which a dock of this kind would not be far more economical than an ordinary stone dock.

With respect to the stiffness of pontoons, he wished to state that in advocating a partially elastic pontoon he was giving the result of practice. He had stated that, from the experience of more than a thousand ships, an elastic pontoon was best, and produced no strain; but if a rigid pontoon was wished for, there was nothing to prevent the sides being made 40 ft. high, and any amount of rigidity might be obtained. If a captain wanted to beach his vessel, he always preferred to do so on a soft place; but that was a matter of judgment.

A great deal had been said with regard to the commercial failure of this undertaking. He did not think he was called upon to enter into that subject, nor did he think it concerned him. An engineer might construct a superior quartz-crushing machine, but it might be sent to a bad gold mine. If proper use was not made of the hydraulic lift machine he was sorry for it.

To return to the subject of cost, he wished to put the matter in a simple form. The cost of lift, engine, pumps, and all complete and fixed, would not exceed £10 per ton upon the weight to be raised—his cost £7 per ton. The cost of the pontoon might be taken at £5 per ton upon the weight to be floated. The cost, therefore, of a lift for vessels of 1,000 tons would be £10,000; and the cost of six pontoons of from 500 tons burthen to 1,000 tons burthen, would be £22,500. Thus six docks were respectively completed for £32,500, allowing a good margin of profit to the manufacturers. That was in the case of a lift not requiring more than ordinary excavation. If a great amount of excavation in difficult ground was required, as in the Victoria Docks, of course it increased the cost. If it were done at a place like Birkenhead, where the value of the stone was more than the cost of excavation, he imagined there must be great economy of cost.

Mr. Abernethy remarked that the Author had omitted comparison with the two docks at Falmouth, which were lined with granite throughout, and only cost £29,000.

Mr. Clarke said that in his illustration there were six docks adaptable to almost any situation, and capable of indefinite extension by adding to the number of pontoons. The machinery was simple and durable in all its parts. In comparison with ordinary floating docks, the whole of the work was perfectly accessible, especially with regard to the painting of the iron work, as there were no closed chambers, and the pontoon was raised out of the water in every operation. The rapidity with which this description of dock could be constructed was another important feature. The dock at Carthagena, of which the model was exhibited, was stated to have been commenced in the year 1861; and now, in 1866, Mr. Rennie had been good enough to promise a descriptive paper when that dock was completed. It did not take more than a year at farthest to put up the lift, and a stone dock certainly could not be built anywhere in that time. He did not know what the cost of the dock at Carthagena would be, but he was told it would be about £200,000.

ON THE DECAY OF MATERIALS IN TROPICAL CLIMATES, AND THE METHODS EMPLOYED FOR ARRESTING AND PREVENTING IT.*

By William Jerry Walker Heath, Assoc. Inst. C.E.

It is proposed in this Paper to allude to those materials which are most used in the construction of permanent buildings, and such as have come under the immediate notice of the Author, during a residence in Ceylon extending over a period of seven years.

The habitations of the lower class of natives are constructed of a rude framework of stout bamboos. the sides and roof formed of reeds, and closed in with the interwoven leaves of the cocoa-nut palm (Cadjans), laid on after the manner of weather-boarding, and secured to the reeds by pieces of coir-string, formed of the twisted fibres of the husk of the cocoa-nut. In the ordinary course, the cadjans require renewing every year; but these leaves may be made to last two or even three years by washing them over with the slimy juice of the 'bellie' (a native fruit), which when dry resembles copal varnish, and acts, to a considerable extent, as a preservative against the weather.

The framework of the huts, built of 'wattle and dab,' is made of roughly-squared jungle trees, morticed and tenoned with some care, and secured by trenails. Small twigs are tied with coir, in parallel rows, vertically and horizontally, both on the inner and the outer sides of the framing. The space between is filled with clay and sand, well kneaded, and, when nearly dry, both the inside and the outside of the hut are covered with the same material. It is then plastered over with earth, which has been thrown up by white ants, after being mixed with a powerful binding substance (produced by the ants themselves), and through which the rain and moisture cannot penetrate. This will hold the walls together, when the entire framework and the wattles have been eaten, or have become decayed.

The material of which the walls of the superior houses and other buildings is built is called 'cabook,' a soft kind of rock, found in most parts of Ceylon, at a few feet below the surface of the ground. A large square pit is excavated, and the cabook laid bare, when it is quarried, by means of a pickaxe, into blocks of a convenient size for transport, or of the size which will best suit the building for which it is intended. Cabook has the appearance of a coarse sponge, the material of the sponge resembling red iron ore, and the interstices being filled with soft clay of a yellowish or brown colour. The block should be exposed to the rain before being used, so as to allow some of the clay to be washed out, as then a better face for the mortar to adhere to is formed. Buildings of cabook require protection from the weather, but if covered with a thin coating of lime-plaster, they will stand for many years. When removing some

* Read before the Institution of Civil Engineers.

old Dutch buildings, the cabook did not appear to have deteriorated in quality.

Hard kinds of stone are not much used for buildings, on account of the expense of working. Rubble masonry is sometimes employed, but it is not approved, owing to the difficulty of obtaining even beds and good bond. The cathedral church of St. Thomas, near Colombo, is an instance of the successful adoption of rubble masonry. It has now been built upwards of ten years, and is in a good state of preservation, having the appearance of having been recently built.

Bricks are so badly burnt, and the clay is so badly pugged, that brickwork will often, after a shower of rain, scarcely bear the least weight without crushing. Although used in some instances with its surface exposed to the influence of the weather, it will undoubtedly exist for a much longer time, if well plastered with lime-mortar. Two or three coats of boiled linseed-oil will preserve brickwork without hiding it, but the expense prevents its general adoption. A coating of coal tar, applied when the day is fine, and the brickwork dry and hot, is also a good preservative: but it cannot, on account of its unsightly appearance, be often employed. Brickwork in exposed situations and unprotected will perish very rapidly. The softer bricks will be hollowed out, leaving the mortar joints projecting; and in damp places the bricks will in less than a month be covered with lichens.

The lime generally used is made by calcining white coral, of which there is an abundant supply on the coast, easily obtained. Timber is the fuel used in converting it. The lime comes from the kiln in a fine white powder, and is in that state ready for immediate use, by mixing it with twice its own bulk of sand and water; but it sets so rapidly, that the bricks have to be kept quite wet, and water has to be continually added, to prevent its setting before the bricks are truly placed. In the Public Works Department, the lime is placed in a tank, and kept under water for two days before being used; this makes it longer in setting, but it is more easily worked, and eventually makes better work. In fact, by the first plan it often simply dries, and is very friable; but in the latter case it sets equal to the best blue lias lime. In using this coral lime for plastering, it is better not to slack it for two days, as mentioned, it then presents a harder face, and will bear a high polish, almost like white marble. A short time ago the exterior of public buildings was painted, but this practice has been discontinued, as it answered no good end, and, after a few months, generally presented a bad appearance.

Timber, well seasoned, and built so as to have free ventilation, will, if white ants be kept away, endure for many years, though not for so long a time as in England. The best wood for general use is Moulmein teak. It begins to fail in about twenty-five years, but the decay is very slow, for after a hundred years, it is still in tolerably good condition. It would appear that woodwork lasts longest when no precautions are taken to preserve it. In exposed situations, and where it is subject to the attacks of the white ant, it is best preserved by a dressing of Stockholm tar, which is easily applied, and which, owing to the heat, is so limp as to insinuate itself into all small sun-cracks or fissures. Several substances, such as corrosive sublimate, have been used with success; but the cost precludes their use, except in cases where a second coating of tar cannot be easily applied. In sea-water, timber is speedily attacked by worms. The piles of the jetties in Colombo Harbour, which are mostly of satinwood, and about 14 inches in diameter, are so pierced in the course of twelve months as to require renewal. There is also a very small worm in the fresh-water lakes and canals, which infests the bottoms of boats, &c., notwithstanding the timber may be painted, oiled, or tarred. Creosoted timber is not attacked by white ants, but the black coating, if exposed, renders it so heat-absorbing that it is apt to split, and, unless thoroughly impregnated with the creosote, a road is opened to the inside, and the ants will soon destroy all that part which is unprotected. Timber near the sea does not warp or split so much as when removed inland; the changes from wet to dry not being so sudden in the former situation.

Iron exposed to the influence of the varying weather, speedily oxidizes, but not to so great an extent in the same time as in England. Painting, if applied at home, will for a time preserve it; but if applied in Ceylon it is not so effectual. Oil applied hot is a good preventative; but when applied cold, or in the same way as paint, it is of little avail, because the iron oxidises under the paint or oil. Coal tar is by far the best covering, applied either cold or hot, before or even after oxidizing has commenced. In the first condition it prevents, and in the latter arrests, nearly all tendency to rust. The heat, which contracts oil or paint, causing minute fissures that admit moisture, in the case of tar has the effect of causing any small parts not properly covered in the operation of tarring to be flushed over with a thin coating. The most valuable timber in Ceylon is quickly decayed by contact with unprepared iron; so that screw-nails or spikes, unless well greased or tarred, may in an incredibly short time be easily drawn out, the wood surrounding them being quite rotten.

Ordinary galvanized sheet-iron does not last many years, except it be protected with good red-lead paint, frequently renewed.

Lead-piping that has been four years in the island is still nearly as bright as when the pipes were first drawn. Brass oxidizes, and becomes very brittle, in a much shorter time than in England. Lacquer is the only preventive applied for the first defect, and for the second, the brass is heated nearly to a red heat, and then dipped in cold water. Zinc is a most durable material; it will last for many years with little or no apparent decay. Glass exfoliates in a short time. It requires constant care to preserve the lenses of optical instruments. Tripoli powder on the hand will remove the exfoliation.

Paper is easily affected by the moisture of the atmosphere. It loses its size, the surface becomes rough, and in a short time is so absorbent as to render it impossible either to write or to draw upon it. It requires to be kept in air-tight cases, and only so much of it should be exposed as may be required for immediate use. Leather, unless well 'dubinged,' becomes so brittle, as to break short off like a piece of wood. Gutta-percha, in about twelve months, is so brittle as to break like glass, but more easily; and after about three years, it may be reduced to a powder in a mortar. Occasional immersions in hot water will arrest this decay, but articles the shape of which would suffer by the heat must be left to their fate.

Mr. Berkley remarked that he had sent out to Bombay both creosoted and kyanised sleepers; native jungle-wood had also been used. He regretted he could not give the details of the results of these several experiments. He could, however, state this general fact, which was of much practical value: the resident engineer of the Great Indian Peninsula Railway, after an experience of thirteen years in India, was now replacing large numbers of sleepers which had failed with teak and iron sleepers. Attempts were made in the first instance to preserve the native wood by the usual processes; but, he believed in consequence of the wood being so hard and close-grained, it was impossible to impregnate it sufficiently with the preservative material.

Keys were a matter of considerable difficulty in warm and variable climates. It had been reported to him that the wooden keys (which were, he feared, perhaps not made with the utmost care) dropped out in great numbers, and he was now giving his attention to the introduction of some other kind of key, which would answer the purpose better than the wooden ones.

With respect to the preservation of iron, the result of his experience was, that whether for rails or bridge-work, iron should be thoroughly cleaned and dried by heat, and be then dipped into hot linseed oil. In the first instance, iron-work was sent out to Bombay not so treated, and the oxidation was excessive; but since that plan had been adopted the oxidation was prevented, and the rails and other ironwork remained in a perfect state.

On the subject of rolling stock, it was stated in Mr. Mann's paper* that the carriages on the Great Indian Peninsula Railway, were sent out with teak panels. If that were so, it was at a very early period, and before he had much voice in the matter. For some years past the carriages had been sent out with "papier mâché" panels; but, notwithstanding his own opinion that it was the best material for the purpose, the locomotive superintendent, who ought to know better than himself, had expressed a desire that the panels should be of teak, and not of "papier mâché."

Mr. Hawkshaw, Past-President, said he had spent three years of his early life in a tropical climate, close to the equator, and had some experience with regard to what timber would do in a country which Humboldt declared to be the hottest part of the world. He had also had many years' experience of Indian and of foreign railways, and of the duration of the rolling stock, sleepers, and iron-work sent out to those countries.

He would say with regard to timber generally, that, being an organic substance, it was impossible for any one to predicate what it would sustain under the varying circumstances in which it was employed in those countries, or, indeed, elsewhere. For instance, he had known

---

* See ante-page 299.

yellow pine, which, according to the statements of joiners, was not a good wood, last in railway sleepers for twenty-five years, and at the end of that period it was as sound as any of the specimens that had been exhibited. But in other cases yellow pine had decayed in five or six years. Dealing with timber was something like dealing with the human constitution; it was impossible to tell what or how many incipient seeds of decay it might contain.

He was acquainted with some of the woods exhibited. He had seen some of these hard woods which, under certain circumstances, had lasted as long as the piles from the Recife jetty; under other circumstances, from causes which he could not explain, the same descriptions of wood had gone to decay after a very short period. Among the large masses of timber that were required in the construction of railways in tropical climates, if native timber were used, it was bought without knowledge, of the soil in which it was grown, or at what period of the year it was cut. Of course, every possible precaution ought to be taken in the selection of the wood, but it was one of those subjects on which it was not safe to draw such large general conclusions as had been done in Mr. Mann's paper.

With regard to the question of sleepers, whether half round or square, he could not understand on what principle the former should be more durable than the latter.

Mr. Mann said, the half-round sleepers were more durable than those of the square form, because, independently of the half-round shape allowing of better drainage, the wood used was of a closer grain than the square sleepers.

Mr. Hawkshaw, Past-President, observed, with respect to the preservation of iron-work, that he could not agree with the suggestion that galvanizing should be substituted for every other process. He had used galvanized iron, and, he was willing to confess, in some cases unfortunately, and, therefore, he had the less hesitation in stating his opinion of it. He had put up roofs of galvanized iron, and found them decay more quickly than other roofs; in fact, if to that material acid were applied, and carbon, as was easily done in smoky situations, it was converted into a good galvanic battery. Roofs in towns were destroyed in that way. In addition to this, the process of galvanizing rendered the iron brittle; therefore he did not recommend that iron about to be sent to India should always be subjected to that process in preference to oiling and painting. The other suggestions were very proper. The iron should be well cleaned and dried before painting, for if wet or rusted iron was covered with any kind of coating, oxidation was certain to take place. No doubt, in tropical climates, there was a difficulty in making durable works, either of iron or wood. He had tried almost every material for sleepers, native woods, and woods of this country, and Baltic timber creosoted and not creosoted, and he confessed he had not derived much better results from one than from another; and he had been driven to the conclusion that in the tropics iron was pretty nearly the only thing that could be employed for sleepers with anything like certainty as to the results. He quite agreed in the opinion that iron made a very rigid permanent way. Rigid ways were not liked in this country, but sheer necessity brought him to the conclusion that a durable road could not be made in tropical climates, except by the use of iron. Iron sleepers, he believed, had been rejected by many engineers. He believed he was the first to use the iron-pot sleepers in England, and he found them rigid and did not like them; but necessity had obliged him to use them in tropical climates; and he was afraid, notwithstanding all the care in selecting native woods, creosoting foreign woods, and taking every other precaution, it would be necessary to use iron very extensively in tropical climates. When in Egypt, he saw the line constructed by the late Mr. Robert Stephenson with Greaves' cast-iron pot sleepers, which, after great consideration, Mr. Stephenson adopted as the best compromise he could make. Those sleepers had been laid, he believed, more than ten years, and the line was a good and substantial one, and the sleepers stood well. Iron sleepers broke only when not made strong enough; but it would be easy to make iron sleepers that would not break; and where the speed was not required to be more than 25 miles or 30 miles per hour, he saw no reason why iron sleepers should not be used. Whether, ultimately, a better material would be discovered, he could not tell. With regard to the laminating of the rails, he could not see what the temperature of the climate had to do with it. Whether the temperature were 100° or 60°, could make little difference; nor did he think that the use of steel could be more beneficial or necessary in a tropical climate than in this country. Steel was better than iron anywhere; but there was no reason why it should be used in the tropics more than here.

Upon one subject there appeared to be a singular confusion of ideas. That was the statement, and similar opinions had been expressed upon other occasions, that the cross girders should rest upon, and not be suspended from a main girder; but the fact was, that cross girders which were said to rest were suspended. It did not seem to be understood that when a cross girder was made to rest upon the flange of a main girder, the flange on which it rested was suspended from the vertical web by rivets.

Mr James Brunlees said, during a short stay he had made in the Brazils, he had an opportunity of observing the different qualities of timber, some of which he recognised in the specimens exhibited; but he had not had much experience as to the durability or otherwise of these woods. On 5 miles of the San Paulo Railway he had laid sleepers of native timber, and by the last reports he was informed that, after having been in use two years, they were decaying very rapidly. On the other portions of the line he had used cast-iron pot sleepers, which, like all the other iron-work he sent out, were boiled in a preparation of tar and asphalte before being shipped, and he found that treatment was a good preservative against rust. He had used the same kind of preparation for iron for about twelve years, and he could refer to its beneficial effects in the case of the Morecambe Bay viaducts. He had had no complaints of the breakage of pot sleepers, nor had he received any complaints of the road itself, which he attributed to the circumstance of the rails having been well fished. A different state of things appeared to have existed on the Pernambuco Railway, where the rails had not been fished in the first instance, and where, therefore, the road was not so effective. He certainly should not lay down the same sort of road in this country for high speeds, but he thought in tropical climates there was no better material than iron, either for the permanent way or for bridges, and he believed that was the material engineers must mainly depend upon.

Mr. Bruce thought the Institution had reason to be indebted to the Authors for the great care with which they had collected the facts, and for the methodical manner in which they had laid them before the meeting. It struck him that there was a weakness in the argument against resting the cross girders upon the lower flange, the general question of which he would not now discuss; but when girders were suspended by rivets, as was virtually done when the cross girders rested on the lower flange, it must be recollected that this strain, which was said not to have been calculated, must ultimately come upon those new rivets in the case of the suspended girders.

Passing to the question of sleepers, he was struck with the similarity of the experience which had been gained in South America with that which had been gained by engineers in India. There were doubtless many native woods suitable for sleepers and for other purposes, if there was only time to get them, and roads along which to carry them; but, in the first instance, if a wood suitable for sleepers was found, there were no roads for getting them to the works, and the only thing that could be done was to send out from Europe either memel creosoted sleepers, which were known to stand, or cast iron sleepers, which were also known to be very efficient. He believed, ultimately, when railways were more extensively opened than at present, the renewals might be made with native timber, because there would be more ready access to the forests, and because it would not be required in such large quantities as was the case at first, when contractors were forced to buy timber where they could, but each supply might be obtained as required for the maintenance without any undue pressure. He thought the use of the bogie engine, as recommended in Mr. Mann's paper, would be attended with great advantages, as it enabled trains to run over somewhat inferior roads with greater ease and safety than could be done without that very useful appliance.

Mr. Hawkshaw, Past-President, remarked that the assumption that creosoted memel sleepers would stand in these climates must not be adopted as correct.

Mr. H. P. Burt said he had been informed that the sleepers first sent out to Pernambuco were of an inferior quality of white wood, and not well prepared. The best evidence he could give of the general estimation in which creosoted sleepers were still held, was the fact that he had contracts to supply upwards of 450,000 creosoted sleepers in various parts of the world. He had recently been in communication with Sir Macdonald Stephenson on the subject of the preservation of timber. The specifications of nearly all the engineers were for the wood to be creosoted to the extent of 10 lbs. of creosote per cubic foot; but it was found, even with that large quantity, that the centres of the sleepers were not impregnated with the fluid, and some of the failures were, no doubt, attributable to that fact. Sir Macdonald Stephenson had suggested, as a means of obviating that defect, the boring of two holes 1 inch in diameter through each sleeper longitudinally, and impregnating up to 12 lbs. or 14 lbs. per cubic foot. By that means the creosote would be sent all through the sleeper. The boring by hand would be an expensive operation, but he had thought of erecting machinery by which he hoped to effect it at a comparatively small increased cost, and to accomplish the object in view.

Mr. A. M. Rendel, speaking from facts which had been communicated to him rather than from his own personal experience, thought there was no cause for supposing that the deterioration of materials was so excessively rapid in tropical climates. He considered that good materials would last nearly as long as in temperate latitudes. There were as good sleepers in India as in this country, but if mere jungle-wood was used, it would perish in a very short time. Bricks also, if made properly, turned out well; but if made after the manner of the country, were extremely perishable.

Mr. Turnbull could corroborate to a certain extent what had just been stated. On the East Indian Railway—of more than 1,000 miles in length—the greater portion was laid with Saul-wood sleepers; a considerable portion with creosoted fir; and a small length with cast-iron sleepers. Although there were various kinds of woods in India suitable for the purpose, such as Sissoo, Assoon, and others, there was difficulty in getting large quantities of any kind, except Saul, and that wood, when of good quality, was very durable; but at first there was a great and sudden demand for sleepers, and many young Saul trees were used, as a matter of necessity, with much sap-wood in them, which perished rapidly; otherwise Saul-wood was very durable, when cut out of large timber and well seasoned. In some instances, he had known Saul-wood sleepers to perish in two years; but he had lately taken up sleepers near Calcutta, which were serviceable after having been in use eleven years. At other parts of the line there were creosoted fir sleepers which had been laid ten years and were still serviceable, whilst others had decayed in less than three years. He had found that, unless the creosoting was thoroughly done, and good timber used, fir sleepers were perishable. Teak was perhaps the best of all Indian woods, but its present scarcity had brought the price about equal to 15s. per sleeper, which precluded its use for that purpose. Saul sleepers and creosoted fir sleepers were about half that price. With regard to iron sleepers, he had used flat ones at first, but without success. Greaves' 'bowl' sleepers were more successful, but as yet the experience of them was not sufficient to warrant a decided opinion. There had been a good deal of breakage in some places, in one year as much as 20 per cent. was reported; but as had been observed, the breakage could be obviated by making the sleepers stronger. He had only laid a comparatively small number of these iron sleepers. He thought, on the whole, it was desirable to introduce these or some kind of iron sleeper, not universally, but partially, in India, from the difficulty of getting large supplies of wooden sleepers, and from the uncertainty of the quality of the timber. A length of one mile near Howrah, had been laid on a plan of his own, as an experiment. It consisted merely of a bridge rail bolted to a continuous longitudinal bearing of plate iron, with a teak wood board between the rail and the plate iron; it had been in use about four years, and seemed to answer tolerably well, except having been made too weak at the joints of the longitudinal bearing.

So many miles of railway in India had already been laid with chairs and wooden cross-sleepers, that a change to iron sleepers would be too expensive, but should be considered on new lines. As regarded creosoting wood in India, it was a costly process, owing to the difficulty and expense of conveying creosote from England; iron tanks were necessary to hold the oil when on board ship, and being unsaleable in India, added to the expense. The native woods were generally too hard for penetration: the creosote did not penetrate the Saul-wood more than $\frac{1}{8}$ of an inch.

The earth oil, or Arracan oil, seemed as good as creosote, but the same objection applied, as to the difficulty of conveyance and the cost. It was brought from Moulmein and Rangoon generally in leathern bottles, or skins. The price is about 6d. per gallon.

General Sir Andrew Waugh regretted he had not come prepared with notes of his experience in India. He had been a short time only in Ceylon, but had visited both Colombo and Galle, and could corroborate much that was stated in Mr. Heath's paper. The decay in the materials of buildings arose obviously from the alternate effects of extreme heat and extreme moisture, but principally, he thought, from the use of bad materials. India presented great varieties of climate, which in the upper districts differed much from that of Ceylon. And the Hindoos there had brick and stone buildings of great antiquity; dating, in fact, anterior to the historic periods.* The masonry of some of the temples and forts was exceedingly strong, and was difficult to destroy when it was requisite to blow the forts down.

With regard to wood, the great difficulty in India was to get it seasoned. Such was the pressing demand for wood, that it was used without seasoning, and there were no capitalists in the trade who could afford to keep stores of wood for seasoning purposes. It was almost impossible to get a piece of well-seasoned timber for a chair or a table. He could fully corroborate what had been stated by Mr. Turnbull with regard to Saul-wood. It was a very hard wood, of great strength, the product of the Shorea Robusta, which grew in great abundance in the central forests, as well as along the skirts of the Himalayas; but though it was a wood of excellent quality for all purposes of construction, there was, no doubt, of late years, a great difficulty in obtaining a sufficient supply of it, well seasoned, for sleepers. Teak was a wood famous all over the world, but it was getting scarce, from the trees being destroyed so rapidly without any equivalent reproduction. There was a peculiarity about that tree; the seeds did not sow themselves readily like Saul, and were floated away by the rains. There were two kinds of teak wood in India, that in the province of Burmah grew to a large size, and was much used in shipbuilding. The same kind of timber grown in a drier range and in rocky parts, as in the Vindhya ranges in central India, became as hard as ebony, or iron-wood, but was of small scantling and of crooked form, nevertheless it was an excellent wood if it could be obtained in sufficient abundance and size for sleepers, or for other purposes requiring strong and durable timber.

* While carrying on the Great Triangulation through the Turai damp forest lands, near the feet of the Himalayas, Sir Andrew Waugh fixed several of the principal stations on the ruins of forts of such antiquity, that forest trees of the largest size were growing in the forts, the building of which was attributed to Bimseu, a demigod of Hindoo mythology. The bricks in these forts, which were used to build the towers for the Triangulation, were so excellent, that their arrises remained quite sharp after many hundred years; and the mark of three fingers on the face of each brick were quite distinct, being either a trade mark, or more probably, a sign of the Triune Deity.—A. W.

Colonel Sale remarked that the results generally mentioned were such as he could corroborate from his own experience; that timber sent from this country to a tropical climate should be prepared beforehand, and that perhaps creosoting was the best method. Simply paying over native woods with coal-tar, he had found to act well as a preservative. In using timber for building purposes, it was necessary to provide for the ventilation of the ends of the timbers, by which means it would last considerably longer, than if the ends were let into the work without the admission of air. Saul was, no doubt, the best quality of wood in Bengal and the north-west provinces of India; teak was both scarce and expensive there. In fact, it might be said Saul was the timber generally used in the works of the public departments in those provinces.* The results mentioned in the first Paper, as occurring in Brazil, he had observed very much elsewhere.

Mr. C. H. Gregory, V. P., thought they were much indebted to Mr. Heath, as a young member of the Institution and of the profession, for the practical observation which he had brought to bear on the subject under consideration. It was curious that two Papers arriving so nearly at the same time from countries so far apart as Pernambuco and Ceylon should agree so nearly in their conclusions; and he thought that this general but independent agreement between Mr. Mann and Mr. Heath made their papers so much the more valuable. The most important difference between them seemed to be as to the use of galvanized iron, of which Mr. Mann gave a favourable opinion, while Mr. Heath, speaking as it seemed from experience, thought that galvanizing was not sufficient without additional protection in such a climate as that of Ceylon. One statement in Mr. Heath's Paper was at first sight striking; viz., that the loss of weight in iron from oxidation had been observed to be less in Ceylon than in England during an equal period of time. In confirmation of the correctness of that statement, he might mention that, while the works of the Ceylon Railway were suspended, a quantity of rails were lying for many months in Ceylon unused, and rails of a similar nature, manufactured at the same place, were lying in South Wales unused: he expected that the loss of weight would have been greater in the rails in Ceylon, instead of which the reverse had been found to be the case. He considered Mr. Mann's Paper as very interesting, because it brought before them the results of experience of some years in a country in which the Engineers of the Railways had been the pioneers of public works, and from the independent and careful nature of Mr. Mann's observations, all he had stated was entitled to great respect and consideration. In reference to the use of timber in tropical climates, it had often been discussed, whether the soft European woods artificially prepared were to be preferred to native woods. He had been surprised at hearing it stated, by a gentleman of large experience in works in tropical climates, that the deterioration of such materials in tropical climates was no greater than in England. He imagined that where there was great heat, accompanied by excessive moisture, the deteriorating effect, upon wood especially, must be much greater than it was in this climate, and that this effect would be most serious on soft woods; and while, in the first instance, from the supply of material being uncertain, and unequal to the demand, it might be desirable to import European timber artificially prepared, he could not but agree with Mr. Mann, that in most tropical climates where timber was plentiful, and certainly in the country to which his Paper referred, after the character of the native woods was known, and their selection and supply properly organised, they might be used with great advantage, while Mr. Mann had shown that in Pernambuco this was done at half the cost of European timber artificially prepared.

It should be remembered that the natural decay of timber was only one portion of the question; for where timber was exposed to great moisture and great heat, the alternate swelling and shrinking must produce shakes in the timber, while the working of rails, chairs and fastenings must produce mechanical deterioration, which would naturally be less in the hard woods of the tropics than in the softer woods of Europe. They had on the table specimens of the woods of Brazil, which in an unprepared state had lasted undecayed for 250 years: even if it could be proved that creosoted soft wood would remain as long undecayed, the durability arising from hardness would still be in favour of the native wood.

In alluding to iron bridges, Mr. Mann differed from some Engineers in condemning entirely the use of suspended cross girders. Those bridges to which Mr. Mann alluded were sent out by him (Mr. Gregory), as consulting Engineer of the Pernambuco Railway, and therefore he felt he was to some extent upon his defence. It was sometimes convenient to suspend the cross-girders, and when these were properly arranged and the bolts sufficiently strong and well secured, he submitted that there was no radical departure from the rules of good construction. With regard to Mr. Mann's proposed substitution of steel for wrought iron in the bracings of bridges, he believed that the adequate use of coal-tar would be a sufficient protection for wrought-iron braces, and he thought that the specimen exhibited of a brace which had suffered from the effects of the weather, might be matched in this country in many structures still considered to be in a permanent and sound condition.

He was not prepared to adopt Mr. Mann's views in ascribing to the heat of the climate the large amount of wear which had been observed

* Teak is procured in the central provinces, and on the Bombay side.—T.H.S.

in rails and tires on the Pernambuco Railway, and he thought they must seek for other causes to account for it. When this railway was projected, the fishing of joints was not so generally adopted as it had since been, and it was not proposed, in the first instance, to use fishes, and they had only been applied after a portion of the line was opened for traffic. Again, from atmospheric alterations, and from the difficulty of obtaining perfect work in a country where railway operations were entirely new, from the nature of the ballast, from the deterioration of sleepers, and from other causes, the permanent way was not for a long time, even if it was now, in the good state attainable on English railways. There were also several considerable curves on the line. He thought the combination of those circumstances sufficient to account for a much greater wear than was usual in England, without the necessity for a theory which had rather startled him in Mr. Mann's very useful Paper.

Mr. C. B. Lane said, as the result of twelve years' experience of Brazilian Railways, he agreed generally with the views expressed by Mr. Mann with regard to the preservation of materials; and some of the results stated in the Paper were very satisfactory to him, inasmuch as they bore out reports he had made from time to time to the Brazilian Government on these questions. He alluded more particularly to sleepers. When he first had to deal with this question in Brazil, there was no time to make botanical investigations, nor was there the knowledge available to enable him to fix upon really fit material, the product of the country. He felt it therefore to be his duty to recommend the employment of such material as practical experience in other intertropical countries had shown to be good, rather than the adoption of what had not this test in its favour. And for this reason, where timber was employed, he had recommended that of the north of Europe creosoted. He had also recommended the 'iron pot' sleepers, having had the high authority of the late Mr. Robert Stephenson in their favour, and having also had the opportunity himself of judging of their value on the Maua Line of Rio de Janerio. That line had now been about eleven years in operation, and he had recently seen some statistics of its maintenance, from which it appeared that the renewals of the pot-sleepers were very small, in fact practically almost nothing. He had heard of their failure on some Indian lines, but he thought it must be owing to their not being thick enough along the centre line of the pot: he would recommend their being cast with an internal ridge in that direction, somewhat similar to the ridge along the vertebral line of the shell of a turtle.

He agreed with Mr. Gregory, that the time might arrive, when it would be desirable for English Engineers in Brazil to fell timber and prepare it, either by shed-drying or other means, so as to get a really good native sleeper. If that could be done at the price mentioned by Mr. Mann, in comparison with the cost of creosoted timber sent from this country, it was obvious to those acquainted with the financial position of Brazilian railways, that it would be a matter of the greatest importance to the railway system in that country.

He was glad to hear the remarks made by Mr. Gregory in favour of "fish joints," and that he partly attributed the injury to the rails of the Pernambuco Railway to the absence of "fish joints" in the earlier stages of the line, as it had cost him (Mr. Lane) some pains to get them introduced into that country.

With respect to the carriages which were sent out about seven or eight years ago, now referred to by Mr. Mann, Mr. C. B. Lane had at that time made a most favourable report of them to the Government, and would now repeat that he never saw carriages more commodious or better designed for the peculiarities of the climate and the country.

With regard to the white ants, he did not think there need be much apprehension of their ravages upon railway sleepers when in use. He had seen many old timber structures in that country unaffected by them, and, so far as his experience and observation went, he thought timber of good quality, which was subject to frequent shaking or vibration, was tolerably safe from their depredations.

He could confirm what had been stated as to bricks, both at Pernambuco and in other parts of Brazil. At Rio de Janerio he had seen buildings comparatively new, which looked like honeycombs, the mortar joints standing out, and the bricks eaten away from half an inch to an inch and a half; and yet that mortar was made in the most careless way, of shell-lime and sea-sand, or road washings mixed with a material called "barro," which abounded amongst the decomposed granites of the district, and which had considerable hydraulic properties, though very inferior to the hydraulic limes of this country. In Mr. Mann's Paper the statement about the iron bridges was only correct in so far as it related to insistent bridges. The earliest iron bridge in that part of South America, or so far as he knew in Brazil, was the suspension bridge over the river Capibaribe at Caxanga, which carried the most important of the provincial roads. He had frequently travelled over the bridge, and regretted not being able to supply any minute details of its dimensions or construction, further than to say that the roadway was suspended from wire ropes, and the bridge in its appearance and in some of its details resembled the suspension-bridges over the Seine at Paris. That bridge was erected about twenty years ago from the designs of a very able engineer, a Frenchman named Vauthier, who at that time held the position of Engineer-in-chief to the province of Pernambuco. He felt sure that all the Members would concur with him, that on a question of priority M. Vauthier's name should occupy its proper place in the annals of the Institution.

Mr. Alfred De Mornay stated, that he had been assistant Engineer to Mr. Louis Leger Vauthier, and had made the working drawings during the erection of the suspension-bridge at Caxanga in 1844; of which, speaking entirely from memory, he would give a brief description, as it was the first bridge of that kind erected in Brazil. Mr. Vauthier was a French Engineer of considerable talent, and, at the time he designed that bridge, had not long been engaged by the Brazilian Government as Engineer-in-chief to the province of Pernambuco. The bridge was situated on one of the main roads of the province, about 9 miles from the city of Pernambuco, in a north-westerly direction; it crossed the river Capibaribe at the village of Caxanga. The roadway, which was suspended from a pair of wire ropes on each side of the bridge, by means of vertical suspension-rods, was about 100 feet long and about 20 feet wide, constructed of the hard wood of the country, and was formed simply of cross-sleepers, placed at the same distances apart as the suspension-rods, and covered with rough planks. The ends of the cross-sleepers rested upon two longitudinal timbers, through which the suspension-rods were also carried. The ropes were constructed of a mass of iron wires, simply laid together and bound round at intervals to keep them in position. Each pair of ropes was connected together by a lacing of wire at each of the suspension-rods, which arrangement served to keep the rods from slipping down the rope. Each rope was composed of four lengths, so that there were in all eight separate ropes—two on each side of the bridge passing over the pillars, and two at each end of the bridge passing under massive stone buttresses. The ends of the side ropes, after passing over the pillars or rocking standards, were looped, and the ends of the ropes that passed under the buttresses were divided into two, and each end looped also, and then all were connected together by means of wrought-iron straps and blocking pieces, thus becoming in effect two endless ropes passing all around the bridge. The rocking standards were of cast-iron, made in three pieces. The rocking-base was a segment of a cylinder, resting upon an iron plate; the shaft was made taper at both ends, and cruciform in section, and the capitals served as a saddle for the ropes to rest upon. Four long wrought-iron bolts connected the top piece of the standard with the four corners of the rocking base, and served as diagonal braces to give greater strength to the light cast-iron shaft. The suspension-rods were of wrought iron, and were placed between the ropes, and attached to strong wrought-iron plates formed to embrace the two ropes. The whole of the work of the bridge, including the cast-iron standards, was executed in the country. The wire of which the ropes was composed was purchased in England. The wire ropes were still sound, as well as the principal parts of cast and wrought-iron. The bridge was estimated to cost 40 contos of reis (about £4,500), and its actual cost was between £5,000 and £6,000.

Mr. Russel Aitken believed, that the rigidity of the "pot" sleepers was due not to the fact of their being made of cast-iron, but mainly to the imperfect way in which the rails were secured to the top of the bowls by the wooden keys. The wooden keys, from exposure to the sun and the rain, and from the vibration of trains, soon worked loose; the result of which was, that the rail rocked and jumped in the chair. The passing trains being thus enabled to spring the rails, gave a series of successive blows to the top of the bowls, which was the chief cause of the sonority and rigidity of the pot sleepers now in use. He thought, that by proper construction this might be overcome, and he had effectually succeeded in doing so by casting the "pot" in two pieces, with a sufficient length of chair-jaw to firmly grasp the sides of the rail, by keying up through legs cast on to the bowls underneath the bottom of the rail. The "pot" by this method of construction, followed the minute deflections of the rail, the rattle of the rail in the chair was prevented, and the wooden key was dispensed with. He did not mean to say that he could make a road equal to the wooden cross-sleeper; at the same time he thought that the "pot" bearing surface was credited with defects that did not necessarily belong to it. The "pot" sleeper was the only iron road he was aware of that was embedded well in the ballast, and which, therefore, had sufficient hold; and he knew of no other form of cast-iron road that was likely to succeed in practice.

Mr. John Bethell had no means of giving any information respecting the relative durability of materials in tropical climates, as he had no experience on the subject. Mr. Gregory had correctly stated that the durability of wood depended very much upon whether it was, from its nature or situation, subject to be alternately wet and dry, and further, upon whether it was soft or hard wood. There was no doubt, that a piece of wood which was wet one day and dry the next, and exposed to considerable heat, was liable to decay very rapidly; and, in the use of native, unprepared wood, it would be safer to select that part that was hard, and which, from having all the pores filled up with ligneous matter, did not so freely absorb moisture. A piece of unprepared hard wood was not liable to get wet or dry so frequently because it did not absorb water so readily as the more porous qualities of wood; but it was the reverse when wood was selected for creosoting, and it was to that particular point he had often urged the attention of Engineers, but he was sorry to say, as far as sleepers were concerned, with little effect. In fact, the specifications issued for sleepers for foreign railways had been of such a character, that he had felt it was utterly impossible to comply with them. These specifications described the sleepers to be entirely of heart wood, and then to be creosoted to the extent of 10lbs. of the oil per cubic foot. If the heart-wood sleepers were employed it was impossible to creosote them to that extent, and he defied any one to get 10lbs. per cubic foot into heart-wood timber. He had samples in his possession, which tended to show that the great value in creosoting was to retain the young wood as much as possible. The creosoting process was not, as often described, a chemical process entirely. It was to a certain extent, because the creosote oil was the strongest coagulator of the albumen in the sap of wood. But that was not his only idea when he introduced the process; his object was also to fill the pores of the wood with a bituminous asphaltic substance, which rendered it waterproof, and by which, in process of time, the wood so treated became very much more solid and harder than heart-wood itself. That result was fully shown by some specimens he had received from Belgium, of half-round sleepers creosoted by him fifteen years ago, which showed that all the young wood had become set, as it were, into a piece of solid asphalte; and Scotch fir and Baltic timber, which had their pores filled with this tar-oil, became entirely waterproof, and so hard that it was with the greatest difficulty they could be sawn. Of Scotch fir sleepers laid on the North Eastern Railway in 1841, 80 per cent. were doing duty at the present time, and such cases of decay as had occurred, were found to have taken place in the heart wood, where the creosote had not penetrated. The engineer of the Belgian State railways sent him some specimens not long ago, which illustrated the same fact. He found one specimen which had lost a piece of its heart by decay; but on experimenting upon the transverse strength of that sleeper against a similar sleeper uncreosoted, it was found quite as strong, though it had lost its heart, because, from the thorough impregnation of the bitumen, the young wood had become so hard that it was more like an iron pipe; and he was satisfied that if it lost all the heart, it would be stronger than a sleeper in its natural state. It was stated in Mr. Mann's Paper, that the half-round creosoted sleepers lasted better than those of the square form; and this result was to be expected, because the half-round sleeper retained all the young wood, and would have more creosote in it; but in the square sleeper it was cut off. He might state that during the last six years, extensive experiments had been carried on by Monsieur Crepin, the Government Engineer, at the harbour at Ostend, for the purpose of testing the different preservative preparations against the attack of sea-worms on wood, and the result of those experiments was. that wood prepared with corrosive sublimate, or copper, suffered as much from the ravages of the worm as unprepared wood; for though the worm did not affect the timber immediately, yet it did so in a short time; but the creosoted wood the worms did not touch, except where an opening had been left to the heart-wood, which the creosote had not reached. The result of those experiments led to the conclusion, that piles used in sea-water should not be squared, but should retain as much young wood in them as possible; and the reason was obvious, that the young wood could be filled with the creosote oil; but if that young wood was cut off, and only the heart-wood left, the creosote could not get into it. The engineer to whom he alluded strongly recommended that all piles used permanently in sea-works should be entirely round.

Mr. Sheilds had examined some timber bridges in Pernambuco during a short visit to that country, and in one, which had only been constructed three years, he found the ends of the timber had been placed in contact with the moist clay; at those places he could readily knock off the crust of the wood, and the interior of the wood was almost filled with white ants. He had no doubt the decay was augmented by the contact of the wood with the moist clay. In such a case he would have taken care that the ends of the timber were embedded in masonry, or that the spot where the wood rested was dry and well drained. At Bahia he had opportunites of making more extensive observations; and timber there appeared to him to be less affected, generally, by the white ant than in Pernambuco. It had been ascertained that timber was preserved for a considerable time by being embedded to the depth of about 2 feet in the sea-sand, which protected it also from the attack of the teredo. Timber was stored for the Government works in considerable quantities in that way, and, having in some instances been forgotten, discoveries of seasoned wood were occasionally made on the shore. That fact appeared to show that timber, when wholly embedded in such situations, was suitable for piled foundations, and might also be applied economically by those who had wharves or jetties to build in that country, by forming the underground part of the piles of timber, and using iron for the upper portion. He had had opportunities, in the earlier part of his life, of making observations upon Australian timber, and it showed the difference of effects between one climate and another, that in Brazil the more porous and open-grained timbers were most subject to the attacks of the white ant, but that in Australia it was the reverse, for there it was the hardest description of timber that those insects first attacked. There was one wood in particular in common use to which this remark applied, it was called "iron bark." Its density was so great that it sunk in water, and its strength was extraordinary, almost approaching to that of inferior iron in tenacity and resistance to strain. It was this wood the white ants particularly attacked. He had tried the effect of coal-tar in destroying white ants. He had taken short baulks of timber where the ants had commenced operations, and tried the system of pouring a very small stream of coal-tar through the heart of the timber which the ants had hollowed out, and afterwards splitting it open to see the result. He found the white ants completely destroyed; they were shrivelled up like shreds of half-burnt paper by the mere effluvium of the coal-tar, and after that experiment he never rejected a piece of timber because the white ants had commenced operations upon it, as had been previously the custom, whilst he was able to destroy them thoroughly in that cheap way. It was to be remarked, with regard to the timber of Brazil, that it was very brittle; and his experience there led him to the conclusion that the best course for an engineer to follow was, as much as possible, to have his materials from England, and that iron-work and iron sleepers were peculiarly adapted for a country of that kind. It occurred to him even now that for tropical climates wrought iron transverse sleepers, if it were possible to make them within reasonable cost, would be the best for permanent way; and the next opportunity he had he should endeavour to design something of that sort. With respect to the suspension of the cross-girders of iron bridges from the lower flange of the main girder, instead of from the vertical web, he thought Mr. Mann was right in the remark that it was better to attach the girder to the vertical web than to suspend it from the flange, but that the correct reason for that opinion had not been stated. The true reason was, that if the cross-girders were attached to the vertical web, they were suspended not from the head but from the shank of the bolts; whereas, if attached below the main girders, they would be suspended not by the shank but by the head. He thought every practical man knew that the weakest part of a bolt was the head or nut, and especially so when it was exposed to any sudden shock, such as the blow of a hammer. He had screwed bolts for experiment very tight, and the fracture occurred generally at the nut, but never in the shank. In attaching cross-girders to the vertical web, the bolt or rivet must be sheared through the shank before a failure should occur, while the heads, which were the weaker part, were only employed in keeping the work together, and were therefore only subject to slight strains. Indeed, if both heads were knocked off the rivet, the work might to a certain extent stand good if suspended from the shank, but the work would give way directly under the same circumstances if suspended from the head. For that reason, he thought girders were better suspended from the vertical web (the proper amount of rivetting being, of course, provided as much in one case as the other), as in so doing there would be a clear shear through the shank of the rivet, which presented greater resistance than the head, and was a safer plan for withstanding the jarring of railway trains.

Mr. John Calvert remarked that a residence of twenty years in tropical climates had given him some insight into the decay of materials, especially of timber, and he would state a few facts that had come under his observation.

With regard to timber as sleepers, he remembered that eighteen years ago the Jamaica line was laid with kyanized sleepers, but in less than twelve months they were nearly all decayed, after which recourse was had to the native "cashaw" wood, a species of the acacia something like mahogany in appearance, and as hard. The timber was sawn down the centre, and laid with the flat side down, and the sleepers had lasted from that time to the present. A similar wood grew in the Punjab, called Babool, which formed the principal fuel for the steamers on the Indus and Chenaub rivers. It was proposed to use it for sleepers also on the Mooltan and Lahore line, but it was doubtful if a sufficient supply could be obtained. With regard to the depredations of white ants, anything of a bitter taste injected into the fibre prevented their attacks, though it might not have the same effect as coal-tar; but even a small quantity of turpentine had the effect of killing them instantly. The kyanized sleepers he had spoken of were destroyed, not by ants, but by rot. He could confirm the statement with regard to hard woods, that the black ants of the West Indies were more destructive in that quality of wood than in soft, and attacked certain kinds of wood with great voracity. In pulling down the old cathedral at Jamaica, some of the timbers of the roof, which were of hard wood, were eaten away, and a cart-load of nests formed by the ants was removed, after being cut away with great labour by hatchets. There were some descriptions of wood in the West Indies, such as the bullet-tree and lignum vitæ, which were not affected either by the teredo navalis or by the black ant, and when used for piles were never known to decay. In surveying one of the great lagoons, he remarked an old post of lignum vitæ in water, about 12 feet below the level of the sea. It was in the shape of a cross, and was said to have been placed there by the Spaniards hundreds of years ago. It was not decayed in the water, and very little affected between wind and water. At the Cape of Good Hope, various methods were adopted for preserving the piles used for the jetty. One method was to case them in iron; another was to drive hard nails all over them, in the hope that the oxidation of the heads of the nails would form a coating on the outside, and defend the timber from the worms. In India the white ants were exceedingly destructive. In piles of sleepers which had been lying ready for use about eight months, at least 10 per cent. were found decayed at the heart. He was inclined to the opinion that frequent vibration, such as was caused by the passage of trains, acted as a protection against white ants; and he knew of an instance in which the timbers of a house were periodically beaten with hammers to keep the ants away. With regard to stone, he had found in the tropics that the application of linseed oil not only acted as a preservative, but rendered soft stone in the course of a short time so hard that a chisel would scarcely touch it, and that remark applied to imported Caen stone as well as to the chalk stone found in the West Indies. In Jamaica he found the finest bricks he had ever seen; not only were those bricks well made, but the material itself was good, and there were buildings which had stood from time immemorial without showing any signs of decay. At the Cape of Good Hope the best mortar was made of shell lime, and, even when mixed with sea-sand, it was exceedingly hard and durable. Both there and in India, sun-dried bricks were much used for inferior and cheap building. At the former place there were vineyard walls of sun-dried bricks now standing which were built before the English took possession, the clay being of a tenacious quality.

In the Punjab, however, the clay was very inferior, and soon melted with the rain, so that when the country was flooded, two or three railway bungalows had been seen to fall in a few days. In spite of this, the Kutcha-work (or mud-work) was largely adopted. The burnt bricks in the Punjab were not so good, from the extensive exudation of phosphate of soda after the work was built. That defect was, however, remedied to a great extent by covering the bricks with plaster. In the neighbourhood of Agra, telegraph posts of stone, obtained in long lengths, had been adopted to a large extent in place of timber posts, the rapid decay of which had greatly retarded telegraphic extension in India; but the difficulty was being met by making the lower part of the posts of cast iron, into which wooden posts were inserted.

Mr. Thomas Webster said that the observations respecting the value of young wood, reminded him of the elaborate experiments that had been made some years ago with chloride of zinc, sulphate of copper, and other chemical preparations; but in all those cases, the question depended upon the quantity of those salts which could be absorbed in the soft woods. With regard to the chloride of zinc, it had a remarkable property of amalgamating or uniting with the albuminous matter of the wood, and thus acted as a preservative. He apprehended that by these experiments, the value of young wood for these purposes, by reason of the albuminous or other matter contained as a vehicle for uniting with the preserving material, was established beyond all question.

Mr. J. G. Cockburn Curtis said no mention had as yet been made of one of the sources of decay of buildings in tropical climates which he had particularly observed in India. He alluded to the presence and subsequent germination of vegetable matter or seeds in the mortar. When he was employed in the Public Works Department of the Madras Presidency, it was found necessary that periodical inspections should be made to guard against this evil. In some instances, where proper precautions had not been taken, roots had formed very rapidly, and of such great size as to bodily dislodge by their pressure large stones from buildings. Mention having been made of the duration of masonry work in India, it might be worthy of attention whether the practice of the native masons prior to the period of railway engineering had anything to do with it. A proportion of "Jagherry," or coarse native sugar, varying from about 2 per cent. in ordinary work to from 5 per cent. to 8 per cent. in arch work, was mixed with the lime. The chemical effects of the "Jagherry" had been investigated by some engineers in India, but no very definite conclusions upon the subject had been arrived at.*

Mr. J. M. Heppel, having been engaged in public works in India, could confirm the statement with regard to "Jagherry" having been used in the mortar, and that the mortar so made set exceedingly well, and was very durable. As the result of his general experience in India, he thought none of the preservative processes for timber which had been mentioned were entirely reliable; and, in connection with the Madras Railway, he inclined to the opinion that iron was the only material suitable to the circumstances met with in those climates. With reference to the loss of metal in rails, he had investigated that question, and found that rails of 72 lbs. per yard had, in one instance, deteriorated to the extent of 3 lbs. per yard by lengthened exposure to the sea air in stacks, though when laid in the sand they lost very little. One great obstacle to the obtaining of reliable results was that from the nature of the climate, and from other circumstances, offices in India were generally held but for a short time, a lengthened residence in that country being the exception. He thought those engineers in Great Britain who, from their connection with Indian railways, had accumulated a large amount of information in the reports sent home from various sources, were usually better able to give an opinion on these matters than those who had been resident in India for a comparatively short period of time. Amongst residents, such men as Mr. Berkley, who sacrificed his life to his zeal in conducting a most arduous undertaking, and Mr. Turnbull (to both of whom he had been much indebted for advice and information collected during a great number of years in India), were the men whose opinions on such matters were entitled to the greatest weight, and he preferred to draw upon the experience of such men, rather than to rely entirely upon his own.

* *Vide* "Reports, Correspondence, and Original Papers on various professional subjects connected with the Corps of Engineers, Madras Presidency," vol. i., p. 119; vol. ii., p. 193.

THE ARCHÆOLOGY OF EASTBOURNE, SUSSEX.

By the Rev. E. Turner.

The design of this paper is to finish a short account of such objects of archæological interest as have been discovered from time to time in Eastbourne and its immediate neighbourhood.

I shall commence with a most interesting discovery which was made here in 1805, when, by the fall of a portion of the cliff at or near to the Wish, four Celtic gold bracelets, very similar to those which were discovered four years ago at Mountfield, were brought to light, the heaviest of which weighed rather more than 3 oz., and the lightest 16 dwts. and 4 grns. The first was found by a man led to visit the spot by curiosity, and who, not at all knowing its value, took it to Mr. Holt, then a silversmith here, who, to his great astonishment, gave him £3 for it. This led the man to make a further search among the fallen chalk, which resulted in his finding two more, and a fourth was subsequently found. These Mr. Holt also purchased. An examination of the cliff where the slip had taken place was afterwards made, when several bronze instruments were found embedded in it, at a depth of about 10 ft. from the surface. These consisted of three celts of the kind called palstraves, two socketed celts, a sword, and three lumps of pure copper, showing that they must have been lost or hidden there by some native maker of such bronze instruments. This discovery reaching the ears of Sir Joseph Banks, he wrote to Mr. Holt about them, and through him they were exhibited at a meeting of the Society of Antiquaries in London, March 19, 1807, together with the celts and sword; after which Sir Joseph became the purchaser of them, and they are now in the British Museum, having gone there from the collection of Mr. Payne Knight, in 1835.

Mr. Harvey, of Lewes, has an ancient British gold coin found here.

I shall now proceed to show the claims which Eastbourne has to be considered a Roman station. That it was so is clearly proved by the Roman remains which have been discovered in and around it. In 1717, a tesselated pavement of considerable size, a bath, and other indicia of these early invaders of this country, were discovered in a field by the seaside, now forming the site of Cavendish-place. The discovery was made by workmen engaged in repairing a post and rail fence. In digging the post-hole, the tool made use of struck upon something that offered a strong resistance, and upon opening a wider space to ascertain what it proceeded from, the Roman pavement was discovered. That eminent physician and antiquary, Dr. Tabor, of Lewes, who drew up an account of it, which will be found in the 30th volume of the "Philosophical Transactions," says that the whole field, which measured four acres, is supposed to be full of foundations. The length of the pavement was about 17 ft., and its width about 11 ft. It was constructed of coarse tesseræ, with a pavement of brick around it, the whole being so firmly cemented together that, as I have already said, the workmen had some difficulty in breaking through it. As Dr. Tabor does not speak of any figures similar to those which so beautifully adorn the Bignor pavement, it was, I presume, quite plain.

Other remains of the same people were found here in 1848, by Mr. James Berry, an Eastbourne architect, at a point to the west of the "Sea Houses," and but a short distance from Trinity Church, the direction of its massive walls, which varied from 2ft. to 4ft. in thickness, and which were constructed of Eastbourne stone, being north and south. Mr. Lower, who inspected it soon after it was opened, succeeded with the help of Mr. Berry, in tracing its connection, by means of a corridor, with the bath, and pavement previously found. Besides fragments of pottery, of various kinds—black, brown, and red—two coins much corroded, a flint celt, bones and horns of various kinds of animals, tiles of red earth, impressed with a variety of patterns, and a small bronze, were found upon the site. As portions of Pevensey Castle, from which Eastbourne is distant about 4 miles, are manifestly of Roman construction, and its claim to have been the site of the Romana-British city Anderida which Dr. Tabor claimed for Eastbourne, is now very generally admitted, the Roman remains discovered here were probably the foundations of the villa residence of some Roman officer, high in station and command there.

On the Downs, north-west and west of Eastbourne, Roman urns, one containing horses' teeth, and others burned bones, and skeletons which had not undergone the process of cremation, have been disinterred. The two fragments of Roman pottery now exhibited were found about two years ago, having been thrown out with the earth which it became necessary to remove for the extension of the esplanade towards the Wish. Mr. Harvey, of Lewes, and Mr. Emary, of Eastbourne, are both of them in possession of Roman coins found in and around Eastbourne.

In the spring of 1847, during the time the railway from Polegate to Eastbourne was in the course of construction, the navvies, in making a cutting in the part that passes through Willingdon, discovered an ancient coffer. It is of cast lead, and measures 12 in. in length by 11 in. in breadth. Its depth is 6in. It has at each end sockets for iron shifting handles. On the longest side it has a triangular device of interlaced work, including a cross; an ornament not uncommon on Runic monuments. The whole is enriched with corded work. Various are the conjectures as to its date and use. By the Archæological Society and the Archæological Institution it is considered to be Anglo-Saxon, and its date to be about the tenth century. Of its original use no satisfactory opinion has been advanced. Mr. Roach Smith thinks that such leaden vessels were used by the Romans for coffins. Its resemblance to the leaden cists in which the bones of Gundrada and her husband, the Earl of Warren, were discovered under very similar circumstances in the priory grounds, at Lewes, are very remarkable.

Another object of archæological interest found at Eastbourne, but in what year I am not able to say, is an ancient bronze seal, bearing an armorial shield, semèe of cross croslets fitchee, a lion rampant, and the inscription.

"SIG : IOHANNIS : LIVET."

In the sixteenth and seventeenth centuries there were Levetts residing at Warbleton and Salehurst in the eastern, and at Fittleworth in the western division. Mr. Walford, however, thinks it not unlikely that this seal belongs to John Livet, who was the certified lord of the township of Firle, in 1316.

Before I conclude my list of archæological discoveries in Eastbourne, I must not omit to notice the most remarkable one, perhaps, of all; namely, the gold coins, with Mohammedan inscriptions of the eighth century, which were found here about ten or twelve years ago. It has hitherto baffled the endeavours of the keenest archæological mind to discover to what fortuitous circumstances we are to attribute the cause of such coins being found here.

Of the two lost towns of Hidney and Northey, both of which were limbs or members of Hastings, as one of the Sussex Cinque Port towns, Northey was about four miles from hence, in the Liberty of the Sluice, near to that part of the coast where the whale was cast on shore two years ago; but Hidney is described as having been situated between Pevensey and Eastbourne. Of these two extinct Sussex towns, I shall say no more at present than that I have been for some time collecting materials for a history of them, the result of which I hope to be able to give to the Society in the next volume of our Collections.

Nothing need be said of the beautiful parish church of St. Mary, of the old parsonage-house adjoining the churchyard, or of the old crypt under the inn, for these we have just visited—the church under the able guidance of the Vicar. Of the crypt I shall only add that the celebrated inn at Alfriston, and the well-known Star Hotel at Lewes, have, both of them, similar crypts under them.

I might refer to the wonders of Beachy Head, which is second only to that renowned cliff near Dover which Shakspeare has so beautifully described; of "The Charleses," which once were conspicuous landmarks, but which have been obliged to lower their heads in submission to the all-devouring hand of time, a fragment of one of the seven only now remaining to mark the spot where they stood, and this remnant tottering to its fall; and of that extraordinary artificial, but evidently ancient, cavern to the west of "The Charleses," the origin and date of which are unknown; such caverns, however, it may be observed, are not uncommon in the cliffs on the coast of Scotland, and of great antiquity. The cavern of which I am now speaking is usually called "Parson Darby's Hole." Parson Darby was the incumbent of Eastdean about the year 1680, and was much in the habit of visiting this cave.

THE CIVIL AND MECHANICAL ENGINEER'S SOCIETY.

This Society has now been in active operation for seven years, and our readers will feel interested in its progress. It was formed by a few junior members of the profession in the year 1859, and has since been perseveringly pursuing its aims. It has met with some of the usual difficulties of all new associations, but may now be considered to have attained a permanent position. Until lately the meetings of the society were held at the Freemasons' Tavern, Great Queen Street; but, owing to the rebuilding of that establishment, temporary accommodation has been obtained, but shortly a more suitable and permanent meeting place will be secured.

The council state that the society is intended simply as a medium for the interchange of ideas and information upon engineering subjects, and generally to promote the acquisition of professional knowledge by its members, who for the most part being juniors, feel that they could not, in the earlier stage of their professional course, derive from the older societies the kind of advantages they need, even if they were eligible for membership.

The President for the session 1866-67, just commenced, is Mr. G. Eedes Eachus, and the society includes among its honorary members Mr. Charles Vignoles, F.R.S.; Mr. G. W. Hemans, F.R.G.S.; Sir Henry James, C.B., F.R.S.; Mr. R. Sinclair; Captain Symonds, R.N.; &c.

At the opening meeting of this session the President delivered an address, some extracts from which we append:—

The properties of materials used in engineering constructions are of two kinds—structural and chemical.

Of all materials used, stone is by far the most important, but the great increase in the value of it which has of late taken place, in consequence of the large engineering works in hand, has led men to look about to seek, if possible, some substitute for it. Granite, for instance, is now about 30 per cent. dearer than it was a short time since. Among such substitutes, Mr. Ransom's invention stands out prominently. He has succeeded in producing an artificial stone of a superior kind, which is to be tried on a large scale at Cranston's Hotel, New York, now in course of construction in that city, which is being built with this material. The character of the materials used for cementing stones and bricks is of almost equal consequence with the stones and bricks themselves. In these cementing materials great improvements have been made, owing to the high requirements of several eminent engineers, and especially the engineers to the Board of Works.

The standard of weight and strength of cements has been so increased as to necessitate corresponding improvements in their manufacture; and, certainly, practical civil engineers will never specify materials which the manufacturer is unable to produce. Iron and steel must continue to increase in favour for engineering purposes, the latter especially giving proofs of such great tensile strain as to make the use of it an absolute necessity; whereas, for instance, in very large bridges it would not be possible to secure the span required if wrought and cast iron, which have less strength, and consequently greater weight, could alone be used upon the work. At present, iron and steel are but little used in the construction of breakwaters and other sea defences, though they enter largely into the construction of jetties, piers, &c., but it seems well that they should be employed much more freely in all such constructions, as by the use of them not only would the expense be much diminished, but it would then be possible to imitate similar works in the Mediterranean, where the sea walls are built on arches, to allow the free passage and consequent scouring of the deep water.

A better knowledge of chemistry has been the means of effecting many great improvements in the manufacture of iron. M. Gaudin discovered two ways of producing a very hard iron, the one by adding to cast iron in fusion boron, and the other by adding phosphate of iron and peroxide of manganese; the metal thus produced he recommended as a material for bells, as being very sonorous.

For supplying London with pure water, and in larger quantities than the present companies are able to do, I consider Mr. Bateman's scheme one of the best. This eminent engineer, in a pamphlet published for private circulation, has advocated the supply of water to London from the sources of the Severn.

After showing the rate of increase in the population of the metropolis, and the still greater growth of the suburbs, he justly concludes that a greater quantity of water will be required for their supply; and, further, from the increase in the amount of impurities contained in the water, that there be also necessitated a purer and softer supply. It has been suggested that the present water is good enough for washing purposes, and that water of the purest kind should be supplied only for drinking purposes; but, in truth, for washing also the softer water would be required, as the softer the water the less the amount of soap used, and, consequently, so much less the expense of cleanliness. Indeed, Mr. Bateman estimates this saving at £400,000 per annum. It is probable that the Thames water, in the course of a few years, will be much purer than at present, and a Bill for Thames purification was passed in this last session; but with all our efforts in that direction, some measures of an entirely new character will have to be adopted. Mr. Bateman, arguing from the quantity of water at present used in the metropolis, and taking into consideration the increase according to past years, is of opinion that no scheme deserves attention unless by gravitation it is able to supply the metropolitan district with 200,000,000 gallons per day. The nearest district for such supply is to be found in the upper basin of the tributaries of the River Severn.

The fall of rain there may be safely estimated at 70 or 80 inches per annum, but Mr. Bateman's calculations are based on about one-half, or 36 inches per annum.

There are no metalliferous veins to contaminate the water in these districts, which have a total area of some 120,000 acres, and the discharge-pipes of the lowest reservoirs would be placed 450 feet above Trinity high water mark. From the two districts which Mr. Bateman selects, he would carry separate aqueducts to Martenmere, each capable of conducting 130,000,000 gallons per day. From Martenmere the water would be conducted by a common aqueduct capable of conveying 220,000,000 gallons daily to the high land near Stanmore, where reservoirs would be placed for supplying the metropolitan districts at high pressure and on the constant supply system. It is probable that the water derived from the above sources will be about 1° of hardness with about 1·25 grains of organic impurity. The cost of the undertaking, which certainly seems large, owing to the distance which is to be traversed (183 miles), is to be met by two rates, one a public rate on house property, the other a domestic rate. The following shows the estimated receipts:—

Probable annual value of surplus property ...	£50,000
Sales of water for trading purposes of companies which may be disposed of, and to suburban districts and places on the line of aqueduct, probably	250,000
Compulsory rate for domestic supplies at 10d. in the pound on £12,000,000	500,000
Compulsory public rate at 2d. in the pound on £18,000,000	150,000
	£950,000

The total cost for the first supply of 130,000,000 gallons per day is estimated by Mr. Bateman at £8,600,000, and the subsequent outlay for completing the whole scheme of 220,000,000 gallons per day would bring this up to £10,850,000. Mr. Bateman's scheme is, I believe, the result of very careful surveys, and deduced from a sound knowledge of both the geological nature of the district traversed and the peculiarities which render it suitable for supplying water to the metropolis. It is to be hoped that the next session may bring this scheme prominently before the public and the engineering world.

The next scheme to which I will allude is that of Messrs. Hemans and Hassard, which, like the one proposed by Mr. Dale, of the Hull Corporation Waterworks, would look for the water supply from the Cumberland lakes. Messrs. Hemans and Hassard, however, propose to supply the metropolis and towns in the direct route to London, while Mr. Dale proposed to convey the water to the populous districts of Yorkshire and Lancashire. The lakes from which the water would be taken lie at a distance of 240 miles from London, and Messrs. Hemans and Hassard would provide for a daily supply of 200,000,000 gallons for the metropolitan districts, with a further 50,000,000 for sale to districts traversed by the aqueduct.

The works on the Eastern side would commence with an intercepting conduit tapping the tributaries of the River Lowther, and running into an auxiliary reservoir at Swindale, hence by another conduit tapping the tributaries of the Hawes water, and into this lake, the surface of which would be raised 42 feet.

Another intercepting conduit would carry the water from the Hows Beck, Gill Beck, and Heltondale Beck streams into the Hawes water. The water from this lake would then follow the course of the River Lowther to a point about 1½ miles south of Askham, where a third conduit is placed to convey the water into the River Eamout and the Ullswater Lake. The waters of the Dacre Beck would also be conducted into the Ullswater by means of an intercepting conduit. The waters of the Mosedale Beck, Trout Beck, Barrow Beck, Watendlath and Coldbarrow Fells, would all be intercepted by conduits and conveyed into Thirlmere. The waters of a further area of six square miles would also be conveyed by means of short intercepting conduits and a tunnel under Dunmail Raise Pass into Thirlmere, which would be raised 64 feet.

A compensation reservoir would be constructed on St. John's Beck to receive the waters when Thirlmere is full; such waters are to be given out as compensation to mill-owners on the River Greta. The waters from Thirlmere and Ullswater would be used for the supply of towns, the waters of the River Lowther being chiefly used for compensation. The water from Thirlmere would be conveyed by means of conduit and tunnel to Ullswater, and from the latter the supply would be conveyed by conduit and tunnel to Harrow, where a regulating reservoir would be constructed, at a distance of 12 miles from London.

The total cost of this scheme, as estimated by Messrs. Hemans and Hassard, is £11,200,000, and the annual expenses £973,000, to meet which there would be a probable income of—

From the sale of 50,000,000 gallons daily to towns, &c., on the line of aqueduct, at 3d. per 1,000 gallons	£228,125
From the sale of 30,000,000 of gallons daily in London for public and trading purposes, at 3d. per 1,000 gallons	136,875
From an average rate of 10d. in the pound on a property of £16,000,000	666,666
	£1,031,666

There is also a scheme of Mr. Fulton's which is to be brought forward next session by the existing water companies, who doubtless are reluctant to relinquish their large profits, and finding Mr. Fulton's estimate considerably below those previously mentioned, seem inclined to support it.

Mr. Fulton's plan resembles very much Mr. Bateman's, but the source is not sought for so far, as he proposes to take the supply from a little above Tewkesbury, to do which he must divert the sewage of all the towns above that point. And if this is impracticable, he would propose to take the water from the sources of the River Wye. In the latter case the estimate would be about five millions and a half, in the former only three millions.

There is another suggestion, to which I have already referred, from Mr. Gower, with an estimate of £4,328,500, but this appears not likely to be adopted, as being only a partial remedy. This gentleman would not supply soft water for washing, but only for drinking purposes. But, as we have said, a great saving would be effected by the use of soft water for washing purposes, which would be a set-off against the increase in the original outlay, and we may feel certain that no scheme for the water supply of the metropolis will be adopted which does not supply soft water and soft water only.

The schemes for crossing the channel are even bolder than those for the water supply of London. This communication, however, is less important than the other great measures, which are urgently called for as essential to the cleanliness and well-being of the inhabitants of this vast metropolis; it is, consequently, less likely of a speedy accomplishment, and I shall therefore allude but briefly to the several plans suggested. In the beginning of the present century, before the time of railways, a French engineer, Mr. Mathieu, proposed a tunnel which was designed for ordinary traffic, and was to be lighted by lamps. Among the many other plans subsequently proposed, one of the boldest is that by M. A. Thomé de Gamond. He would connect Eastware, near Dover, with Cape Grisney, at an estimated cost of seven millions. His idea includes the construction of an island in mid-channel, also subterranean approaches to the submarine tunnel (that on the English side 3¾ miles long, that on the French side 5 miles long), and two large shafts at either end of the submarine tunnel, an immense tower being also provided for access to the island, and for ventilation in the central part of the tunnel. This scheme was brought forward by M. Gamond about nine years ago, and since then the question seems to have been but little mooted until last year, when Mr. George Remington made the necessary surveys for laying down a line between Dungeness and Cape Grisney. This route was chosen by Mr. Remington as avoiding the chalk, which, from his experience, would render futile any attempt to tunnel between Dover and the French shore. So far, however, as that point is concerned, it would, in my opinion, be quite possible to tunnel between those points, and I see no great advantages in the route suggested by Mr. Remington as compared with the Dover route, for the object is not to connect England with France alone, but with the whole continent. As regards the approaches, Dungeness, from its lower level, would be probably more suitable, and the less amount of water in this route is also a decided advantage. I am not aware that the estimates of Messrs. Remington and Hawkshaw are definitely given, but they would probably be about 10 millions. Mr. Remington proposes to construct three shafts, one at Dungeness, one on the ridge which is crossed by his line in mid-channel, and the third at Cape Grisney, in France.

For the construction of the tunnel, temporary shafts of wrought iron would be used, and the tunnel would be made sufficiently wide for two lines of railway, two smaller tunnels being provided for ventilation, &c. There is not published sufficient information concerning Mr. Hawkshaw's tunnel to allow me to give a full description, but we shall doubtless before long have complete details, not only of the route to be taken, but of the construction of the Channel Railway, according to the designs by this eminent engineer. A bridge across the channel is also said to be suggested by Mr. McClean, but of this I can say little. It would, if completed, be more acceptable than a tunnel, but the expense would probably be nearly double. Pending the execution of these gigantic undertakings, Mr. Fowler's Channel Ferry is the readiest remedy, and might be used in the meantime.

Military engineering now becomes a part of the civil engineer's education, and the successful progress in the manufacture of large artillery makes it a matter alike interesting and important, interesting on account of the great experience it gives in the manufacture and manipulation of the largest masses of metal, and of the utmost importance, not only because artillery forms the vital strength of our national defences, but also because we are sadly forced to admit that, notwithstanding all her expenditure, England is now, in this respect, behind two, if not three, other European nations, and these the nations from whom she would always have most to fear.

The Americans, without doubt, are far ahead of us in the size of their naval artillery. The Rodman gun, with which many of their Monitors are armed, could only be successfully opposed by our 600-pounders, of which we have the good fortune to possess an unlimited supply in the two disabled specimens, "Big Will" and his brother, and a prospect of six or a dozen others to bear them company in their misfortune. The French are also unanimously in favour of heavy guns for their fleet, the ironclad portion of which we must allow to be cased with much thicker metal than our own ironclads. They have 18 vessels with a 6-inch coating, and 7 with 8-inch coating, against 3 vessels of ours, with 6-inch and 1 with an 8-inch coating. The French seem also to have adopted the plan of casting their large guns, and have apparently succeeded in making guns capable of throwing 150 or 300 lb. shot.

The largest cast gun at present employed in the English navy is the Somerset 100-pounder, the Woolwich authorities seeming to be bent upon making larger guns, according to some one or more of the built-up processes. The Armstrong has been for some years the favourite at Woolwich, but, owing to its numerous failures, this seems about to be finally abandoned for some other method, and it is to be hoped, for the sake of England's purse, credit, and power, that better success will attend the efforts of the present Government than we have recently seen achieved in this department, as they succeed to their work invigorated by a long term of repose. Perhaps the principal methods of construction now before the English public, and which may be briefly mentioned, are (in addition to the well-known Armstrong) the Blakely, the Fraser, the Mackay, the Whitworth, the Palisser, the Parsons, the new Woolwich, the Ericcson, the Longridge, the Ames, the Krupp, and the non-recoil gun.

The Blakely system (which includes the Armstrong, Fraser, and new Woolwich) is, as is well known, founded on the principle of strengthening guns or tubes by means of hoops or rings shrunk on so as to give an external tension and an internal compression to the material. The Fraser, Armstrong, and Woolwich guns differ from the Blakely merely in the construction of the hoops, or the mode of putting them on, so as to include the breech.

The Palliser and Parsons guns are constructed on a new principle, and have for their chief object the making use of the existing stock of old guns. In these systems a steel tube is inserted into the bore, and it need not be said that to do this requires the most careful workmanship, or very uncertain results will be obtained. The Mackay gun, like the Whitworth, is not so much a novel construction of gun as a new method of rifling, but the principles of the two systems are exactly opposite.

The Whitworth, aiming at tight, close-fitting shot, would require to be made according to one of the above-mentioned methods if made of a large calibre, while the Mackay, having a very great amount of windage, allows English gunpowder to act similarly to the slow-burning powder used by the Chinese, and probably by the Americans, for it is scarcely likely that the Rodman cast guns would stand a full charge of English powder.

The Mackay gun principle, then, is suitable for guns throwing heavy shot, and such guns, on account of the rotation given to the shot, would excel the Rodman or Somerset smooth bores, not only in point of accuracy, but also in durability, if strengthened on the Blakely system. The Ames gun is purely a wrought iron gun, made by welding together in succession rings or cross sections of the gun, and possesses no advantage of initial tension, but merely of material. As might be expected, it yields beyond the limit of elasticity, so as to become permanently enlarged.

The plan which has been proposed of inserting a steel tube into the bore would probably prolong the life of such a gun, but it would thus become a most costly article, and scarcely less difficult to make than the cast steel guns of Krupp.

There are two other methods of strengthening a tube to form a gun. One is the Ericcson method, which consists in forcing on to the conical tube discs of iron or steel; but here again, as in the Blakely, there must be most careful workmanship, otherwise no satisfactory results can be anticipated. The other plan is an old one as regards the time of being patented, and has not yet received the attention it deserves; I allude to the wire system of Mr. Longridge. This, in fact, is the same as the Blakely system, carried almost to perfection as regards the number of rings or hoops, but without its disadvantage of requiring great accuracy of work. In fact, in the wire system a gun can be made of almost unlimited size or strength, and that, moreover, at very much less cost than on any of the other systems. The limit to the size is not the difficulty of manufacture, but the mere question of facility of use. In this system, where the wire is wound with a calculated tension on a rough, light casting of steel or iron, a gun can be made with all the advantages of steel for the interior, and of steel wire, the very strongest material known, for the outer portion, and the gun is made in the easiest manner by winding on the wire. This is the cheapest form of gun; the cost, for instance of a 600-pounder on the Woolwich system is £4,000, while the same sized and more effective gun constructed on the Longridge system would cost about £800 or £1,000. If this system were applied to the non-recoil gun, I think we should have a more effective and cheaper gun than any at present in use. The question of breech-loading small arms is also one of great interest to the engineer, as it is a question of the best mechanical means to accomplish a definite end, and here again the Americans have gone ahead of us, as there is little doubt that as effective weapons the Spencer Henry and other repeaters must be superior to a simple breechloader like the Snider.

The Atlantic Telegraph now forms the grandest of connecting links between the old and new worlds. The laying of the cable of 1857, commenced on the 6th August, when the Niagara started from Valentia, and on the 6th day, August 11th, the cable parted in 2,000 fathoms. It was, however, decided to lay a similar cable the next year, and, accordingly, on the 29th May, 1858, the Agamemnon and Niagara sailed for an experimental trip to the Bay of Biscay, their object being to ascertain the practicability of splicing and submerging the cable in mid ocean. The experiments were made in 2,500 fathoms, and having been successful, the expedition left England on the 10th June, 1858, and the splice was made in mid ocean on the 26th of June, but on the same day, after paying out 2½ miles, the cable broke in the machinery, and the splice had again to be made; the laying out progressed favorably until the following day, when the continuity ceased, and on an attempt being made to wind in, the cable broke, and 42 miles of it were lost.

On June 28th, a third attempt was made, and after paying out 142 miles 230 fathoms, the cable again broke close to the stern of the Agamemnon, and the vessels then returned to England.

On the 17th July, the vessels left England, and after some little delay in meeting at the rendezvous, on the 29th the work of paying out commenced; after ten hours paying out the continuity partially ceased, but only for a time; on the return of continuity the paying out was continued until the eighth day, August 5th, when the cable was landed in Trinity Bay, and was in partial working order until September 1st; on that day, however, it finally ceased to transmit the slightest signal. The last message sent from Valentia to Newfoundland was, "Please inform American Government we are now in a position to do best to forward their Government messages to England." The message was sent correctly as far as the word "forward," but that was the last word ever transmitted through the cable. The total number of letters which were sent from August 10th to September 1st, was 21,220. The core of this cable consisted of seven copper wires, surrounded by three coats of gutta percha, then six strands of yarn, and, lastly, eighteen strands of No. 7 iron wire.

Great improvements have since been made in the construction of the cable. The conductor, this year, is the same as it was in 1865, that is to say, seven wires imbedded in Chatterton's compound. The insulator is also the same as in 1865, four layers of gutta percha, interlaid with four of Chatterton's compound. The core was protected in 1865 by tin wires, No. 13 gauge, each wire surrounded by five strands of Manilla yarn, and the whole wound in spiral form round the core, the latter being padded with jute yarn, which as well as the Manilla yarn, was saturated with preservative mixture. In 1866, the same method has been adopted, but white Manilla yarn has been used, and, in place of jute yarn, ordinary hemp.

The breaking strains in 1866 was 8 tons 2 cwts., or 12 times its weight in water per knot, as against 11 times in 1865, and less than 5 times in 1858. The means of testing the perfect state of the wires has also been brought to much greater perfection.

The success which has at last crowned the bold undertaking is a cause of sincere congratulation, and the raising of the 1865 cable has formed a double crown for the reward of persevering labour; but we must not rest here, but enquire whether there are not still imperfections in both cables, which can be remedied in the future.

The use of a lighter, and therefore a comparatively stronger cable, seems strongly urged by our experience gained in these late efforts; such, for instance, as that advocated by Mr. Allan, which has a weight of 8½ cwt. per mile, as against 31 cwt. per mile, the weight of the present one. In water the difference is still more striking, the former weighing 2¾ cwt. against 14¾ cwt., the weight of the latter per mile; so that in raising to the surface the strain upon the grappling wire, instead of being for 9 miles of suspended cable a tension of 9 times 14¾ cwts., or nearly 7 tons, would be only 1¼ tons. The raising of a cable on Allan's system would therefore be much easier, the cable itself more durable in deep water, and the laying infinitively safer, and if we continue to apply our thought and experience in this direction we shall have in a very few years the benefit of deep sea cables laid throughout the ocean with almost as much facility as they are laid in shallow water.

Another subject which will probably claim the attention of Engineers is the growing science of æronautics, which, by means of the Æronautical Society, seems likely to take a firm hold upon the public. Here young and old are alike inexperienced, and consequent run an equal race in endeavouring to construct a machine which shall be for the air what the locomotive is for the land, and the steamboat for the sea.

In reference to the works completed they are so numerous as to allow a very brief allusion to the most important only. The connecting link between the London Chatham and Dover Railway and the Metropolitan has been completed, by the opening for traffic of the Blackfriars Railway Bridge, and the Ludgate Hill is now continually crossed by railway carriages. This line places the railways north and south of the Thames in direct communication.

During the past session many important additions to the metropolitan and other lines have been sanctioned by Parliament, one of the most important being the new line to Brighton, which had such a hard struggle in the committee rooms of the Lords and Commons. Many new pneumatic tubes have been or are being laid down, and this system bids fair to become much more generally adopted, as it enables metropolitan lines to be laid with greater economy, as well as to be worked by a much smaller rolling stock; indeed, with little more than actually necessary for carrying the passengers or goods, whereas the heavy locomotives at present in vogue serve rather to draw the heavy carriages than the passengers or goods which they contain. The Thames Embankment has been vigorously pushed forward, and already many portions of what will be a very handsome wall are unveiled to public view. On the south side the foundations of the new St. Thomas's Hospital are being laid, and this structure, when finished, will form a handsome *vis a vis* to the houses of Parliament. The Cannon Street Station was opened to the public on the 1st September, but the line from Charing Cross to Cannon Street can hardly yet be said to have got into working order. The widening of Victoria Bridge has been completed from the designs of Sir Charles Fox. The Inner Circle, part of which will run along the Thames Embankment is rapidly progressing.

Among the important engineering events of the past year is the launch of the Northumberland, upwards of 9,000 tons in weight, after three unsuccessful attempts.

One of the great works of the day, the Forth Bridge, seems to have come to a standstill; and many of the railway companies, owing to a complication of unfortunate events, are at present in a very shaky state. The fact seems to be that while the majority of engineers have been endeavouring to lessen the prime cost of railways by the adoption of the locomotive to steep inclines, some others have constructed lines in the metropolis at such enormous cost, as to render it impossible that they should yield adequate returns for some time to come. The general body of contractors and engineers have thus received the blame which belongs only to a few of their number, but much more blame is to be attached to those who have made it a necessity for the constructors of railways to obtain loans at enormous rates of interest.

In reflecting upon the difficulties attending the execution of these enormous undertakings, it becomes an important question whether it would not be well for the engineer to subdivide oftener the large works placed under his control, so as to remove the necessity for the acquisition of the limitless tackle and implements, which at present consume the capital and hamper the operations of the contractor.

THE ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last monthly meeting of the committee of this Association was held in Manchester, on the 25th September, William Fairbairn, C.E., President, in the chair, when Mr. Fletcher, chief engineer, presented his report, which on that occasion was for two months, since the committee meeting for August had been postponed. Of this report the following is an abstract:—

During the last two months 568 engines and 834 boilers have been examined, as well as four of the latter tested by hydraulic pressure. Of the boiler examinations, 584 have been External, 21 Internal, and 229 Entire. In the boilers examined 225 defects have been discovered, 10 of those being dangerous.

Injury to Furnace Crowns.—This occurred to a double furnace boiler, and was due to the negligence of the watchman, as most of such cases are. He was getting up steam at five o'clock on Monday morning, when he filled the boiler brimful of water, steam pipes included, and, being alarmed at what he had done, went to call the engineer. Before doing so, however, he had opened the blow-out tap, which he either forgot or could not shut, so that the water was rapidly pouring from the boiler all the while, with two brisk fires in the furnaces at the same time. When the engineer arrived the boiler was empty, the fires burning brightly, and the plates of both furnaces overheated and seriously drawn out of shape, while, in addition, the shell of the boiler was rendered so hot, that a piece of wood lying on it was set on fire. The communication of the heat from the furnaces to the shell is an interesting fact; and in another case met with some time since, in which a fire was put into a boiler without water, similar results followed, and not only were the furnace crowns injured, but the shell of the boiler strained. It has frequently been recommended that the openings in boilers, both for the feed inlet and blow-out * should be above the level of the furnace crowns, and the adoption of this in the present instance would have saved them from injury. The boiler was fitted with a scumming apparatus, but the outlet was carried down to the bottom of the shell, whereas had it been at the surface of the water, although the watchman had left it open the furnace crowns could not have been laid bare. It is true that there must be a tap or valve at the bottom of a boiler for convenience in washing out and emptying, but this should be entrusted solely to the care of the engineer, and the spanner kept under lock and key. Were this simple suggestion generally carried out, the expense and annoyance of injury to furnace crowns through watchmen carelessly emptying boilers would be prevented.

Fracture.—One of these cases occurred at the bottom of an externally-fired boiler immediately over the furnace, the overlap of four of the ring seams being cracked through from the rivet holes to the edge of the plate, and this not at a few holes at a distance one from the other, but at a considerable number consecutively, so that the strength of the plates was seriously reduced. This boiler was stayed longitudinally by a flue tube running through it from end to end, which reduced the strain upon these seams of rivets, so that no serious rupture occurred. In the plain cylindrical egg-ended boiler there is no longitudinal stay, and hence, when the transverse seams give way, the shell tears in halves. This case is an illustration of the tendency of externally-fired boilers to fail at the ring seams of rivets, and, at the same time, of the advantage of having a longitudinal tie from end to end.

External Corrosion.—This case was met with at the bottom of a two-flued boiler, 7 ft. in diameter, and set on a mid-feather wall 10 inches wide. The corrosion extended from one end of the boiler to the other, just where the plates rested on the brickwork, and the inspector easily knocked a hole through them, and found the thickness not to exceed one-sixteenth of an inch. This shows the objection to setting boilers of so large a diameter on midfeather walls, and the importance in those cases in which they are retained of ploughing out the brickwork where the transverse seams of rivets rest upon it, so that the condition of the plates may be seen at each inspection. The necessity of a satisfactory examination of this boiler had been for some time pressed upon the owner, and it will be seen that explosion was but narrowly escaped.

Defective Safety-Valve.—The valve referred to was effectually held down by some machinery, temporarily stored over the boiler, which, slipping out of place, rested upon the lever and bent it out of shape. Such a case as this is but rarely met with in the boilers under inspection; but, nevertheless, it shows the value of a duplicate safety-valve.

In addition to the above a dangerously Defective Manhole may be referred to. This manhole was unguarded, and fitted with the ordinary internal cover, secured with suspension bolts and bridges, though in a boiler 8 feet in diameter, made of plates three-eighths of an inch in thickness, and worked at a pressure of 40lb. on the square inch. The edge of the plate at one side of the hole was so rotten from corrosion, that the inspector made a breach in it with a hand chisel alone; in addition to which the plate at the edge of the opening was buckled by the pressure of the bridges, and just commencing to rend. It appeared to need but a slight additional strain, such as might be given it from an extra turn of the nuts, to force the cover completely through the hole, and thus lead to the explosion of the boiler, as in several similar cases lately reported. On the danger being pointed out, it was at once arranged that this manhole should be strengthened with a mouthpiece rivetted to the plates.

Explosions.—The Engineer reports that eleven explosions have occurred since the last return, by which 23 persons were killed, as well as 29 others injured. The details of three of these explosions are given. They are of considerable interest, and will confirm the view that steam boilers do not explode from some mysterious cause that cannot be grappled with, but either from neglect in their construction or subsequent working.

No. 35 explosion was due to the gross mal-construction of the boiler, and resulted in the death of two persons and serious injury to seven others. It occurred at about half-past seven o'clock on the morning of Saturday, July 28th, at a colliery, to one of two boilers which had but just been laid down for driving a new engine. They were not under the inspection of this Association.

The boiler was of horizontal cylindrical construction, perfectly flat at the front end, and hemispherical at the back, having within it a single horse-shoe shaped flue, both ends of which were attached to the flat plate at the front. It was internally fired, and had no external brickwork flues, the furnace being placed in the left hand leg of the horse-shoe, and the chimney at the end of the right, so that the flames merely passed up one leg of the horse-shoe and down the other before escaping to the chimney, which was made of wrought-iron, and planted upon a smoke box attached directly to the front end plate of the boiler.

The length of the boiler was about 36 feet, and the diameter 9 feet in the shell, 3 feet 3 inches in the leg of the horse-shoe that contained the furnace, and 2 feet 6 inches in the return flue, while the thickness of the metal was seven-sixteenths to three-eighths of an inch throughout, with the exception of the flat plate at the front of the boiler, which was fully half an inch. There were two safety-valves loaded to 35lb. on the square inch, but at the moment of explosion the pressure was a pound or so in excess of this, in consequence of the steam blowing off freely while the engine was standing.

The boiler burst at the flat plate at the front end, which tore away completely from the shell, rending the connecting angle iron through the root. The shell of the boiler was thrown northwards to a distance of about 50 yards, and the horse-shoe tube as far in an opposite direction, passing in its flight over the pithead gear and a range of four boilers, three of which had steam up at the time, driving another colliery engine. This horse-shoe flue, which was about 33 feet long and weighed about four tons, struck the ground just where the man in charge of this engine had been standing but a moment before, having run behind his engine-house for shelter on hearing the report of the explosion. Had the flue fallen to the ground a few feet short of the distance it did, it would have pitched into the range of boilers just referred to, and, since they had steam up, this must inevitably have led to another explosion. One of them was struck by the funnel of the exploded boiler; but, as it was merely a light one, being made of sheet iron, no mischief resulted. The roof of the engine-house adjoining the exploded boiler, however, was brought down, as well as the side wall and a portion of both end ones, the engineer to the colliery being buried in the ruins, though, fortunately, not killed; while the fireman who was attending to the furnaces was literally blown to pieces, and the engineman thrown against the fencing round the pit's mouth, and would have fallen down the shaft had it not been guarded. The boiler alongside was lifted from its seat, and blown to a distance of about 50 yards, where it alighted on a public roadway, and had one of its plates staved in by the fall. This boiler was not completed, and five men and a boy were engaged upon it at the moment of explosion. Three of them were working outside, and of these one was killed, and the other two seriously scalded and bruised; while two boiler-makers and a boy at work inside were carried away with the boiler and rolled over in it, all three being cut and bruised, one of them very seriously.

There cannot be the slightest doubt as to the cause of this explosion. The boiler was defective both in design and workmanship. In boilers made with horse-shoe shaped flues, the ends do not receive any support, as they do in those of Lancashire and Cornish construction, from the flue tube running directly through the shell, and thus not only tying the two ends securely together, but at the same time materially lessening the amount of pressure on them by reducing the area on which

* This can be accomplished by blowing off from the surface of the water, a plan which is being increasingly adopted, and with good results. If the outlet pipe be carried to the bottom of the boiler, one of the advantages of this system is lost, as in the case referred to in this report.

the steam acts. It is imperative, therefore, that the horse-shoe shaped flue should be secured to the shell by substantial stays, which, however, in the present instance had not been done, and the omission was fatal. The flue tube was merely supported on cradles, and not bound by any longitudinal stay to the shell, while the mode of stiffening the flat plate at the front end was most defective. There were five gusset stays above the furnace, but these were of the roughest workmanship. They did not run back for more than 2 feet, and were attached to the cylindrical portion of the shell with but three rivets, from which, as might have been expected, they tore away. Below the furnace mouth there was no gusset stay at all, while the plate was weakened by a manhole, which, as well as another in the cylindrical part of the shell, was not strengthened by any mouthpiece. Added to this, the angle-iron attaching the front end plate to the shell, was not welded up into an entire ring, as it should have been, but was in four separate pieces, connected by common jump joints.

This boiler, which had not worked four days before it burst, was designed by the engineer to the colliery, and made on the spot by their own men, as well as the one alongside, which was of very similar and equally dangerous construction, and would inevitably have exploded in the same way as the other had done on being set to work. The case is altogether one of the most glaring mismanagement, and the lives of the poor men who were killed have simply been lost through the mal-construction of the boiler, the design and workmanship of which were alike defective.

No. 39 Explosion occurred at a quarter-past nine o'clock on the morning of Wednesday, August 22nd, to a boiler on board a screw steam yacht, not under the inspection of this Association. The yacht had been ordered on a cruise, and was just moving out of the dock in which she had been lying, when her boiler exploded, killing three persons, as well as injuring five others, and seriously damaging the vessel. The engineer was blown overboard, and halfway across the basin into the water, whence his lifeless body was extricated by drags about an hour afterwards. His wife and another woman on board at the time were both killed, the body of the former being blown to the north end of the lock and her head to the south, while the latter was picked up dead in the forecastle. The vessel was gutted, the deck torn up, the engine, the funnel, as well as the masts and rigging, blown overboard, and pieces of the wreck scattered about the quay in every direction, the boiler being hurled across the basin and thrown to the ground at a distance of 60 to 80 yards, passing over the stern of the vessel in its flight, and a little to the port side of the helm; while the end plate of the boiler, which divided into two pieces, flew in the opposite direction, one part being caught in the forecastle, and the other probably falling into the water, as it could not afterwards be found.

The boiler, which was a new one, having been put on board in January last, and only worked for a few short trips since then, was of the multitubular marine type, being internally fired, and the furnaces, of which there were two, running into a flame chamber at the back of the boiler, connected to the smoke box at the front by a number of small return flue tubes passing over the furnace crowns. The shape of the shell was that of a short horizontal cylinder, flat at both ends, having a diameter of 6 feet 6 inches, and a length of 5 feet 9 inches. It was worked at a pressure of 60 lb. on the square inch, and had been proved before leaving the maker's yard up to 120 lb. by hydraulic pressure. The flat plate at the back of the boiler was flanged at its entire circumference for attachment to the shell, and consisted of two pieces joined together by a seam of rivets running in a horizontal direction, as nearly as may be through the centre of the circle, the plate being half an inch thick, and strengthened with copper stays seven-eighths of an inch in diameter, about 5 or 6 inches long, screwed throughout, and spaced about 12 inches apart from centre to centre, which, passing through the water space between the flame chamber and the shell of the boiler, were screwed through the two plates and rivetted over at the ends, just as in the flat sides of a locomotive fire-box.

It was at this end plate that the boiler gave way, tearing round its entire circumference through the root of the flanging, drawing one of the copper stays through the plate, and pulling the others asunder, while, in addition, the plate divided at the longitudinal seams of rivets.

Two causes combined to produce this explosion: One, undue pressure of steam; the other, weakness of the boiler. The undue pressure of the steam was due to the defective condition of the safety-valve, which was of lever construction, held down by a Salter's spring balance. I am not able to speak of the condition of the safety-valve from a personal examination, since it had been taken to pieces before I saw it; but the captain of the yacht stated at the inquest that the engineer was in the habit of raising the lever of the safety-valve by hand, because it used to stick, and that he had done this about five minutes before the explosion; while a master boiler maker, who made an official investigation at the order of the coroner, reported that he did not find the valve in free working order; and this was corroborated by the maker of the boiler, who examined it but half an hour after the explosion had occurred. It was a serious defect in the equipment of this boiler that there was but one safety-valve, whereas there should always be a duplicate. A Select Committee of the House of Commons, appointed in the year 1817, to consider the best means for preventing the explosion of boilers on board steam vessels, recommended 'that every such boiler should be provided with two sufficient safety valves;' while this recommendation was repeated in America, in the year 1836, by a committee of the Franklin Institute, 'appointed to examine into the causes of the explosions of boilers used on board steamboats,' and the Board of Trade now enforce that no British steam vessel shall carry passengers unless this condition be complied with. Had the boiler under consideration been on board a passenger vessel instead of a gentleman's pleasure yacht, it would not have been allowed to put to sea equipped as it was with but one safety-valve. The other cause of the explosion—viz., the weakness of the boiler—was due to the insufficient staying of the flat end plate. These stays being spaced 12 inches apart, would, with steam at a pressure of 60 lb. on the square inch, be subjected to a strain of nearly four tons each, which,—since they were made of copper, and only seven-eighths of an inch in diameter at the outside of the thread—was dangerously near to their ultimate strength, and allowed but little margin either for indirect strains being thrown upon them through the working of the boiler or for flaws in the metal, so that to rend these stays asunder there was required but a slight addition to the ordinary working pressure of the steam, and this appears to have been produced by the sticking of the safety-valve referred to above. These stays should either have been more numerous or larger in diameter; but as it was they were insufficient, and the explosion is attributed to the combined defects in the equipment and construction of the boiler.

No. 45 explosion has excited considerable interest from the fact of its having occurred at one of Her Majesty's dockyards. It took place at about half-past seven on the morning of Friday, September the 7th, and resulted in the death of two persons, as well as in injury to three others.

I visited the scene of the catastrophe a few days after the explosion had occurred, and received every assistance from the authorities of the dockyard in making my examination. I am the more desirous to acknowledge the courtesy I received from these gentlemen since I find myself compelled to take a very different view of the cause of the explosion than that which I understood they entertained themselves.

The boiler, which was not under the inspection of this Association, was the left hand one of two set side by side, both of the Lancashire type, with two cylindrical furnace tubes running through them from end to end, their length being 21 feet, and their diameter 7 feet 4 inches in the shell, and 2 feet 9 inches in the internal tubes, while the thickness of the plates was three-eighths of an inch in the former, and seven-sixteenths in the latter. The boilers were set upon side walls, and each of them had two open lever safety-valves, 4 inches and seven-eighths in diameter, loaded by a weight to a pressure of about 55 lb. per square inch. From this it will be seen that the boiler was of a safe class, and not worked at an excessive pressure.

"The manner in which the boiler was rent was somewhat complicated, and resulted in its entire destruction. It was separated into four main fragments, the furnace tubes, although not rent themselves, being torn away from the remainder of the boiler, along with the back end plate to which they remained attached; while the cylindrical portion of the shell was divided into three irregular belts, two of which were opened out nearly flat. The primary rent appears to have been a longitudinal one, about 4 feet 6 inches in length, and to have occurred at the bottom of the shell, and at the back end, a little to the right hand of the centre or keel line, and close to one of the side walls on which the boiler was seated. This primary longitudinal rent, after running across two widths of plate, assumed a circumferential direction, and extended completely round the shell in an irregular and jagged line, passing in many places through the solid metal, and starting in its course other rents, which resulted in dividing the boiler into the fragments already described. All of these were thrown from their original position, and the twin boiler alongside blown from its seat.

At the inquiry into the cause of the explosion, conducted before the coroner, evidence was given by three scientific witnesses, as well as by two boiler makers engaged at the dockyard, all of whom unanimously attributed the explosion to shortness of water, supposing that the engineman had neglected his duty, and allowed the water supply in the boiler to run short, and then suddenly readmitted it, when an excessive and uncontrolable pressure of steam had been generated, which burst the boiler. In consequence of this evidence the jury concluded that 'the deaths of the deceased were caused by the accidental explosion of a boiler, and that such explosion resulted from an insufficient supply of water in the said boiler.' Thus the onus of the explosion was thrown upon the engineman who had been killed.

My own examination led to a different result. Had shortness of water occurred with steam at the pressure at which this boiler was worked, viz., 55lb., the furnace crowns would certainly have bulged down, and in a short time have rent, whereas they still retain their original shape uninjured, and are covered with a slight cake of incrustation, while the seams of rivets are not opened. The general character of the explosion was altogether different from those which occur to this class of boiler from shortness of water. In this the shell was rent and not the furnace tubes, in those the furnace tubes are rent and not the shell. It is true that the left hand furnace tube was somewhat bulged down; a fact to which much importance was attached at the coroner's inquest, but this depression is clearly the effect of a blow from some portions of the building falling upon it, and not of overheating. It is situated some feet behind the firebridge, and thus not at the hottest part of the tube; in addition to which it is not directly on the crown, but a little on one side, while the entire tube is slightly bent laterally from end to end, the result evidently of a blow of considerable force. It may also be mentioned that the bottom of the tube is bulged upwards, which could not possibly be due to overheating, but is an illustration of the violence the tube had been subjected to subsequent to the explosion. These indentations, therefore, are regarded purely as effects of the explosion, and not as in any way connected with its cause. The consideration of these facts clearly shows that the explosion could not have been due to shortness of water, so that the cause must be sought for elsewhere.

On examining the fragments of the shell, I found that the plates at the bottom of the boiler at the back end, which was the part at which the primary rent occurred, were seriously wasted away by external corrosion, and it is to the thinning of the plates from this cause that I attribute the explosion. This corrosion was so apparent that the thin plates must have been discovered in time to prevent the explosion on a competent and faithful flue examination being made. Yet, one of the boiler makers who gave evidence at the inquest, and occupied the post of superintendent, his duty being to repair the boilers and inspect them when cleaned out, had carefully examined the exploded boiler but seven weeks before it burst, when he reported that it was 'in a good working state;' while another boiler maker—also witness at the inquest—who had repaired it two years ago, was satisfied from the appearance of the exploded boiler, that it was quite fit to do its duty at the moment it burst. Boiler makers clearly do not make good boiler inspectors. They may be perfectly competent to wield a hammer and make a steam-tight seam of rivets, but know little about the principles of boiler construction, or the power of steam. Nothing can show more forcibly the necessity of independent periodical inspection by men trained for the special work and accustomed to it by daily practice.

In conclusion, this explosion was not due to shortness of water, through the neglect of the engineman, who was the victim of the disaster and not its cause, but was attributable to the weakened condition of the boiler, through thinning of the plates by external corrosion, which might have been detected in time to have prevented the explosion by competent inspection.

THE RAILWAY SYSTEM OF GERMANY.*

By Robert Crawford.

There are few subjects which afford more varied and interesting questions for consideration than the growth and development of railways. Whether viewed with regard to the general influence which they exert on the commerce of nations, or their beneficial effect in promoting the introduction of improvements in machinery and manufactures, they cannot fail to present abundant matter for examination and reflection. Nor can an outline of their progress within fixed territorial limits be without some value, in furnishing and grouping together the elements of information, which may aid in the formation of correct opinions, as to the advantages and defects of certain systems.

It is in this latter respect that Germany has been selected as the field of investigation for this paper, since, although in the first instance railways were there adopted with reserve and caution, their construction was afterwards prosecuted with considerable steadiness of purpose, and with but slight fluctuations in the regularity of their progress, except such as arose from political questions, or state policy. In Germany, as in England, tramways formed the germ from which subsequent enterprise developed the vast network of railways now extending throughout the length and breadth of the land, facilitating its commerce, and increasing in no small degree its material prosperity and wealth.

The oldest of these undertakings originated in a fifty years' "privilege" granted by the Austrian Government, upon the 7th September, 1824, for the construction of a line from Budweiss, in Bohemia, to opposite Linz, on the Danube, a distance of upwards of 80 English miles. In the beginning of the year 1825, this concession was transferred to a Joint-stock Company, formed in Vienna, under the title of "The Imperial Royal First Railway Company of Austria." The works were immediately begun, and about 40 miles finished before the close of 1828. The completion of the remaining portion occupied until the 1st August, 1832, the day of the opening of the line throughout its entire length. About this time a new project was set on foot, and a concession granted to an association of business firms in Vienna, for a line from Linz to Gmünden ($42\frac{1}{4}$ miles), which was made over, in 1834, to the Budweiss and Linz Company. The works were begun in the same year, and finished in 1836. This line, although claiming the name of railway, was in reality a tramway, worked by horses. The gauge was 3 feet $7\frac{1}{2}$ inches in the clear. The rails consisted of flat bars of iron, $2\frac{5}{16}$ inches wide by rather more than $\frac{1}{2}$ an inch in thickness, and weighed $14\frac{1}{2}$ lbs. per yard; they were laid on longitudinal timbers, supported and kept in place by cross sleepers, 6 feet 3 inches apart from centre to centre. The maximum gradients were 1 in 20 on the length between Budweiss and Linz, and 1 in 46 between Linz and Gmünden. The junction of the northern and southern sections was affected by means of a short line, on which occur gradients of 1 in 15 and 1 in 28, passing over the Danube on the timber bridge between Linz and the north shore of the river, which answers for the purposes of ordinary traffic as well as for those of the tramway. The cost of the Budweiss, Linz and Gmünden line was about £4,877 per mile. In 1854, small locomotive engines were adopted for the working of a portion of the southern section, and this system was extended in the following year to the entire length between Linz and Gmünden. The gauge remained the same, but the permanent way was altered on the inclines and sharp curves: the original flat bars and longitudinal timbers having been replaced by small solid rails of the contractor's, or broad-based pattern, laid on transverse sleepers. Still more recently, the whole of this undertaking has been incorporated with that of the "Empress Elisabeth Western Railway of Austria," from Vienna to Passau and Salzburg; and it is contemplated, eventually, to convert both the branches to Budweiss and Gmünden into ordinary railways, with the regular normal gauge of 4 feet $8\frac{1}{2}$ inches.

Returning from the digression occasioned by tracing down to a recent period the salient points in the history of what was not only the first line in Austria, but in all Germany, the enterprise which next attracts attention is that of a proposal for connecting

---

* Read before the Institution of Civil Engineers.

Prague with Pilsen, by means similar to those already described. The works were begun in 1828, and a portion of the line was opened in 1830. The original project was never completed, and a length of 34½ miles of tramway, the extent to which it was carried into execution, after changing ownership twice, was finally made over to a Colliery Company for local purposes.

These preliminary remarks bring down the subject to the most important and decisive period in its history, occasioned by the proposal to adopt steam as a motive power instead of horse labour; a proposition carried into effect for the first time in Germany in the case of a railway 4 miles in length from Nürnberg to Fürth, which was opened for public traffic on the 7th December, 1835. The works on this line were unimportant, and presented no engineering difficulties whatever, occupying only nine months in their construction. The cost was £4,745 per mile. The rails, which were for a single way, were laid for about three-fourths of the distance on stone blocks, and the remainder on timber sleepers, which were subsequently replaced by stone supports. The maximum gradient was 1 in 250.

Thus Germany, possessing, at the close of the year 1835, upwards of 108 miles of tramways, had up to the same time only 4 miles of railway, properly so called.

The five years following in regular succession from this date served to introduce railways into all parts of the country, and to give them a fair start. It appears that upon the 31st December, 1840, five years after the completion of the first line, there were twelve railways in Germany, either wholly or in part finished, and yielding a total length opened, equivalent to 377 miles. These, arranged according to the priority of opening of any part of them, assume the following order; it being premised, that those lines worked by steam power are alone referred to:—

1st,	Railway in Germany from	Nürnberg to Fürth	opened	7th Dec. 1835
2nd,	„	Leipzig to Dresden,	a portion was opened	24th Apr. 1837
3rd,	„	Vienna to Oderberg	„ „	23rd Nov. 1837
4th,	„	Berlin to Potsdam	„ „	22nd Sept. 1838
5th,	„	Düsseldorf to Elberfeld	„ „	15th Oct. 1838
6th,	„	Brunswick to Wolfenbuttel	„	1st Dec. 1838
7th,	„	Madgeburg to Leipzig	„ „	29th June 1839
8th,	„	Cologne to the Belgian frontier	„	2nd Aug. 1839
9th,	„	Munich to Augsburg	„ „	1st. Sept. 1839
10th,	„	Frankfort-on-Maine to Wiesbaden		26th Sept. 1839
11th,	„	Berlin to Anhalt	„ „	1st Sept. 1840
12th,	„	Mannheim to Heidelberg	„	12th Sept. 1840

Such was the position of railways at the close of the year 1840, after which they became so numerous and varied that it would be impossible, keeping in view the object of this paper, to follow them any further in detail. It is sufficient for the present purpose to review in general terms their progress from time to time, from their first adoption down to the present day, as exhibited in the following statement, showing the extent opened at different fixed periods:—

There were	4	miles of Railway in Germany	opened	up to the close of	1835
„	377	„	„	„	1840
„	1,817	„	„	„	1845
„	4,487	„	„	„	1850
„	5,750	„	„	„	1855
„	8,512	„	„	„	1860
„	88,66	„	„	„	1861

The local distribution of this latter quantity and the cost per mile are as follows:—

				£
In Prussia there were about . .	3,417	miles constructed at an average cost per mile of		15,200
In the German provinces of Austria	1,706	„	„	22,700
„ Bavaria	1,172	„	„	13,670
„ Hanover	450	„	„	13,100
„ Saxony	435	„	„	18,350
„ Baden	260	„	„	16,600
„ Würtemburg	260	„	„	14,500
„ the other German States .	1,166	„	„	14,390
Total	8,866	miles constructed, at an average cost of about £16,400 per mile.		

Nearly one-fourth of the entire length is provided with two lines of rails.

About 38 per cent. of the existing lines are Government property.
„ 10½ „ are the property of Companies, but worked by Government.
„ 51½ „ are the property of, and are worked by private, or Joint Stock Companies.

Many railways which were originally constructed by State means have been sold, or rented to Joint Stock Companies, and the reverse of this has in some instances taken place. Hence it becomes necessary to return to an examination of the manner in which they were at first carried ont, in order to estimate the extent to which Government resources participated in these undertakings. In this respect it appears, that

39¼ per cent. of the entire length were constructed by different States.
24⅞ „ by Companies under a guarantee of interest, or a Government subvention.
35⅞ „ „ at their own risk and cost.

That is to say, Government aid has been granted directly, or indirectly, to nearly two-thirds of the entire system. These 8,866 miles of railway comprise sixty-two different undertakings as at present constituted, under as many separate organisations, and are managed by nineteen Government departments, and forty-three boards of Directors, or some substitute, whose control however is not confined to Germany proper, but extends to adjoining territories, over an aggregate length of 10,830 miles of line.

Not long after the introduction of railways in Germany, it became apparent, that their management would be far from sufficiently perfect to meet the continually increasing requirements of commerce, except some common plan of action could be agreed upon, which would bring all the railways in the country into one large association, for regulating to a certain extent, their relations with each other, according to general rules, somewhat after the manner of the German political Confederation. For this purpose a conference was held at Cologne, in June, 1847, which resulted in the formation of a society under the title of "The Association of German Railway Directions," which now embraces the whole of the lines already referred to, with very trivial and unimportant exceptions. Each railway subscribes a fixed sum towards the general management fund together with a variable amount depending upon its length, and is represented at the meetings of the Association and in the debates, in proportion to its importance. Yearly general meetings are held, at a time and place mutually agreed upon, and when considered expedient, special meetings are also called. At all of these, such matters as relate to the interests of the Association are discussed and settled. A code of laws has been drawn up, and agreed to, by the Engineers and managing directors present at these meetings, which is revised and enlarged from time to time, according to the requirements. These rules express the decided opinion of the associated body, upon all the points which are usually involved in the construction and working of railways, and are adopted by all concerned, as the standard source of guidance and instruction in such matters. It may here be proper, before passing on to the consideration of the engineering points involved in the present subject, to state that Germany at the close of the year 1861, had, in addition to railways, about 143 miles of tramways, constructed at an average cost of £3,200 per mile.

The battle of the gauges can scarcely be said to have been fought in Germany, or, if so, it was conducted with almost all the energy on one side; as, early in the movement, the gauge of 4 feet 8½ inches came off victorious, and the line from Mannheim to Heidelberg, which represented the opposing interest, having been laid to a medium width of 5 feet 3 inches between the rails, after struggling along for some time in its unsocial loneliness, was obliged to yield under the pressure of public opinion and the inconvenience arising from a break of gauge, and was altered to the ordinary width of 4 feet 8½ inches, which is now the universal gauge of the country.* The width between the ways on a double line of railway is usually fixed at 2 metres between the centres of the rails, or 6 feet 4½ inches in the clear. At stations this allowance is generally greatly increased.

With regard to curves and gradients, the rules laid down are —First, The radius of curvature shall, if possible, not be less than 3,600 feet on level land, nor than 2,000 feet in hilly districts, except in particular instances, when it may be necessary to reduce it to 1,200 feet. This latter is to form, as a general rule, the minimum rate of curve on railways in mountainous countries, to be diminished in exceptional cases, where necessary, to 600 feet, but never less.

* To this must be mentioned as an exception the branch from Lambach to Gmunden, 16 miles in length, already described.

Secondly. The generul scale of maximum gradients admissible on railways is 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountain lines.

As examples of sharp curves upon works already executed may be noticed :—One of 570 feet, and another of 590 feet radius on the Baden State Railways; two curves of 618 feet radius on the railway from Magdeburg to Wittenburg, and a similar minimum radius on the railway from Breslau to Schweidnitz; one of 560 feet and several of 622 feet radius occurring on the passage of the Alps, on the line from Vienna to Trieste; the viaduct approach to the Cologne bridge, on the left bank of the Rhine, is on a curve of 618 feet radius; a curve of 780 feet radius on the line between Passau and the Austrian frontier, and of 824 feet as the minimum radius of curvature on the Main Weser Railway, from Frankfort-on-Maine to Hesse Cassel; besides numerous other curves of importance on existing lines.

The increased power of locomotive engines has introduced into practice a severer character of ruling gradients than was formerly contemplated. On main lines, when practicable, 1 in 100 is now generally adopted as the maximum rate of inclination. In many instances, where the districts traversed are very level, the gradients are much easier than this; but, on the other hand, Germany has ample proofs of having approached the limits recognised at present as suitable for the working of locomotives, in gradients of the steepest description, which are not confined to one state or locality, but are to be found in both north and south. As an illustration of this statement, it will suffice to instance some of the most important cases. Between the stations of Erkrath and Hochdahl, on the railway from Düsseldorf to Elberfeld, there occurs a continuous incline of 1 in 30 for a distance of 8,038 feet, or upwards of 1½ mile. This was originally worked by stationary engines and a long endless rope. In 1841 the plan was altered, and the trains in opposite directions arranged so as always to meet at this point, and the weight of the descending train was made use of in helping to draw the other up by means of a rope attached to both trains, and passed round rollers at the top of the incline. The difficulties arising from the necessity for the meeting of trains brought about another modification in the system of working, which is that now in use. A pilot engine is always ready, with steam up, to assist the ascending trains, which it does by acting as a counterpoise attached to the upper portion of the rope, in the same capacity as was formerly fulfilled by the descending train. This latter now always passes down without being attached to the rope, and under the control of powerful breaks, and by these means the inconvenience of the traffic, from being compelled to depend upon meeting trains, has been removed. The Aix-la-Chapelle incline of 1 in 38, for a length of 6,814 feet, stands next on the list. It begins immediately on leaving the station, and rises westwards towards the Belgian frontier. It, also, was intended to be worked by stationary engines, but a tank engine, with three pairs of coupled wheels of small diameter, now answers the purpose, by pushing the train from behind up to the station at the level on the summit, where an ordinary engine is in waiting to take the train on. Several gradients of 1 in 40 and 1 in 45 were adopted on the Semmering Railway, of which a particular account has already been brought before the Institution. An incline of 1 in 40, for a distance of 17,680 feet, or upwards of 3⅓ miles, upon the Bavarian State Railway, from Augsburg to Hof, serves to surmount the water-shed between the rivers Maine and Saale, near the village of Neuenmarkt. The short Schneeberg branch line in Saxony has gradients of 1 in 40, and the total ascent which it makes averages at the rate of 1 in 48. The passage of the Swabian Alps, between Geislingen and Amstetten, on the Würtemburg State Railway, from Stuttgart to Ulm, is accomplished by means of an incline of 1 in 45, 16,720 feet long, or 3⅙ miles. There is a gradient of 1 in 45, for a length of about 1,800 feet, at Viennenburg, on the Brunswick State Railway, from Wolfenbuttel to Harzburg. On the railway from Bamberg to Asschafenburg there is a gradient of 1 in 50, extending over 4⅝ miles. The same rate of inclination occurs on the line from Breslau to Schweidnitz, and also between Eisenach and Coburg, near the former place, on the Werra Railway, the length of the gradient being 3 miles.

The Semmering Railway, already alluded to, is one of the most remarkable instances of a combination of heavy gradients with sharp curves. This line, which is in reality but a section of the Southern Railway of Austria, from Vienna to Trieste, extends from the station of Gloggnitz to that of Murzzuschlag, a distance of 25·44 miles, or more exactly 134,300 feet. In considering the nature of the gradients, it may be divided into three sections as follows:—

1st	from Gloggnitz to Payerbach . . .	20,815 feet.
2nd	„ Payerbach to the Semmering summit .	64,033 „
3rd	„ the summit to Murzzuschlag . .	49,452 „
	Total	134,300 „

In going southwards the rise is gradual until Payerbach is reached, the maximum inclination being 1 in 100. From thence, until attaining the summit level, which gives its name to the pass, the gradients and curves are of the heaviest and sharpest character, in order to overcome the various natural obstacles in the way. On this middle section several gradients of 1 in 40, one of them, the longest on the line, being 11,618 feet, or 2¼ miles, and curves of 622 feet radius occur. From the summit to Murzzuschlag station the descent is rapid and steep, the heaviest rate being 1 in 41·4. The difference of level between Gloggnitz and the summit is 1,506 feet; the height of the latter being 2,937 feet above the sea-level; and the fall from thence to Murzzuschlag on the South side is 714½ feet. The nature of the inclines, and their effect upon the working of the line, will be best understood by referring to the following tabular statement:—

List of Gradients.

From 1 in 40 to 1 in 50 . .	61	per cent. of the entire length.
„ 1 in 51 to 1 in 70 . .	9	„ „
„ 1 in 71 to 1 in 100 . .	8	„ „
„ 1 in 101 to 1 in 120 . .	15	„ „
„ 1 in 121 to 1 in 500 . .	6	„ „
Level	1	
	100	

The curves under 1,000 feet radius are,

1	Curve of	560	feet radius.
29	„	622	„
1	„	746	„
2	„	871	„
1	„	902	„
34	„	933	„

The proportion of straight line and curves stands thus,—

Curve of 560 . . .	feet radius .	0⅞	per cent. of the entire length.
„ 622	„	15⅛	„ „
„ 623 to 1244	„	26	„ „
„ 1245 to 1867	„	6	„ „
„ over 1867	„	2	„ „
Straight lines		50	„ „
		100	„ „

Several of the curves of 622 feet radius occur upon inclines of 1 in 45.

There are fifteen tunnels on this work, of the aggregate length of 14,867 feet. The longest is that through the summit, called the Semmering, which is 4,695 feet. The next, in point of length, is one of 2,280 feet.

The viaducts, of which there are sixteen, are built of masonry and brickwork, and are principally composed of semicircular arches, varying in span from about 25 feet to 65⅓ feet. The longest of these works is 614 feet, and the four which attain to the greatest height, from 119 to 150 feet, consist of two rows of arches, one above the other; the lower of which tends to strengthen the piers and add stability to the structure. Many of the viaducts are placed on curves of 622 feet and 933 feet radius, and on gradients of 1 in 45.

The permanent way consists of flat-based rails weighing 76⅓ lbs. per yard, resting on cross-sleepers, laid 3 feet 1⅛ inch apart from centre to centre, which in their turn are supported by longitudinal timbers, into which they are let, and held firmly in place by small angular iron brackets. The rails are 4$\frac{6}{10}$ inches in depth, have a similar width of base, with a head 2¼ inches broad, and a thickness of $\frac{7}{10}$ inch for the central web; their usual length being 18 feet 8 inches. The joints are made fast by fish plates, with four screws-bolts in the usual manner; underneath are placed wrought-iron chair-plates, to prevent the working of the ends of the rails into the sleepers. A similar plate, but of smaller dimensions, is interposed between the base of the rail and the timber at each, of the intermediate bearings. The joint sleepers are 12½ inches wide, by 6¼ inches thick, and the intermediate sleepers are 9 inches by 6¼ inches. The ballast consists of a lower course of angular broken stone of large dimensions, laid with the hand, on which rest smaller broken stone and gravel. Its depth at the centre of the gauge, measured from the surface of the "boxing," which reaches to within 2 inches of the rail level, is 2 feet 4 inches, and the width to which it extends outside the rails is 4 feet 6 inches on embankments, and 3 feet 9 inches in cuttings.

The engines used for working the line are of a peculiar description, the result of a prize offered by the Government, for the best locomotive to take a given load up the inclines, with a fixed minimum velocity. The engine and tender are in one, and rest upon five pairs of wheels; the three leading pairs are coupled together, and attached to axles fixed at right angles to the axis of the boiler. The other two axles are placed, one in front of the fire-box, and the other under the tender, and are attached to a moveable carriage, or frame, which admits of the wheels suiting themselves to the nature of the sharp curves to be traversed. The following statement shows the comparison between the passenger and goods engines on this line, and their principal average dimensions:—

	Passenger Engine.		Goods Engine.			
	Ft.	In.	Ft.	In.	Ft.	In.
Diameter of Driving-wheels (3 pairs coupled	4	3	3	4 to	3	6
Ditto of uncoupled wheels (2 pairs)	3	1	3	4 to	3	6
Ditto of cylinder	1	$6\frac{3}{8}$	1	7 to	1	$7\frac{1}{3}$
Length of Stroke of Piston	2	0	2 ft. 0 in.			
Diameter of Boiler (mean)	4	3	4	3		
Length of ditto	15	6	15	6		
Number of Tubes 2 in. diameter	No. 191		No. 191			
Average Heating Surface in sq ft.	1,694		1,694			
Maximum pressure of steam in Boiler, per square inch	100 lbs.		100 lbs.			
Thickness of Iron Plates in Boiler	$\frac{6}{10}$ in.		$\frac{6}{10}$ in.			
Distance apart of centres of extreme coupled wheels	ft. 8	in. $11\frac{1}{3}$	ft. 7	in. 6		
Ditto, ditto, uncoupled about	8	0	8	0		
Total length of Engine from buffer to buffer	37	11	ft. 34	in. 9 to	ft. 35	in. 10
Total weight of Engine on 5 pairs of wheels (empty)	44 tons.		48 to 50 tons.			
Adhesive weight of Engine on 3 pairs coupled wheels, loaded with an average supply of water, &c.	39 tons.		38 to 41 tons.			

The cost of one such engine was about £3,500.

The experience derived from the working of this line goes to show, that one of the goods engines can ascend the inclines of 1 in 40 at the rate of $9\frac{1}{2}$ miles per hour, taking with it a train whose gross weight varies from about 100 tons to 165 tons, according to the state of the rails and the weather at the time. The normal rate of speed fixed is as follows:—

	Ascending.	Descending.
For Express Trains	$14\frac{1}{7}$ miles per hour	$16\frac{1}{3}$ miles per hour.
„ Ordinary Passenger ditto	$11\frac{3}{4}$ „ „	$14\frac{1}{7}$ „ „
„ Military Transport and Goods Trains	$9\frac{1}{3}$ „ „	$9\frac{1}{3}$ „ „

In case of a train being late, any one of the foregoing speeds may be increased, if necessary, by $4\frac{7}{10}$ miles per hour. The maximum number of trains which have passed over the line in one day occurred during the Italian war, and amounted to seventy-two, counting both ways. The ordinary average daily number of trains is twenty-seven, with from seven to eight carriages in each train. The actual works of construction on the Semmering Railway were begun towards the close of the year 1848, and the line was opened for public traffic on the 17th July, 1854. Previous to this, however, during the year 1853, rails were laid throughout the entire length of the line, and goods were transported over it by means of locomotives. The line, which is laid with a double way throughout, cost £98,270 per mile.

The Foundations of the Old Louvre.—Excavations have recently been made in the court of the old Louvre, with the view to the discovery of the real position of the older Louvre, that of Philippe Auguste, and the search has been crowned with success by the uncovering of the foundation walls of the whole of the five towers of the former building. These ancient works are very solid, and are now in part open to the view of all the world.

THE INSTITUTION OF CIVIL ENGINEERS.

The Council of the Institution of Civil Engineers have just awarded the following premiums for papers read during the session 1865-66:—1. A Telford medal, and a Telford premium, in books, to Richard Price Williams, M. Inst. C.E., for his paper, "On the Maintenance and Renewal of Permanent Way. —2. A Telford medal and a Telford premium, in books, to John Grant, M. Inst. C.E., for his paper, "Experiments on the Strength of Cement, chiefly in reference to the Portland Cement used in the Southern Main Drainage Works."—3. A Telford medal and a Telford premium, in books, to Edwin Clarke, M. Inst. C.E., for his paper on "The Hydraulic Lift Graving Dock."—4. A Telford medal to Sir Charles Tilston Bright, M.P., M. Inst. C.E., for his paper on "The Telegraph to India, and its extension to Australia and China."—5. A Telford medal and the Manby premium, in books, to Robert Manning, M. Inst. C.E., for his paper, "On the Results of a Series of Observations on the Flow of Water off the Ground in the Woodburn district, near Carrickfergus, Ireland; with Rain-Gauge Registries in the same locality, for a period of twelve months, ending 30th June, 1865." —6. A Telford premium, in books, to William Humber, Assoc. Inst. C.E., for his paper, "On the Design and Arrangement of Railway Stations, Repairing Shops, Engine Sheds, &c."—7. A Telford premium, in books, to George Rowdon Burnell, M. Inst. C.E., for his paper, "On the Water Supply of the City of Paris."—8. A Telford premium, in books, to William Ridley, for his paper on "The Grand River Viaduct, Mauritius Railways."—9. A Telford premium, in books, to Theodore Anthony Rochussen, Assoc. Inst. C.E., for his paper, "On the Maintenance of the Rolling Stock on the Cologne-Minden, and other Prussian Railways."—10. A Telford premium, in books, to William Hemingway Mills, M. Inst. C.E., for his paper on "The Craigellachie Viaduct."

FACTORY SMOKE.

At the recent meeting of the Social Science Association at Manchester, the following papers were read:—

Dr. Angus Smith, F.R.S., remarked that warm interest had compelled him for many years to attend to the condition of the air of towns. Habit had no power of rendering smoke pleasant. Few men living in a smoky town required to be convinced that they were in the daily endurance of a monstrous evil. Many substances made their appearance as smoke from chimneys; that to be now considered was coal smoke. Some time ago he calculated that sixty tons of carbonaceous matter were sent off in a day into the atmosphere in Manchester. A very small amount affected the atmosphere; a grain, or 18 cubic feet, was sufficient to convert good air into Manchester air, so far as carbon was concerned. About one-half the colour was due to tarry matter, and the other half to black carbon only. Dr. Smith continued:—This black matter is the colouring material of all our smoky towns, and, to a great extent, of the clothes as well as of the persons, of the inhabitants. We live in houses coloured by it, and we walk on roads coloured by it, and we can see the sun, the moon, and the heavens only after they have been, to our eyes, coloured by this universal tincture. These are calamities of themselves; but, although some men would look on such a view of the case as mere sentiment, not one amongst us can fail to have his spirits tinged with the darkness of the sky. I found this strangely corroborated lately. One of the best men of business in Manchester informed me that on an atmospherically dull day no one would give a high price for goods, no one had the courage to give it; but, on the other hand, they could buy goods at a lower price, the seller had not the courage to hope for better. These dull days are caused in part by the climate, but their remarkable oppressiveness is unquestionably due in great part to the smoke. We do not consider that by the smoke we make we are affecting our own spirits and clouding our own judgment. It is my belief that this effect on the spirits is the most powerful of all objections to smoke, even in the minds of those who believe themselves above such feelings. There is, however, no denying the great fact that everything coming in contact with a smoky atmosphere is so blackened that cleaning becomes difficult or impossible. Smoke gives to every household it visits either a greater amount of labour or a lower social appearance. Dr. Smith proceeded to show that the poor paid directly for the smoke, living where it prevailed, and that the middle classes and the wealthy suffered proportionately in being compelled to live out of town, and to spend time in going to and fro. Dr. Smith remarked that it was quite true that carbon, tar, and sulphuric acids were disinfectants; but we did not wish to breathe them constantly—we could not live on medicines. The disinfecting power of smoke had not rid us of disease, nor did it prevent occasional pestilences. If it did good, it did more evil, and much of the mortality of Manchester must be attributed to smoke. It had been said that if the carbon was thoroughly burned, the amount of sulphurous acid would be so great as to be intolerable; but when the blackness was removed, the sulphuric acid seemed to escape more easily. The very stones decay under the constant action of acid, and the bricks crumble more rapidly. Even in places less troubled with smoke, we see the decay. The Parliament Houses, built to remain for ages, are rapidly, before our eyes, turning into plaster of Paris and Epsom salts. Probably some of the evil might be avoided. The finest buildings in London appear less handsome than flimsy structures in many continental cities. With us, the peculiarity of the climate is a great enemy. On certain days the acids rise rapidly; but, as a rule, they fall. Great extremes of dryness and of rain are the best protectives, and, during heavy showers, the air of Manchester is not unpleasant to breathe, because the sulphur is carried down on the rain. One of the foremost printers of Lancashire told me that there were some colours which he found almost instantly to fade. They were frequently sent back upon his hands. He was annoyed to find that the French sent the same colours to the same markets, without the risk of having them returned, and it was only after much time and loss that he found that the goods must not be allowed to pass through Manchester. One day was enough, but in some weather two hours were sufficient for their deterioration. The only sure mode we know of diminishing the amount of acid given out by chimnies is by burning no sulphur. This can be done, perhaps, to some extent, by burning less coal, and burning it more economically; next, by not allowing the most sulphurous of the coals to be burnt in large towns. This latter is a simple mode of doing some good, and cannot in all cases be considered too great a demand on manufacturers. Dr. Smith would not speak of the means of burning smoke, which some years ago numbered twelve dozen. It would be a cause of great gratification if the movement began with an association of manufacturers. Municipal bodies had failed to produce any important reform. We must remember that we could not live without rendering the air impure, and, rich as the country might be, we could not afford to destroy our manufactures in order to preserve the beauty of our fields. In such cases there must be compromise. We should oftener arrive at the truth if these questions were considered from wider points of view.

Professor Crace Calvert, F.R.S., read a paper on the same subject. Dr. Calvert said:—The action of the products of the distillation of coal upon vegetation varies a great deal according to the circumstances under which they have been produced; thus, the products of the perfect combustion of coals may be represented by carbonic acid and water with small quantities of nitrogen and sulphurous acid, all of which are invisible gases, having no action on vegetation except sulphurous acid. But if coals are introduced into a gas retort and heat applied the products given off are numerous, chemists having already isolated and characterised more than 30 distinct substances, many of which are most destructive to both animal and vegetable life, being highly poisonous when administered in even minute quantities; therefore, the products obtainable from coals vary enormously according to the circumstances under which they are produced. The above statement will enable us better to understand what is commonly called "smoke," and the reasons why it varies so considerably in composition. Thus the smoke issuing from the chimneys of private dwellings may be considered on the whole as belonging to the class where perfect combustion occurs, for the gases, as they emerge from the chimney, carry with them, only carbonic acid, carbonic oxide, and sulphurous acid, and a small quantity of the most volatile hydro-carbons which are given off, and this only takes place at the time and shortly after the coals are freshly added to the fire; the less volatile products being condensed in the flue of the chimney, forming what is called soot; but as soon as the volatile products (which are characterised by burning with flame when coals are put on the fire at first) are consumed, the carbonaceous mass which remains in the fireplace may be considered as undergoing perfect combustion, and emitting, as stated above, only gases, having little or no action on vegetation or man, more especially when they become diffused in the atmosphere. But the results of burning coals under the steam boilers employed in our large factories are very different.

1st. Because coals are constantly being added to the mass in combustion. There is not, consequently, that cessation of the distillation of tarry products above stated, as taking place in the fireplace of private dwellings, and it follows that the products of perfect combustion, which are generated near the grates of the fireplaces in factory furnaces, are constantly mixed with a considerable quantity of tarry substances produced by the distillation of the coals, and, therefore, through their imperfect combustion.

2nd. As stated above, in the chimneys of our dwellings, the draught is such as to permit many of the imperfect products of combustion, or most of the tarry products, to condense, whilst in the tall chimneys erected in our factories the draught is such as to carry out from them the above noxious volatile products; and as many of them will easily condense into liquids and solids when they come into contact with a cold atmosphere, they cannot diffuse nor be carried far before they fall upon plants and other bodies existing in the neighbourhood of such chimneys, and as many of the tarry products are highly poisonous to plants, they affect vegetation in a very marked manner.

3rd. "Black smoke" is a mixture of the products of the imperfect combustion of coal with carbon in a high state of division; the solid particles of carbon when floating in the atmosphere become, like all solids, centres of attraction for fluids, and thereby assist in the condensation of the liquid and poisonous products above mentioned, and help to carry and fix them on the surrounding vegetation, which is characterised by a deposit of such products upon the surface of the leaves and bark of plants, which prevents that free contact with the elements of the atmosphere which is so essential to their health and growth; for, as you are aware, plants absorb carbonic acid from the atmosphere from which their carbon is derived, and they reject oxygen and watery vapour. Further the intensity of these actions is in exact ratio with the intensity of light, and when "black smoke" is produced in large quantities it interferes with the rays of light arriving on the surface of the earth, and thereby affects vegetation materially. It appears to me that the above facts give an explanation of the activity of vegetation observed in London as compared with that witnessed in Manchester, Leeds, Sheffield, Birmingham, &c. I am well aware that the vegetation in these towns may be slightly affected by the large proportion of sulphurous acid which the smoke issuing from the factory chimneys contains as compared with the quantity of sulphurous acid produced by the consumption of a better class of coal in London, but sulphurous acid, like all gases, has such a high diffusive power and the mass of air with which it mingles is so considerable, owing to the high temperature at which it leaves the top of the high chimneys, that, although it may somewhat affect vegetation, still I consider its action is comparatively small in proportion to the injury effected by the fixation of "black smoke" upon plants, &c., as described above. As to the comfort which the inhabitants of our large manufacturing towns would derive from the perfect combustion of the fuel in our large mills, works, &c., no one can venture to say; at all events, as a matter of health and comfort, an opinion can be formed by comparing the state of the atmosphere in large towns like Manchester on Sunday as compared with that which is witnessed on the other days of the week. It is hardly necessary to add that it is on record in evidence before a Committee of the House of Commons that manufacturers can effect a saving of 15 or 20 per cent. by burning their smoke, and it is most painful to reflect that after the weighty evidence which has been adduced by many of the leading manufacturers of Manchester, such as Messrs. Bazley, J. Whitworth, Henry Houldsworth, &c., before a Committee of the House of Commons some twenty years ago, we should still live in such a noisome, unsightly, and unwholesome atmosphere as that of this city; and, lastly, to witness how Acts of Parliament are put on one side, when they are to be carried and enforced by local authorities who are in such cases the offenders, and at the same time the authorities called upon to inflict fines and punishment.

Mr. Peter Spence, F.C.S., read a paper on the same subject, in the course of which he said the black smoke of our manufacturing operations is, as one would naturally imagine from the continual outcry made against it, the worst form of the evil: that, in fact, it is, all things considered, in a sanitary point of view, an evil at all, I am here to deny; and as I have for years made this a subject of thought and investigation, I think I shall be able to substantiate my opinion. If, in getting rid of black or visible smoke, we were at the same time to get rid of the products of combustion altogether, no doubt the advantage would be great; but if we only increase the quantity and intensify the power for evil of the invisible substances produced, the benefit is not apparent; and if by getting rid of visible smoke we merely get rid of a body not only inert for evil, but in other circumstances fully allowed to be a body of a health-producing character, then we not only do no good, we do positive harm. The facts are decidedly in the inverse ratio of the theory of the sanitary smoke consumers, but harmonise completely with what I believe to be a true theory, founded on a consideration of the nature and ordinary effects of the body with which we are dealing. Would it not be well, therefore, for our sanitary friends to leave this matter to the economist? While we have nothing to gain on the score of health by consuming our smoke, and may have something to lose, we have much to gain in the economy of our fuel.

Mr. Handsel Griffiths contributed a paper, read by Captain Clode, one of the secretaries. Mr. Griffiths proposed, as a practical remedy, that the large chimnies of manufactories should be supplied with five or six diaphragms of wire gauze, the lowest to be easily removable, and to be placed at so great a distance from the furnace that the heat should not affect it. The second diaphragm was to be also removable, as, indeed, all of them, for the purpose of cleaning.

ON THE UTILIZATION OF METROPOLITAN RAILWAY ARCHES AS DWELLINGS.*

By B. Emanuel, C.E.

The want of good and sufficient accommodation for the labouring classes in the metropolis has been felt more within the last few years than at any other previous time, and has at length attracted public attention to the means for its redress. It is unquestionable that the evil has been caused to a great extent by recent metropolitan engineering works, and particularly by railway extensions. It is estimated that 20,000 people have already been evicted, while 100,000 more will be dispossessed by the various schemes now on foot. No further argument than this statement is needed, to prove the necessity for prompt action.

Whilst it is clear that that scheme is the best which, if capable of being practically carried out, would make the cause of the evil the means of its removal, it follows that no such perfect scheme can be devised as the one which would make it the *interest* of the railway companies (which turn out the poor wholesale) to find means for their accommodation.

To compel railways, by direct legislative interference, to give house-room to the poorer classes whom they evict, would be impracticable. The principle has already been attempted to be enforced and it has signally failed. As matters stand at present and with the strong opposition which railway companies can raise in Parliament to an unpalatable scheme, it is a matter both of policy and of necessity to endeavour to adopt other than compulsory measures. If, then, a feasible scheme could be shown by which the railway companies would increase their revenues, and by which the poor would be housed and benefited, the interest of the railway companies would be, not to oppose, but perhaps to further that scheme.

In and about London there are thousands of railway arches belonging to the various companies. Some few of these are used as shops, a few more as warehouses and workshops; but the great majority are, at the present moment, totally unoccupied and unproductive.

To convert these existing arches into labourers' dwellings, and to provide for similar accommodation in all future viaducts built in the neighbourhood of great cities, will at least provide for a large proportion of those now ejected.

It is the object of this paper to discuss the means which can be taken to best carry out this scheme, and the advantages or otherwise arising from its adoption.

For each dwelling that is built inside a railway arch, two side walls and a roof are already constructed. It will immediately suggest itself that an advantage is gained in point of economy of construction over the same amount of accommodation anywhere else; and this saving may be calculated at about £30 each arch, or £5 per room.

It may be urged in opposition to the idea itself, that tenants could not be obtained for this class of dwelling:—that the noise and vibration arising from the traffic overhead would render such arches practically uninhabitable. It is believed that this objection, though popular, is groundless. A *very* few of these arches *are* fitted up and occupied as dwelling-houses, and the author during the investigation of the past few months into this subject has met with and questioned the occupants of most of these—the experience of some ranging over a period of six years. They have been unanimous in the statement that no great inconvenience is experienced. Indeed it is a fact that the noise and vibration arising from the passing trains is more felt in the houses by the side of the railway than in the arches themselves; and if further evidence be required it is possible to point to shops, restaurants, &c., where business is carried on with no more disadvantages than if the premises were streets distant from the railway.

It may be a matter of surprise that such an obvious expedient as the utilization of the arches should not have been previously carried into effect. It is probable that had they been the property of individuals they would long since have been so utilized. But although the idea has, doubtless, been suggested before, and notwithstanding the difficulty of dealing with any new idea by a railway company, other causes have had their effect in delaying the scheme. The causes which have prevented private individuals from taking the arches from the companies and converting them as proposed, are somewhat numerous; but, as will be seen, are matters of practical detail only.

One of the most important preventive causes is the policy of the companies, hitherto, in refusing to grant long leases. Many of them will give only a yearly tenancy—the most liberal a 7, 14, or 21 years lease—while all insert clauses reserving power to regain possession by a three or six months' notice.

This policy, if persisted in, would be fatal, for it would prevent capital being employed by private individuals on such a precarious tenure. But as possession is only likely to be again required by the companies in case of a desire to widen their lines, it would meet the requirements if a short lease only were granted, and compensation be given in case of eviction, for the money laid out in fitting the arches as dwellings.

Again, the present arches vary a great deal in size, and, therefore, in adaptability to the purpose. The best type is an arch about 25ft. to 30ft. frontage, about 30ft. deep, and 20ft. high to crown. In each of these arches could be built five rooms, a washhouse, yard, and offices. But only a small proportion of the whole number of arches closely approach this type. In the construction of a railway viaduct, the requirement insisted on by Parliament is a headway of about 17ft. where the arches of the viaduct cross public roads. For purposes of economy, the height of the arches is reduced directly the roadway is passed. The consequence is that the generality of arches do not average nearly 20 ft. in height. Those on the London, Chatham, and Dover extension system average only about 14ft. from ground to crown of arch.

Again, there are also many arches under four lines of rails, where a necessary depth of about 50 feet for this purpose would render them too closely approaching tunnels, for the light and ventilation essential to a dwelling-house. Though then a double dwelling-house *can* be constructed, with six rooms in each arch of such a railway as the London, Chatham, and Dover, yet the accommodation in point of economy of building, of light, and of ventilation, would not be perfect. It is necessary to add, however, that a very large number of arches of the latter type are at present in existence round London.

Again, it may be objected that the smoke arising from the chimnies would be likely to be a nuisance to the passengers on the railway. The few chimnies which now exist without complaint are at the level only of the top of the parapet; but, if future inconvenience be experienced, it will be a slight matter to carry the chimnies up to above the level of the carriage tops.

* Read at Manchester Meeting of Social Science Association.

If this is found to be inefficacious, it will be possible to use one of the numerous smoke-consuming grates or stoves, or the principle (which has been carried out in some of the buildings of the Metropolitan Association for Improving the Dwellings of the Industrial Classes) of conveying the smoke from a number of flues into one large common shaft, may be applied. In any one of these ways it is possible to obviate any objections on this head.

The difficulty of access to some, and the absence of water-pipes and drainage, have also hitherto acted as a slight draw-back to the utilization of arches as dwelling-houses.

The above are the principal objections which can be urged against the scheme. It is believed that the whole of them are matters of detail which can be satisfactorily solved by the introduction of clauses into future railway Acts, without the opposition of the companies themselves, if (in order to disarm this opposition, and to prove to the companies that they would not be prejudiced, but, as before stated, benefitted by it) private enterprise first showed the value of the proposed scheme.

It is, accordingly, in contemplation to try the experiment by a private association on (say) twenty arches. Such an experiment can in no way be a very bad, and it is possible that it may be a good, investment.

If the latter is found to be the result, it will then be possible, without the opposition of the railway interest, to introduce into future private Acts some such compulsory clauses as the following:—

(1.) Compensation, *pro rata*, for outlay in building to be given to tenants of dwelling-houses under arches, in case of summary eviction.

(2.) Where a viaduct is required to be wider than 30 ft. (or two lines of railway), to build a second viaduct at a distance from the first.

(3.) Sufficient land to be bought to get access on one side (say 15 ft. in width), and light on the other side (say 6 ft. in width).

(4.) Standing orders to be altered to a compulsory minimum height of 20 ft. to crown of arch.

(5.) Fireplaces and flues to be constructed in piers and parapets.

These clauses, though entailing an extra cost upon the railway companies, would repay them in the rent obtainable from the dwellings.

In all future railway schemes which come before Parliament for sanction, the policy also should be in favour of constructing overground rather than underground railways. In all of the latter class, with the exception of those under carriage-roads, property is destroyed without an opportunity for provision being made for those dispossessed. In those of the former class, it may be possible to provide dwellings for nearly the whole number evicted.

The author has now indicated what he believes to be the best means to adopt to give good house accommodation to large numbers of the labouring classes at the present time, and to provide for future wants as they are created by the chief cause of the wants. It remains now only to prove that the commercial value of the scheme claims for it that support which its higher results demand.

The following figures are taken from a tenement of this nature on one of the existing lines of railway, and which is within the author's knowledge.

The tenant, who is also lessee, a working builder, took the arch six years ago, and built himself a house within it, consisting of two sitting-rooms, three bed-rooms, kitchen and washhouse combined, and offices, and states the cost at £100,

Which at 5 per cent., gives	£5	0	0			
Rates and taxes	2	0	0			
Insurance	0	13	0			
Add cost of collection of rent (say) ...	1	0	0			
And repairs per annum (say) ...	2	0	0			
Total outgoings per annum (exclusive of rent of arch)				£10	13	0
Now, at an estimate of 8s. per week for rent of the dwelling, the income from each arch, per annum, would be				20	16	0
Leaving a net income to the railway company on each arch, per annum, of (say)				£10	0	0

On the thousands of arches in existence and in contemplation in and about London, the increase of revenue to the railway companies may at once be seen.

But taking the arches as worked by private enterprise, and each therefore as subject to an additional charge to the company of ground-rent, and taking this ground-rent at an average of £4 (an ample charge to cover the ground-rents of five-roomed dwellings in the district where these are contemplated), a further deduction of £4 would be made on the above net income. This would leave an interest of £11 per cent. on their outlay to any lessees under the company; and a simultaneous profit, free from risk, of £4 per arch per annum to the companies themselves on the thousands of arches which they will be in a position to lease.

In many districts in London large blocks of buildings have been erected with new materials, and on a scale which should not be attempted in this scheme; and yet at a cost of £160 per tenement (capitalising the ground-rent in the same way as has been done above), 5 per cent. is paid to the shareholders of the company over which Alderman Waterlow presides; and this instance is from buildings in the City-road, where ground-rents are certainly higher than in the out-districts where the railway arches would be utilized.

Review.

Architecture of Ahmedabad, the Capital of Goozerat. Photographed by Col. Biggs, R.A. *With an historical and descriptive Sketch, by* Theodore C. Hope, *Bombay Civil Service, and Architectural Notes by* James Ferguson, F.R.S., M.R.A.S., F.R.I.B.A. Published for the Committee of Architectural Antiquities of Western India, under the patronage of Premchund Raichund. London: John Murray. 1866.

This is not a country nor an age prone to the publication of handsome architectural books. From time to time elaborate volumes leave the press, but their frequency has not kept pace with the late general advance of architecture. The work before us is, however, one of the most important and most novel which it has fallen to our lot to notice for a long time past, and forms some exception to this rule, for it introduces the architectural student to a series of fine examples, the merits of which are in England but little understood, nay it is not too much to say, the very existence of which has been but barely known to the majority of Europeans; and it makes use of photography as a means of illustrating architecture in a more systematic and complete way than almost any previous publication. Many series of photographs illustrative of buildings have been published, and some books partially illustrated by photography have also appeared, but this volume appears to us more completely to develop the capability of this new art to lend itself to the highest class of book illustration, in the same way as the art of engraving has hitherto been used, than any previous attempt in the same direction.

To understand how it comes to pass that in Ahmedabad there should be found a series of buildings uniting the patient industry and endless elaboration in decoration of the Hindoo, with the purer architectural forms and unerring skill in ornament of the Mahommedan, we must go back some little way into the history of that northerly province of Western India known as Goozerat, of which Ahmedabad is the capital.

Goozerat is a province marked out by well-defined natural boundaries, and having an extended sea-board. It is described in this volume as possessing great and varied natural beauty, and containing many cities and places of note, and as having from very early times maintained a strongly marked independence.

"The population consists of several distinct elements, each holding its appropriate position in the whole, and resembling each other in little more than that all are bold and warlike. The aboriginal Bheels and Khoolies, swarthy children of the bow, still lord it in the forest and on the mountain; but elsewhere they have either blended with, or been displaced by successive waves of immigration, among which the fair-haired Kathi still proclaims his Scythic origin, and the chivalrous Rajpoot maintains his political supremacy.

"Possessing as we have seen a central and naturally defended position, an extensive sea-board, a fertile soil, and a high-spirited people, Goozerat has from the earliest times had a distinct and self asserting nationality, a position in history disproportionate to its area, and a vitality which has over surmounted foreign conquest and internal strife."

The inhabitants of Goozerat appear to have held from early days the Jain religion, which is a form of Buddhism, and connected with which flourished a very distinct and remarkable architectural style, already well illustrated by Mr. Ferguson in previous works. Politically, the history of Goozerat was eventful, and even romantic, and Mr. Hope's historical sketch, commencing before the Christian era, and coming rapidly down to our own day, will be read with great interest. In the tenth century, the Mahommedan invasion broke upon India, and early in the eleventh the Mahommedans assailed Goozerat, and even possessed themselves of Somnauth, but they were eventually driven out of the province, and did not again attack it for a century and a-half; nor does their authority appear to have been at all generally established there till the end of the fourteenth century, and then only by dint of continued effort could it be maintained.

In the year 1412, Ahmed Shah, Viceroy of Goozerat, determined on founding a new capital, to which he gave the name of Ahmedabad, and which embraced in its circuit the site of one, if not more, earlier cities; and here we have reproduced that blending of the arts of the conquering and the conquered nations which has so often been seen in various parts of Europe; the Jain architecture of the existing temples and palaces becoming blended with the well-known peculiarities of the Moslem.

The leading feature of Jain architecture appears to have been an octagonal dome, resting upon architraves supported by short stone pillars. In the simplest plans these pillars were twelve in number, eight under the angles of the dome, and the remaining four so placed as to carry out the octagon to a square. From this simple plan great elaboration was eventually reached, and upon the surfaces carving of the most profuse richness was lavishly displayed. The mosques and tombs of Mahommedan structure display almost universally these domes resting on a forest of pillars; but with the addition, in many instances, of enclosing walls, pierced by pointed arches, and of minarets, Moslem in shape, but very Hindoo in details. In the earliest of the mosques indeed, the enclosing external wall of masonry is very solid, with a few wide arched openings, and the enrichments sparingly introduced. Later on we get not merely the large arched gateways, but numerous window-like openings, many of which are filled in with the most exquisite patterns, usually geometrical, pierced through thin plates of marble, and producing an effect which those who have seen it on the spot describe as little short of magical. This species of decoration reached its acme in the two windows from Seedee Seyeed's mosque given in this book, of which it may be safely affirmed that nothing more beautiful has ever been produced by all the resources of mediæval tracery. These windows have an arched outline, the springing line of the arch being on a level with the cills. They are 7 feet wide and 10 feet high, and the entire space is filled with flowing ornament, formed into the general resemblance of some flowering plant, the arrangement of the principal lines and the rich filling in being alike perfectly satisfactory to the eye, while the novelty of the mode of treatment gives them an extraordinary charm.

Another variety in the treatment of the external openings consists in enriching square-headed openings, resembling Italian windows, by throwing out a broad projecting cill on corbels carrying shafts detached from the wall, and which support a kind of overhanging cornice, the whole very Hindoo in its treatment, but closely resembling in its general outline and aspect some of the best examples of the same feature in Florentine Italian, only that the Ahmedabad examples are far bolder and far richer in surface ornament, though less pure in form.

Another very striking and characteristic feature to be found equally in those buildings where the exterior is enclosed by walls, and in those buildings or portions of buildings which present a row of columns carrying an architrave, is the cornice. This is very peculiar, and wonderfully well designed for a vertical sun. It consists of sloping slabs of thin stone, apparently projecting from three to five feet from the walls, with more or less of corbelling below them, and a parapet surmounted by a kind of ornamental battlement or brattishing above. This has the effect and appearance of a refined pent-house roof, which it, in fact, is, and will throw during the mid-day hours a delicious and sheltering shadow over the colonnade beneath.

The forms of the columns made use of are very various; they are most usually square or octagonal, with elaborate well-designed bases, and repeated bands of ornament on their shafts. The capitals are ordinarily rather too heavy to an eye trained in European schools; they are usually elaborate, and partake more or less of the type of bracket capitals common in Jain temples, though from these Mahommedan structures the elaborate in fact exuberant brackets seen in the pure Jain buildings are very properly absent.

The surface decoration is astonishing, whether we regard its wonderful elaboration or the purity and correctness of its design as ornament. It is most lavishly applied to the bases of the minarets of mosques, and here its character seems ordinarily to be purely Hindoo, but examples both of panels and of flat wall decoration occur in abundance in these volumes, where, although the class of geometrical patterns found in the pierced panels is not employed, there is a sensible modification of the Hindoo style, so as to produce something better even than pure Saracenic wall decoration. As an example of this, we may refer to the wall decoration from the tomb of Ranee Seepree, photograph 24.

Perhaps the most characteristic of all the features of this series of buildings is the dome, but this, unhappily, is less capable of being distinctly shown by photography than almost any other part of the building. It is externally distinctly visible in some cases, but is partly screened by the parapet and cornice surrounding the outer structure in others. Internally, both its height and its gloom render it a difficult subject for the camera; nevertheless, in two or three cases, the base at least of some of these domical structures is tolerably shown, as seen from the interior of the buildings they cover.

The series of buildings comprising the great glory of Ahmedabad were completed within the compass of a century (the fifteenth of our era), although examples are given of later date. In what measure the architectural features of which we have endeavoured to point out the characteristics, were combined into the structures here illustrated, we can hardly attempt to describe. Without numerous illustrations, the effort would be almost futile, but in the book itself are combined both the needful illustrations and a lucid explanation from the pens of two practised writers. One hundred and twenty photographs are here given, and at a price for the whole volume which reduces their cost to below one shilling for each. They form a volume equally valuable for the study or the studio as for the drawing-room, and one which can be recommended with more than ordinary confidence to all who desire to form an acquaintance with this very distinct and singularly excellent school of art, hitherto all but unknown in Europe.

NITRO-GLYCERINE IN THE SANDSTONE QUARRIES OF THE VOSGES, NEAR SAVERNE.

The explosive properties of nitro-glycerine [$C^6 H^5 (NO^4)^3 O^6$], and the results of experiments made with this substance in various parts of Sweden, Germany, and Switzerland, have induced Messrs. Schhmidt and Dietsch, proprietors of extensive sandstone quarries in the valley of the Loire (Bas Rhin), to try it in their workings.

These experiments have been successful both as regards economy, facility, and rapidity of work, and the use of powder has been temporarily abandoned, and for the last six weeks only nitro-glycerine has been used for blasting purposes in these quarries.

1. *The preparation of nitro-glycerine* is commenced by mixing in a vessel, placed in cold water, fuming nitric acid, at 49° or 50° Baumé (1·476 or 1·490 sp. g. English), with double its weight of the strongest sulphuric acid. (These acids are both expressly manufactured at Dieuse and sent to Saverne.)

The glycerine of commerce, which should be free from lime and lead, is evaporated in a vessel until it indicates 30° to 31° Baumé (1.245 and 1.256 sp. g. English). This concentrated glycerine should become solid when completely cold. A workman then pours 3,300 grammes (about 7¼ lbs.) of the mixture of sulphuric and nitric acids, well cooled, into a glass vessel (a stone pot or porcelain vessel will equally answer the purpose), placed in a trough of cold water, and then pours slowly, while gently stirring it, 500 grammes (1lb. 1oz.) of glycerine. The most important point is to prevent a sensible heating of the mixture, which would cause a rapid oxidation of the glycerine with the production of oxalic acid. It is for this reason that the vessel in which the transformation of glycerine into nitro-glycerine takes place, should be constantly kept cool externally with cold water.

The mixture being stirred well, it is left for five to ten minutes, and then it is poured into five to six times its volume of cold water, to which a rotating motion has been previously given. The nitro-glycerine is rapidly precipitated in the form of a heavy oil, which is collected by decantation in a deep vessel; it is then once washed with a little water, which is also decanted, and then the nitro-glycerine is poured into bottles ready for use,

In this state the nitro-glycerine is still a little acid and watery; but this is no drawback, as it is used shortly after its preparation, and these impurities in no wise impede its explosion.

2. *Properties of Nitro-Glycerine.*—Nitro-glycerine is a yellow or brownish oil, heavier than water, in which it is insoluble, but it dissolves in alcohol and ether. Exposed to a cold, even slight, but prolonged, it crystallises in long needles. A very violent shock is the best mode of making it explode. · Its management is otherwise very easy, and not dangerous. Spread on the ground, it is difficult to make it take fire with a lighted match, and even then it burns but partially. A flask containing nitro-glycerine may be broken on stones without exploding it; it may be volatised without decomposition if carefully heated; but if the ebullition becomes brisk explosion is imminent.

A drop of nitro-glycerine falling on a cast iron plate moderately hot, volatalizes quietly; if the plate is red-hot, the drop inflames immediately, and burns like a grain of powder, without noise; but if the plate is hot enough, without being red-hot, for the nitro-glycerine to boil immediately, the drop is briskly decomposed, with a violent detonation.

Nitro-glycerine, especially when impure and acid, may decompose spontaneously after a certain time, with release of gas, and production of oxalic and glycolic acids. It is probable that spontaneous explosions of nitro-glycerine, the disastrous effects of which the newspapers have made known, are occasioned by a similar cause. Nitro-glycerine being enclosed in well-corked bottles, the gas produced by its spontaneous decomposition cannot release themselves; they exercise a very great pressure on the nitro-glycerine, and under these circumstances the least shock and the slightest shaking may occasion an explosion. Nitro-glycerine is of a sugary, sharp, and aromatic flavour; it is also a poisonous substance. In very small doses it occasions very severe headaches. Its vapour produces like effects, and this circumstances might well be an obstacle to the use of nitro-glycerine in headings in mines, where the vapour could not be dispersed as easily as in open quarries.

Nitro-glycerine is not a properly nitrous componnd, analogous to nitro-, or binitro-benzol, or to the mono-, bi-, and tri-nitro-phenisic acids. For instance, under the influence of reducing bodies, such as hydrogen, glycerine is set at liberty, and caustic alkalis decompose nitro-glycerine into nitrates and glycerine.

3. *Methods of using Nitro-Glycerine.*—Supposing that it was required to detach a mass of rock at 2.50 metres or three metres (8 to 10 ft.) distance from the external edge; a hole is drilled about two to three metres (from 6ft. 6in. to 10ft.) in depth, five to six centimetres (2 to 2½ inches) in diameter; after having cleared this hole of mud, water, and sand, 1,500 to 2,000 grammes (3lbs. to 4½lbs.) of nitro-glycerine are poured into it by means of a funnel A small cylinder, in wood, card, or tin, of about four centimetres in diameter and five to six centimetres (1⅝ inch, 2 to 2½ inches) in height, filled with powder, is then put in. This cylinder is attached to a fuse, that penetrates it a short distance, to ensure the explosion of the powder. By means of this the fuse is lowered to the surface of the glycerine, which is known by practice.

The fuse is then held steady, and fine sand is run in until the hole is entirely filled. It is unnecessary to compress or plug up the sand. The fuse is then cut off a few inches above the hole and lighted. At the end of a few minutes the fuse burns down to the cylinder and ignites the powder, which occasions a violent shock, and causes the nitro-glycerine instantly to explode. The explosion is so quick that the sand never has time to be thrown out. The whole mass of rock is raised up, displaced, settles quietly down without any being projected, and a dull report is heard. It is only on the spot that any idea can be formed of the immense force developed by the explosion. Formidable masses of rock are easily displaced, and cracked every way, and ready to be cut up by mechanical means. The principal advantage is that the stone is but little crushed, and there is but little waste. With charges of this nitro-glycerine 40 to 80 cubic metres (1,400 to 2,800 cubic feet) of pretty hard rock may be detached.

BELL-FOUNDING.

Mr. H. M. Blews, in his contribution to the recently published work, entitled "Birmingham and the Midland Hardware District," writes:—This trade seems to have been unknown in Birmingham till the middle of the last century, when a foundry was in existence opposite the "Swan" at Good Knave's End, on the road to Harborne. This foundry supplied peals of bells to three adjoining parish churches in 1760. Twenty years later, one Ducker had a foundry at Holloway Head, and cast chimes, since which time there is no record of large church bells in peals having been cast in the town, although an extensive trade in other descriptions has continued to flourish and extend. Church, school, plantation, factory, and ship bells still closely adhere to the mediæval type. They vary in size from half a hundred-weight to half a ton, the largest size now cast at Birmingham. There is a great demand for them in the home and nearly every foreign market, including South America and the Colonies, Railway and dinner bells, from four to seven inches wide at the mouth, with a wooden handle attached, are largely used for domestic purposes; and the majority of railways in England, India, Russia, Brazil, &c., have been supplied from Birmingham. Musical hand-bells are still made, but the demand is very limited, as they are seldom required by any but village ringing clubs. Cattle and horse bells are oblong at the mouth, the size varying from three-and-a-half inches by two-and-a-half inches to seven inches by three-and-a-half inches. They have conical sides, and a square iron loop at the top. They are in great demand for Australia and New Zealand, the smaller sizes being suited to the Brazilian and South American markets. Sheep bells are circular at the mouth, and an elongated semi-circle in shape, with a loop at the crown. They are used in England, and exported to the Cape, Australia, New Zealand, &c. House bells are so familiar, as to need no description. Some exceedingly small bells, from ¾ to 1½ inch, are used as an article of barter in the African trade. Sleigh, dray, and caparison bells, small circular bells, with an iron ball cast inside, are largely used in Canada and India, and command a limited sale at home. During the last ten years an increasing demand has arisen for fancy, table, office, and call bells, constructed of the ordinary clockbell, mounted on a stand, and struck by the pressure of a spring. Not very long since, Messrs. Schofield, Sons, and Goodman executed an order for 10,000 green bronzed and lacquered house bells, 12oz. in weight, for a West African Prince, to adorn his new iron palace. Messrs. J. Wilson Browne and Co. recently also received an order from another African prince, for a number of polished ship bells, in elegant brass frames, and mounted on mahogany stands, some of which were engraved with the name assumed by the distinguished potentate, "Yellow Duke, Esq."

A new Belt for Soldiers.—M. Heeremans, a Belgian, has invented a belt for soldiers, which deserves the attention of all interested in military affairs. After an engagement or battle, an idea may be formed of the miserable position of the wounded, who, without timely care and dressing for their wounds, often perish without succour, or from the heats or colds that bring on gangrene. The belt is buckled on as an ordinary belt; it is 1·30 m. in length by 8 centimetres in width. It is lined outside, so as to receive a band of dressing of the same length, which is readily drawn out. Close to the buckle are two india-rubber pockets, containing, firstly, a bandage for a second wound; secondly, lint, plaster, pins, &c. The soldier wears it on his trowsers, and the total weight does not exceed 150 grammes, or about 5 ounces, In many cases the soldier would be enabled to dress his own wounds or those of his wounded comrades. Once the wound dressed, which might occupy two minutes, the belt may be used as a great bandage, whether the wound be in the body or leg; if in the arm it serves as a sling. This belt, of so slight a weight, and at a price not exceeding a franc, does not impede the movements of the soldier.

Microscopic Printing.—One of the objects that have excited the most curiosity in the recent exhibition at Toledo, was a complete edition of *Don Quixote*, printed in microscopic characters, on fifty-four cigarette papers, in four volumes.

THE ARCHITECTURAL ASSOCIATION.

The regular fortnightly meeting of this Association was held on the 9th November, Mr. R. W. Edis, President, in the chair. Mr. S. Lane, Mr. M. Fergusson, Mr. William Day, Mr. Frederick H. Reed, T. H. Watson, Mr. Arthur Briggs, Mr. Thomas Kedge, Mr. Reginald Worsley, Mr. C. W. Mulligan, Mr. E. B. I'Anson, Mr. C. Eals, Mr. W. Birdseye, Mr. I. Walker, Mr. W. H. Arber, Mr. R. W. Woodcock, Mr. Edward Newson, Mr. George Allin, Mr. F. M. Harvey, Mr. Charles Bell, Mr. D. J. Ross, Mr. Talbert, Mr. Arthur Vernon, Mr. A. S. Alluin, and Mr. W. G. Davie, were elected members of the Association.

An address was then delivered upon

THE RELATIONS WHICH SHOULD EXIST BETWEEN ARCHITECTURE AND THE INDUSTRIAL ARTS.

By M. Digby Wyatt, F.R.I.B.A., F.S.A.

The Lecturer commenced his address by stating that, one primary object which he had in addressing the Association was, to call the attention of young architects to the importance of being ready to seize upon any new invention or discovery, any new materials, or processes, or revivals of ancient processes, or disused materials, and to fit themselves for introducing them with judgment and success in their buildings. His purpose was not then to compare the relative merits of one style of architecture with another, but rather to show the means by which all styles might most safely and surely advance and keep pace with the requirements of the age. There was a continual debate about new styles of architecture,—a cry for something different from the Classic or Gothic styles which were prevalent. It was not by inventing new styles, but by improving and advancing the styles which we possessed, and by the introduction of new materials, that architects would be enabled to obtain novelty and freshness in their work. Progress in the industrial arts was steady and constant, owing to their dependance upon the incessant wants of humanity, and there was a natural connection between those arts and the architect, as between master and servant. New inventions were being continually introduced to the architect, to be made use of in his work; and it was by availing himself of this natural connection that the architect would advance in a right and safe path. Knowing this, architects should take great interest in manufactures, in the introduction of new technical elements, and in the formation of new materials and processes. "More novelty" was to be got by altering and bringing in adjuncts from industrial arts which had not been heretofore habitually applied to architecture, than by attempting to use the old materials which have been constantly used by our forefathers, and twisting them into forms different from those hitherto seen. Mr. Wyatt said, that if the members would carry their mind's eye back for twenty-five years they would at once recognise the great advances which had been made. He instanced first mosaic work. Twenty-five years ago that art had scarcely any existence at all in this country. Now, one could scarcely pass along the street without seeing large pieces of pavement covered with it, so universally had it come into use.

It was also rapidly spreading over wall surfaces, and he believed it would ultimately change the whole style of the interior architecture of the finest ecclesiastical structures of the land. Again, in the article of stained glass. Twenty-five years ago it was quite rare. Now, it is quite common, and its introduction or non-introduction altered the effect of the entire building. He thought they could scarcely have the brilliant colours in the windows without wishing to have colours also on the solid surfaces which surrounded the windows. And so the architect was led on to make his design richer and richer by the introduction of new materials. Thus he might restore to the skeleton of the grandest monument time had alone bequeathed to him from past ages, those elements which once made it a living form. The architect must engraft on the works of the past, the arts of the present, for thus alone could he emulate the beauty and grandeur which the monuments of the best ancient architecture presented. The mason's art again had been essentially modified by the number of coloured materials which had been introduced. That alone had changed architecture within his (Mr. Wyatt's) experienee. Great changes had been also wrought by the introduction of coloured pottery and bricks. From these the architect gained the only polychromatic effect which could be gained in a country with a variable climate like England. It was impossible to use artistic painting to any extent in England on exteriors, owing to its limited durability, but all materials which were permanent, were at the disposal of the architect; and greatly as his range of choice had been recently enlarged, there was every reason to hope that in a few short years it might be vastly increased.

During the building of the Houses of Parliament, mainly through the efforts of Pugin and Sir Charles Barry, great advances had been made. While engaged in the construction of that national undertaking, these great architects at once took advantage of every new art and brought it into use. Pugin made himself acquainted not only with excellent stone carving, but with metal work, wood work, stained glass, encaustic tile designing, hangings, carpets, paperings, and in short with everything which could furnish the monument which he was assisting to design. Especially in the mason's art great advances were then made. The old methods of vaulting which had fallen into almost entire disuse, were again introduced. Setting out complicated stone work had almost died away, since the period when St. Paul's had been completed. If reference were made to any general treatises on architecture of the last century—Batty Langley's for instance—it would be found that there was an almost entire blank in whatever related to stone vaulting. The period from about 1780 to 1830 had been especially poor in this as in other particulars. A little while before the earliest of those dates, Blondel had published his work, "on the arrangement of luxurious houses and the decoration of buildings in general," which was far from being so poor as those of the English writers of the era. There was the gardening and masonry, the iron-work and wood-work given in detail, and the whole of the directions for elaborately fitting up every part of the structure. With him the wood-work was not the simple rails and styles and panels, as given in the ordinary terms of a modern specification, but the designs were much more varied, and intricate, and taxed the ability of the workman. It was a kind of work which made the workman feel proud of its execution. In those days the man who did his work well was an honored workman. The same system ought to prevail at the present day. . That part of the art which might be called the industrial, or to revert to classical tradition, the "technical," was really the backbone—the substratum of architecture. He was fully aware, he said, that there were other branches of study with which a student must be acquainted. But no knowledge of the higher branches of the art would compensate for the want of a practical acquaintance with the technical arts. In the ancient Greek structures it would be found that the basis from which the architects began their work was the perfection of their masonry. It was wrought lovingly with a finish and fineness, and the example of those ancient architects showed that perfection in workmanship was no less necessary now, and constituted the only means by which modern work could be made to gain as high a position in the world's estimation as had been won by the monuments of ancient civilization.

Having considered the dependence of the mother of the fine arts on industry, Mr. Wyatt proceeded to touch upon the manner in which, as it were by reciprocation, industry was dependent on the fine arts. For instance, he said, there was a class of arts which were dependent on painting. Coloured surfaces could only be had upon the principle of mosaic work, or by the addition of colour superficially. The architect who had studied colour in connection with the industrial arts could as easily design paper-hanging as he could any more structural mode of mural decoration; if he could design paper-hangings well, he could also, by a little special study, learn to design carpets, curtains, textiles generally, and he would be in a position to exercise a trained taste and judgment in any department of industry, even to selecting or composing that most difficult problem a lady's dress. The same process of study carried on by the natural principle of dependence which led from one art to another, enabled the student to follow out every branch of design. Having once acquired a knowledge of general principles, he could, without difficulty, master the separate details of each specific branch, so if a student made himself acquainted with the laws of sculpture in its various plastic forms, not only in the round, but upon flat plain surfaces, and also upon curved surfaces, he would be able to apply all this knowledge on a smaller scale in relation to works of industry. By the natural sequence of things, everything in the way of designing gravitates naturally towards the architect. His mind should be trained to appreciate whatever was artistic with special relation to the material employed. If an article were designed with beauty and taste, the architect would see it and feel it the moment he looked on it; in fact, having had the mental training, he could scarcely keep himself from the practice of industrial design. Looking to metal work as an illustration, it would be found that architects had almost involuntarily of late years changed its character altogether. The various books written by archæologists had called attention to this branch of industrial art, but the architects for the most part had given the revived and beautiful forms it was now frequently seen to assume. Till lately it had been very much lost sight of, but when men began to think about it, and to insist upon taste in ironwork, improvement commenced, and people would not now tolerate bad designs. In this manner not only artists, but the public and the trades were benefited. Now-a-days the public got a much better article than they did twenty or thirty years ago; and this improvement in the industrial arts had been effected mainly through the influence of the architects. Artists and architects had not sought sufficiently industry, but industry had sought the artists. He (Mr. Wyatt) strongly recommended students to exercise themselves in designing for the industrial arts to which he had been referring. To design for those arts required the same general power of combining which was necessary in an architectural edifice. Thus whatever an artist designed, he should make specific in its function; if it were a box which he designed, its purpose should be borne in mind, and it should be *like* a box, and not like two books, as boxes were sometimes designed externally. The purpose of an article, as of a building, should always be expressed by its external configuration.

The same quality in an architect's mind which made him design a church like a church, or a warehouse like a warehouse, should enable him to make a box like a box, or a chair like a chair; it should express the purpose, the right purpose, and the class of purpose to which it was to be applied. Much improvement in this respect had been effected, and it was mainly due to archæologists that it had come about. Artists owed a debt of gratitude to those who had brought together in museums the various beautiful classes of objects which had been designed on these principles by the great artists of past ages. If, for instance, the golden altar at Milan, the Pala d'Oro at Venice, or the wood carvings on the screens of some of the Parisian churches, were studied, it would be found that all of them had been designed by men who had made metal work and wood carving subservient to architecture. An architect's duty was to create beautiful things, big or little, cheap for the million, sumptuous for the millionaire, and he ought not to turn away from the manufacture of any ordinary objects upon which the stamp of beauty might be impressed. Mr. Wyatt said he did not need to remind them of the number of architects who had been not only artists in their own particular branch of art, but had been also artists in the industrial branches. The middle ages were fruitful of men who were not only architects, but goldsmiths and metal workers, and who took as much interest in wood and ivory carving as in the design of a large building. He (Mr. Wyatt) had with him a number of original designs by old masters, which he had lately had an opportunity of purchasing in Italy, shewing that it was in the power of an architect to make himself master of the details, both of his own profession and of the industrial arts. (The sketches were mostly details of wood and metal work, majolica, wall painting, and stucco and sgraffito work.) Mr. Wyatt continued his remarks by observing that these sketches proved that the men who were the finest draughtsmen, and the finest artists, were also the men who could best enter into the special technical requirements of industrial art. He believed that wherever society had been highly cultivated, the highest artist had been employed to make industrial objects beautiful. Many of the ancient architects were universal in their powers of design. The men who were contemporaries with Raffael were special instances during the period of the renaissance in Italy, and during the best times of Greece and Rome, the same universality of power was noticeable. The same intellects which constructed the great buildings of the country, were also able to descend to little industrial details; and the same people which admired the one most profoundly, could not exist without the other. For the opportunity of noticing and generalizing such facts regarding ancient work, artists were much indebted to the Manchester Exhibition of 1857. He had specially noticed at that exhibition the vitality which was shewn in every branch of artistic production at the great culminating periods in the history of monumental art. There was a general harmony among the objects exhibited, and however remote and distinct the period of their production might have been, yet as the highest point of artistic power was reached, there was found to be a common feeling pervading them all. It was the same colour lighting up the highest peaks, and the beholder could see that there was the same art, the same nature, and the same God ruling above all. To the Crystal Palace, the Hotel Cluny, and the Kensington Museum also the artistic world were under great obligations, as in those interesting collections the same general principles to which he (Mr. Wyatt) had adverted, were noticeable. No country in the world, not even France, had such a collection in which the student could so readily observe the connection between the industrial arts and the architects, as we possessed, thanks to Mr. Cole's energy and Mr. Robinson's fine taste, at South Kensington. In the museums in Paris, it was true there were many beautiful objects, mostly of the renaissance period, and their "loan collection" of the year before last had been most instructive. There might have been seen multitudes of old processes worthy of active revival by modern architects, such as inlays, veneers, and new modes of designing joiners' and cabinet makers' work, in the study of which latter the observer was made to take a delight in the ingenious complication of the true art workman revelling in his craft, and had his perceptions of beauty in that field of design altogether quickened. There were also in the Paris Exhibition some of the finest specimens of Henri II. ware, especially suggestive for ceramic revivalists, as well as some beautiful specimens shewing the art of applying enamel. There had been another continental exhibition, especially interesting from an ecclesiastical point of view, at Mayence. Mr. Wyatt produced a fine series of photographs of articles in that museum, which he considered were extremely interesting, especially those showing the metal work of Namur, wrought by that magnificent art workman of the thirteenth century, "Hugo des Oignies," and the "dinanderie," or old ecclesiastical "latten" work of Dinant.

In speaking of the relations between the industrial arts and the architect, Mr. Wyatt begged his hearers to bear in mind that it was not only the industrial arts which might be benefitted by drawing closer the bonds of intimacy, but that the architect also would be correspondingly and reciprocally benefitted. There was no class of practice which was more improving to the young architect than one in which he could not only design, but could have his design executed. There was a great difference between making such a design and one which passed only to the student's portfolio, without being really put into execution. The latter had not half the instruction which it would have were it to be executed. Only then could the designer discover his faults. Execution was the crucial test of a design. Now, a student or young architect could rarely get this test in the form of a large building, but he could readily in some small industrial object, which might only cost a few shillings; and thus his taste and judgment were exercised, and he was trained for larger works when called on to design upon a larger scale. With such practice and experience, he would not be nervous about how his building was going to look. Let him but give himself a training in designing industrial objects, and he would find that he would easily anticipate what his drawing was going to look like, and this knowledge would give him strength to advance when called to deal with responsible problems. A somewhat baser consideration (Mr. Wyatt said) was the emolument to be derived from designing industrial objects. The manufacturers of the country were earnestly looking out for intelligence. Manufacturers did not want draughtsmen and modellers only, but artists with knowledge, taste, and talent. Many of the industrial arts had improved, but there was still much room for advancement. He held it the duty of every architect who could design, to design for this class of objects. It should be the pride of all those whose occupation it was to deal with matters of beauty to endeavour to advance the industries of the country and of art in all its forms. The aim of the British architect should be that all art should be perfect, just as among the ancient Greeks, everything was perfect from the Parthenon to a little necklace, from the philosophy of Plato to the gem he might have worn upon his finger.

Mr. Spiers said the subject which had been brought before the Association by Mr. Wyatt was most important, and deserved the earnest attention of young architects. The enormous extent of the publication of drawings and photographs of every known style had since the sixteenth century produced a perfect chaos, in which it was difficult to steer, so that in an ordinary domestic dwelling, as many distinct styles might be formed in the furniture, carpets, &c., as there were rooms in the house, or even articles of furniture. In France, however, a certain consistency had always existed between the interior decorations of the rooms, furniture, &c., and the exterior architecture,—so that each of the reigns of Louis XIII., Louis XIV., and Louis XV., may be said to have possessed a distinct style. The architect's attention, therefore, should be drawn to the furniture of a house, as well as to the exterior design. He (Mr. Spiers) had noticed a growing interest in industrial subjects in the class of design in connection with the Association. Sideboards, chimney-pieces, church plate, &c., had been treated at various times, and last year the decoration of a chancel arch, an extremely difficult subject, had been well worked out; it was not probable that an architect could be called upon to design fresco paintings on church walls, but it was as well he should have ideas and judgment in the matter. Next year, when the Paris Exhibition is opened, we shall have an opportunity of judging of the progress made in industrial art since 1862; he (Mr. Spiers) could remember the Exhibition of 1851, and was able to note in 1862 the progress which had been made in the interim. Whilst we had learnt much from our French neighbours before, now perhaps something might be learnt from English work, and in no branch more than in that of stained glass and iron work; whilst in architecture proper, the employment of coloured materials, of bricks, tiles, marble, &c., in our exteriors, might offer many suggestions to French architects, who hitherto had designed in plain stone only. Mr. Spiers concluded by moving a vote of thanks to Mr. Wyatt for his excellent lecture.

Mr. Mathews seconded the vote of thanks. The Association was greatly indebted to Mr. Wyatt for his valuable lecture. It was one that members would do well to think over, and act upon. He trusted it would stir them all up to attention to the minor details of their art.

The President, in putting the vote of thanks, observed that it was very disagreeable for a young architect to find after he had designed his house with all care, that the external effect was to be entirely marred by the wretched design of the chairs and other furniture in the internal embellishments of the dwelling. Architecture was not only an art but a science, and the student must bear in mind that if he studied it only as an art, and not as a science, he was in danger of becoming a mere theorist. He quite agreed, however, with all that Mr. Wyatt had said, but considered that the one difficulty was the greater expense of furniture specially designed; he believed that architects were sufficiently competent to design artistic furniture, but it was somewhat difficult to design it sufficiently inexpensive. Englishmen desired cheap articles, and they would rather endure the ugly designs than pay more for really artistic work. He (the President) had often tried to get clients to have furniture designed, and they had always said, "what will it cost?" The answer of course was that it would cost a little more than ordinary furniture, and the people had always declined to get it done. It was only when manufacturers could be got to do things cheaply from architects' designs that art furniture could be obtained. So long as they threw obstacles in the way of the artist, so long would the present system continue. He could not comprehend why cheap things should necessarily be ugly things. The common articles of the ancients were always beautiful and artistic, and people now paid high prices for antique vessels, which were probably once cheap enough, but would anybody, four or five hundred years hence, give guineas for a ginger beer bottle of the nineteenth century! It was quite clear that the relics of ancient times which were stored in museums were valued because they were objects of beauty. In those days, mechanics were more or less artists, and artists were more or less mechanics. They designed carefully, and all worked co-operatively together. Why things could not be done as well and as artistically now, he could not tell; but if an artist took designs to a tradesman, he would find the cost from fifty to two or three hundred per cent. above the price of the articles they put in their windows. The President concluded by thanking Mr. Wyatt for his valuable address, and putting the vote of thanks, which was carried unanimously.

Mr. Wyatt, in thanking the meeting for the vote of thanks, observed that the difficulties which had been referred to were but additional reasons why architects should give greater attention to the subject he had had the honour of bringing before them. Manufacturers might be still conservative in their trade principles, but they had been well stirred up, and ought to be so still more, and made to move on in the current of improvement. Pugin did much to urge them forward in the path of progress, and it was by other architects continuing what he had so well commenced that architects would soonest obtain what they all desired—objects of industrial art in good taste, and at such moderate prices as should render them rather the rule than the exception throughout the country.

Spanish Railways.—The line of railway crossing the passes of Sierra Morena is now open for traffic; thus the journey may be made without interruption between Paris, Madrid, Cordova, Seville, and Cadiz. Within a few months, Madrid will be united with Lisbon by the Badajos Railway.

RAILWAY BRIDGE AT LA PLACE DE L'EUROPE, PARIS.*

By Thomas Cargill, C.E., A.B.

(*With Engravings*).

As a nation, we undoubtedly enjoy the distinction of having been the first to introduce and adopt the present system of railway engineering. We were the pioneers of steam locomotion in France and on the continent generally, and are, at this very time, actively engaged in carrying into far distant lands the benefits which have accrued to ourselves from its constituting the most prominent of our internal resources. Those who are the first to witness the advent of an improvement, whether its origin be fortuitous or otherwise, may naturally be expected to be also the first to imitate it, provided they have the sagacity to distinguish between an improvement and an innovation. Every innovation is not an improvement, nor is every novelty a reform. There are still railways in progress of construction in France whose professional head-quarters are to be found in Victoria and Great George streets; but there is no question that a great proportion of the work formerly designed by English engineers and executed by English contractors, is now carried out from first to last by the French themselves. They have now their own engineers and contractors, and we no longer possess a professional monopoly. Viewed in a jealous and narrow-minded light, this may appear a matter of regret, but to the man of enlightened mind, to the engineer anxious for the advancement of his profession, for the diffusion of its utility, and for the universal recognition of the truth and soundness of its principles, it is a subject of cordial congratulation. A vast difference exists between an abstract principle, theory, formula, or equation, and its application to actual practical examples. The former are the embodied results of scientific researches and natural laws, and are unalterable; the latter is susceptible of infinite variations. Given certain theoretical data in common, every engineer will deduce an identical theoretical result; but no two will produce an identical practical result. The difference, probably, may not involve any departure from sound and established principles of construction, but it will, in all cases, be sufficiently marked to indicate that the designs emanated from different individuals. Thus, every nation will practically apply those principles of science which it may either have discovered itself, or received from a neighbouring people, in a manner most in unison with its own particular tastes and ideas. Hence arises the diversity of execution attending similar designs, since the character and style of the work will always be, more or less, strongly tinctured with those peculiar habits and opinions which, in fact, constitute a nation's individuality. Consider the influence of succeeding nations upon architecture, and the manner in which various styles sprang into existence among different people. With respect to ourselves, it must be admitted, however unwillingly, that our ideas of architecture are becoming rapidly merged into an appreciation of the capabilities of iron, and all our efforts to maintain its ancient grandeur and beauty are confined solely to ascertaining how far this modern substitute for stone and timber may be rendered subservient to its interests. If an engineer of the present day required an inspiration to complete his design, Vulcan is the only deity he could legitimately invoke to his assistance. A stone bridge, of dimensions sufficient to render it worthy of the name, will soon be a rarity, not only in this country, but on the continent and elsewhere.

The physical features of a country no doubt exercise a considerable influence upon the most advantageous method of constructing engineering works within its boundaries. So far as iron structures are concerned, they appear to be independent of this influence, for we have erected bridges and roofs in Russia and India differing in no essential points from those put up in our own country. The introduction of railways and that of iron bridges was contemporaneous. Iron bridges may be divided into two principal classes, viz., those carrying railway traffic, and those carrying ordinary road or street traffic. It is only recently, comparatively speaking, that iron bridges have been employed for the purpose of carrying road or street traffic. They were generally confined, in the early days of railroads, to carrying the railway over an intervening space, and were consequently limited to under bridges. The over bridges were

---

* Read before the Society of Engineers on the 5th ult.

usually built of masonry or brickwork. Latterly, however, this restriction has been removed; and considering the success that has, in every point of view, attended the erection of Westminster Bridge, and the probable success that will also accompany the construction of new Blackfriars Bridge, it is almost certain that our next street bridge over the Thames will be constructed of a similar material. An example of the erection of a wrought-iron bridge for the purpose of carrying street traffic, has very recently been afforded in Paris. It is the object of the present paper to give a general and detailed account of this recent construction, which possesses some features of peculiar interest to the engineer. The locality where this remarkable structure is erected is known by the name of "La Place de l'Europe," and is appropriately so termed, since it is the common focus to which converge six of the principal streets of Paris, named respectively "London-street," "Berlin-street," "St. Petersburg-street," "Constantinople-street," "Vienna-street," and "Madrid-street." Without reflection, it might be supposed, granting that there was a choice in the matter, that it is bad engineering to run a line across the junction of roads and streets, whereas it is in reality a point to be aimed at in laying out a line of railway, as one bridge thereby answer the purpose of several. It is true that it will probably be larger than any one of the others considered separately, but it is cheaper to build one good-sized bridge than three or four small ones. The late extensions of our metropolitan lines in and about London will furnish numerous examples of the junction of several roads and streets being crossed by railway bridges both under and over. The plan of the bridge evidently owes its peculiar and irregular shape to either the wish or the necessity for preserving the directions of the converging streets unaltered. In London, where a glance at the railways is sufficient to convince the observer that the question of utility is paramount to every other consideration, we should unhesitatingly have sacrificed the gardens in the angular portions of the ground, diverted each pair of side streets into the main channels, Berlin and Madrid streets, and by so doing reduced the size and cost of the bridge to about a third of its present dimensions and value. There is very little doubt, however, that the engineer had no choice in the matter; a paternal government marked out his ground-plan for him, and all that he had to do was to employ his professional skill and ability in designing the most suitable bridge under the circumstances. In consequence of the bridge being close to a station, viz., the terminus of St. Lazare, there are numerous sidings and turn-outs running in all directions under the bridge. The main lines are, therefore, considered to be parallel to two of the piers, and to one of the abutments, and these latter will be referred to as the piers and abutment on the square, and the others as the pier and abutment on the skew. The shape of the bridge on plan (see fig. 1, Plate 40) may be subdivided into three parts—the central portion, and the two side portions or wings. The reason for the introduction of the skew pier is not by any means clear; it appears to have been introduced for the purpose of giving an uniformity of span to a number of the intermediate girders, which have the other end resting upon the abutment on the skew, to which it is parallel. It certainly divides the whole distance into two spans; but a single column of masonry or cast-iron pillar would have accomplished this result equally well, without the necessitating a continued pier of masonry. The girders may be classed under the following heads—face girders, or those which can be seen in elevation, looking from the railway on each side of the bridge; intermediate girders, or those running continuously from abutment to abutment; girders in the angles under the converging streets; and, lastly, the cross girders. The face girders are six in number, two of which AB, CD, are called the central girders, and are the only two absolutely identical in span and other details out of forty-one, which constitute the entire number of main girders, as distinguished from cross girders. The span of these central girders is 82ft. The remaining four face girders have the following spans V, or that under Vienna-street has a span of 137·29ft.; L or that under London-street is divided into two spans, of which the shorter is 72·62ft. in length, and the longer 191·80ft., being the longest single span of any girder in the bridge. The girder C, under Constantinople-street, is 137·25ft. in span, and may be considered identical in all respects with that under Vienna-street, as the difference in their relative spans is only 0·04 of a foot, or just half an inch. The other face girder P, under St Petersburg-street has a span of 112·47ft. With respect to the rest of the main girders the plan of the bridge may be divided as follows—a central portion, comprising all the intermediate girders, and the four angular portions, connected respectively with the girders already mentioned. The intermediate girders, running continuously from the square abutment to the skew one, are nine in number. Of these nine, Nos. 1, 2, 3, 4 are regarded as continuous over three spans, and the remainder, Nos. 5, 6, 7, 8, 9. extend over four. Strictly speaking, Nos. 2, 3, and 4 are continuous over four spans, but the span between the skew pier and the square one is so small as to be disregarded. It would be to no purpose to give the total span of any one of these nine girders; it will be sufficient to mention that the total span from abutment to abutment of the shortest No. 1, is 304·81ft.; that of the longest, No. 9, 340·85ft; and that of No. 5, 322·81: which may fairly be taken as the average total span of the whole nine. It will be seen that the three same spans in each girder have the same constant length. The span from the square abutment to the square pier is constant for the whole nine, and is 98·40ft.; the central span, from one square pier to the other, is also constant, being 82ft. in length; and the span from the skew pier to the skew abutment is the same for all, and is 101·90ft. in length. The variable quantity is the span between the square and the skew pier. The distance from centre to centre of the intermediate girders is 16 72ft.

Passing on to the girders situated in the angles of the bridge, we will commence with those under London-street. They are eleven in all, seven of which rest partly upon the skew abutment and partly upon the face girder, and have an average span of 64.23ft. The remaining four bear at one end upon the skew abutment and at the other on the skew pier, and are not continuous over it. They have, therefore, a constant span of 101·90ft. The distance from centre to centre of the nine intermediate girders is 18·14ft., being about 18in. more than that of the intermediate girders. The girders supporting Vienna-street are five in number, and supported partly by the square abutment and partly by the face girder. The span of the shortest is 21·95ft., and that of the longest 97·19ft. Of those under Constantinople-street the shortest has a span of 23·40ft., and the longest of 98·65ft. Those under St. Petersburg-street are also five in number, the first having a span of 7·20ft. and the last of 102·29ft. The girders under Vienna and Constantinople streets are 18·29ft. apart from centre to centre, and those under St. Petersburg-street are placed the same distance apart as the intermediate girders. The reason for these varying distances is probably the desire to divide the spans of the face girders into a number of bearing points equally distant from one another. The cross girders are arranged parallel to one another, but their respective spans are not constant. Those in the central part of the bridge placed between the intermediate girders have a span of 15·21ft., and those between the girders in the angles of 18·92ft. All the face girders are what are known as double lattice girders, and, in order to preserve an uniformity of appearance in the elevation, have the same depth, although their spans vary considerably. The intermediate and the girders under the side streets, with the exception of those under Vienna-street, are also of the double lattice form, but of a simpler description. The girders in the corners, in consequence of the limited dimensions of their spans, are single lattice girders. The girders resting upon the faced girder supporting Vienna-street are of the plate form, two of them being single or plate girders proper, and three of them being double, or what are known as box girders. The whole of the cross girders are plate girders.

One of the principal difficulties to be overcome in the construction of the present bridge arose from the streets being on different levels. It is a common enough observation that "facts are stubborn things." Well, levels are engineers' facts. They cannot be disregarded or got rid of. A diversion of a road or stream may frequently be accomplished in half a dozen different ways, but given a certain height to rise in a certain distance, and there is no choice but to adopt the only gradient that can be got. The rise in Vienna-street is 1 in 28, the whole rise of the street being obtained in the span of the face girder V, the roadway continuing horizontal over the central part of the bridge. This difference of level is provided for by constructing the girders resting upon the face girder with ends of unequal depth. The consequence of this difference of level in the streets is to cause the roadway to be suspended at about the centre, vertically, of the face girders, and to produce both an unpleasing and unscientific appearance. The distribution of a load either over the top or bottom of a girder appears, so to speak, natural; but the position given to it in the elevation has not only rather an unsightly appearance, but is the very worst position a load can occupy, since it is in close proximity to the neutral axis of the girder. The actual disadvantage resulting from so placing the load depends, in a great measure, upon the amount of vibration exercised by the moveable portion of it. In a bridge similar to that at the Place de l'Europe, where ordinary street traffic has only to be provided for, the concussive action of a moving load may be neglected, as it will be absorbed in the mass of the bridge, whose *vis inertia* would more than compensate for any slight shock occasioned by the passage of a very heavy weight. In railway bridges, unless of very large spans, these conditions are reversed, the moveable load preponderating over the fixed or static load. The author considers that the face girder supporting Vienna-street might have been placed on the incline of 1 in 28, and the central girders raised to the level of the present streets with considerable improvement in point of appearance. The roadway and its support would then appear in their proper relative positions, the centre of gravity of the whole structure, together with its load, would be lowered, and the rigidity of the bridge increased. The cost of raising some of the piers would be counterbalanced by the reduced height in the abutment, and, if otherwise, the additional expense would be very trifling. The end spans of Lambeth Bridge are upon an incline of 1 in 23·33, and, although it is by no means a handsome structure, yet it is doubtful whether the inclination of the shore ends has anything to do with its want of beauty. The masonry of the Paris bridge presents no features worthy of particular notice. The piers and abutments are faced with coursed ashlar, dressed and chamfered, and relieving arches are built in them between the solid pilasters, supporting the ends of the girders. The greatest pressure upon the square abutment is 1·86 tons per square foot upon one of the square piers, and upon the skew abutments 2 tons, and upon the other square pier and upon the skew pier 3·2 tons per square foot. The greatest pressure per square foot immediately under the bearing of any of the large face girders does not exceed 3 tons.

In a longitudinal section of a portion of the roadway, see Fig. 2, the cross girders are shown 6·56ft. apart from centre to centre, and between them are turned arches of hollow bricks, 9in. deep, and weighing 0·145 ton per foot run. The haunches of the arches are filled in with thin concrete, weighing 0·108 ton per foot run. Over the arches is spread a layer of asphaltum, rather more than ½in. in thickness, and weighing per same unit of length 0·018 ton. On the top of the asphaltum the metalling is laid; it is 1ft. in depth, and weighs 0·356 ton. Adding the weight of the cross girder itself, equal to 0·032 ton per foot run, we obtain for the total weight, supported by the cross girders per running foot, 0·66 ton, or nearly 13¼ cwt. This weight, however, is only constant for the cross girders situated in the angles of the streets, and in the end spans of the intermediate girders. Those in the centre of the bridge, owing to the greater depth of metalling, carry half as much again, and may be therefore said to have a load per running foot of exactly 1 ton. Making W to equal the total weight per running foot, and putting d for the distance of the cross girders apart, we find $\frac{W}{d} = 0·1006$ ton, the weight per square foot of the cross girders and roadway. Adding a proof load of 0·0366 ton, we obtain 0·1372 ton as the total load per square foot. The weight of the main girder is, of course, not included in the above calculations. In a similar manner, the maximum weight per square foot, occurring in the central part of the girder, will be found to be 0·1828 ton. The minimum load per superficial foot is therefore 2¾cwt., and the maximum a little under 3¾cwt. Of this total load, the portion 0·0366 ton represents the maximum live weight per square foot supposed to be brought upon the bridge, and is equal to 82lb. This is nearly the proportion adhered to in many of our own bridges. In apportioning the live load upon a bridge, the chief points to be regarded are its size and character. A smaller load per square foot may be assumed as the maximum for a large bridge than for a small one, as the effect of any violent and sudden transition of a live weight will be more severely felt in the latter instance than in the former. Again, the situation and character of the bridge determine whether the ordinary assumption of the weight of a dense crowd as a maximum load is tenable or not. An iron bridge, especially a lattice, offers peculiar facilities for being loaded to an amount considerably above what could possibly come upon a stone bridge having the same area. Imagine the bridge at La Place de l'Europe under the circumstances attending a public royal departure from the terminus of St. Lazare. It is not too much to assert that not only every inch of space available upon the roadway and footpaths would be occupied, but every part of the sides and top; every nook and corner into which a hand or foot could be inserted, would be taken advantage of for the purpose of sight-seeing. Any bridge situated in a locality similar to the one in question, is liable to be thus overloaded. The author has seen the chains of Lambeth Bridge covered with a live load, in addition to the platform.

The manner in which the final thrust of the hollow brick arches supporting the roadway is disposed of is very ingenious, see Fig. 2. It is manifest that although the arches rest upon the cross girders, yet the thrust of each half arch is resisted by that of its neighbour, acting in the opposite direction. This process of thrust and resistance is continued until we come to the last half arch, which has no fellow to take its thrust. This thrust is not taken by the abutment, as might be supposed, but the following method is employed. The last cross girder, upon which the arch rests, is tied by strong plate braces to the last cross girder but one, at the points of its bearing upon the main girders, thus transferring the thrust to these points. As an additional precaution, the last two arches are tied, the last by a diaphragm, and the last but one by a flat tie rod. This arrangement makes the iron and brickwork to form one complete frame, so that if we were to imagine the whole superstructure lifted bodily off its supports, it would still be self-containing. If the thrust of the last half arches were taken by the abutments, the effects of the expansion, by alteration of the temperature of the main girders, would be accumulated upon them, and the consequences might be serious. By the method adopted, the total expansion is subdivided at every cross girder, and the effect upon each arch is inappreciable.

The limits of a paper of this nature will not permit of a detailed investigation into the proportions and dimensions of a the various girders constituting the superstructure of the bridge, and, moreover, there would not be the slightest practical utility in attempting the task. A description of the details of the most prominent will amply suffice to give a clear idea of the manner in which the work is designed and executed, and to multiply examples on a smaller scale would be wasting both time and labour. It has been already mentioned that the girder V, under Vienna-street, has the same span as that under Constantinople-street, and since that under St. Petersburg-street has a smaller span than both, we shall select the first as a fair type of the three. It is shown in elevation in Fig. 3, and in section in Fig. 4. Its construction is peculiar, and consists of two single lattice girders, connected by a strong vertical diaphragm, but with a small space left between the respective flanges. The span being 137·29 ft., and the depth 16·40 ft., the proportion is very large, being $\frac{1}{8·37}$. It is clear that the girders under Vienna-street transmit half of their load to the abutment, and half to the main girder V, and that in consequence of the inequality of these loads, the main girder is very unequally loaded; the greatest weight being brought upon it at one extremity, and the least at the other. The girders are placed 18·30 ft. apart, and in order to find the total amount of the load brought upon the main girder we must first ascertain these weights separately. Taking the weight per square foot of the cross girders and roadway 0·1372 ton, and multiplying it by the distance, 18·30 ft., we have 2·52 tons as the weight per foot run of the girders V^2 to V^6, which is constant for all of them. To find the weight transmitted to the main girder by each of them, let P equal the constant weight of the foot run, and p the weight per foot run of each of the girders itself; making l to equal the span, and W the weight brought upon the face girder by any of those V^2 to V^6, we have $W = \frac{(P + p) \times l}{2}$. In the annexed table the weights, calculated by this formula, are given with the respective values of the letters:—

$$W = \frac{(P \times p) \times l}{2} \qquad P = 2{\cdot}51 \text{ tons.}$$

	p	l	W.
V^2	0·089	22·46	29.198
V^3	0·119	42·21	55·295
V^4	0·179	61·03	81·780
V^5	0·270	80·50	111·895
V^6	0·323	99·84	140·732

Adding together these separate weights, we find the total load transmitted to the main girder to be 419 tons. The girder itself weighs 82 tons, which will make the total weight it has to carry, in round numbers, 500 tons, which is equivalent to 3·65 tons per running foot uniformly distributed over it. From the unequal manner in which the load is brought upon the girder, it cannot be designed upon the usual hypothesis of an uniformly distributed load, and will, therefore, present two principal points of difference in comparison with girders designed on that assumption. One is that the reaction on the supports, and consequently the strain upon the ends of the girder and the lattice-bars, will not be equal at both extremities; the other, that the point of maximum strain on the flanges will not correspond with the centre of the span. It should be remarked here that the French engineers in their calculations have taken the clear span between bearings, and not the distance between the centres of bearings, as is sometimes done. The reactions upon the abutments can be easily found from the principle of the lever, upon which is based all the theory of horizontal girders. Let R and R^1 be the two reactions, taking R to represent the greater, or that upon the square pier, and R^1 the lesser, upon the abutment. If w^2, w^3, w^4, &c., be the weights calculated for the girders, V^2, V^3, V^4, &c., and d^2, d^3, d^4, &c., their distances from the abutment, L^1 the span of the girder, V and W^1 its total weight, we have

$$R = \left(\frac{w^2 \times d^2 + w^3 \times d^3 + w^4 \times d^4 + \ldots \&c.}{L^1}\right) + \frac{W^1}{2}$$

Similarly, $$R^1 = \left(\frac{w^2 (L^1 - d^2) + w^3 (L^1 - d^3) + \ldots \&c}{L^1}\right) + \frac{W^1}{2}$$

The value of R is thus found to equal 350 tons, and $R^1 = 150$ tons. It is evident that since the total weight supported by the girder is equal to $(R + R^1)$, when one of the reactions is known, there is no necessity for working out the equation.

The principle adopted by the French engineers in designing the girders is that of determining, firstly, a minimum section of flange which is constant throughout the whole span, and then of adding such additional plates at the centre and elsewhere as the amount of the strains may render necessary. The reverse is the usual method employed by us. We generally first ascertain the maximum sectional area required, and then drop the flange plates accordingly as the decrease in the strains towards the supports will allow. The former method is synthesis; the latter, analysis. The object to be gained in making each girder to consist of two separate girders is not by any means apparent, as all the diaphragms and stiffening in the world would never make the two act like one, and necessarily involves a much larger amount of bracing and extra material than what would be otherwise required. This will be evident on comparing the diaphragm in the sections with the light lattice bracing between the separate bars in the Charing Cross and Blackfriars railway bridges. The diaphragm is composed of a plate ½in. in thickness and is riveted all round to angle-irons 4¾in. × 4¾in. × ⅝in. To lighten the material a piece of the upper part of the plate is cut out; but although this occasions a slight saving in weight it causes none in the cost, as the metal cut out would have to be included in the estimate. The distance between the centres of the flanges of each separate girder is 4·92ft., and the breadth of each flange is 1·47ft. There is another peculiarity to be remarked in the manner in which the sections are built up. It is the introduction of the angle-irons at the outside edges of the flange plates, which almost seem as if they were placed there for the purpose of covering or protecting the edges. The compression bars are of channel iron, which is undoubtedly the best section that can be used when a large sectional area of strut is required, but it is not so well adapted for bars of a small section. For these, and, in fact for all ordinary purposes, there is no section which, for cheapness and facility of procuring, can compare with angle-iron. T-iron is also an excellent form of section for large compression bars, but when used on a small scale there is a loss incurred, in consequence of the necessity of riveting it on both sides of its rib. All the ties are of flat bar iron, riveted at the crossings to the back of the channel irons. Except at the diaphragms, which are placed about 13ft. apart, there is no connection between the webs of each separate girder composing the section. The points of intersection of the struts and ties are 6½ft. apart, and the greatest length of unbraced strut is a little over 7ft. The lightest section of channel iron used is 9·84in × 2·95in. × 0·47in. × 0·51in., or, as it might be called, 9⅞in. × 3in. × ½in., having a sectional area of little above 7 square inches. The section is therefore fully strong and stiff enough to dispense with any intermediate bracing for the above length. The minumum section of this girder is built up of four angle irons, two to each of the separate flanges, of 4·72in. × 4·72in. × 0·63in., or 4¾in. × 4¾in. × ⅝in. The author would have wished to give all the French measures of angle-irons and plates in their usual corresponding English dimensions, but was compelled to renounce the attempt, as the sectional areas calculated thereby would not tally. It would also have increased the labour very considerably, and involves a double calculation. The few tables available for converting French weights and measures into their corresponding English equivalents are little better than useless for scientific purposes. They serve in some instances as a check for one's calculations, but for nothing more. In addition to the four angle-irons there are two plates 17·71in. × 0·47in., and also the two angle-irons at the edges 4·33in. × 2·55in. × 0·51in. Of these last angle-irons (Fig. A) only the horizontal part is included in the calculation of the area. The two side plates are each 17·71in. × 0·59in. The total gross area is 6·372 square inches. At the point of greatest strain this area is increased by the addition of extra plates, all 72in. in thickness to 97½ square inches, the total thickness of flange being 2½in. The strain per square inch of gross sectional area upon the flange is 3·20 tons. The maximum strain per same unit of area, in any part of the bridge, is not greater than 3·82 tons, and the metal has been apportioned upon this datum. This is rather a low factor of safety, and perhaps accounts for the fact that there is no difference made in the sectional areas of the top and bottom flanges.

The ends of the girders are consructed of plates and angle-irons, and it will be sufficient to investigate the strain upon the heavier end, or that resting upon the square pier. The available material to resist the strain consists of one plate 11·21 ft. × 0·59 in., giving a section of 79½ square inches; of eight angle-irons 4¾ in. × 4¾ in. × ⅝ in., having a total section of 44¼ square inches, and of two vertical plates 2 ft. 4in. × 0.47in. The total end sectional area is therefore 147 square inches. The strain upon the heavy end of the girder has been already ascertained to be 350 tons, and we therefore find the metal to be strained to only the amount of 2·31 tons per unit of area. Although the strain is very small, yet it must not be supposed that there is a corresponding loss of material, for the ends of girders, particularly of lattice girders, require to be made extra strong. The principal object to be kept in view in designing the end of a lattice girder is, that all the strains brought by the bars upon the end pillars should be conducted to a rigid bearing, and should not have to draw for support upon any of the neighbouring bars. Each of these has its own work to do, and should not be loaded in addition with strains belonging to another part of the structure. There is no doubt that solid end plates offer the easiest method of accomplishing this result, but at the same time it is the most uneconomical. There is no more necessity for a lattice girder to have solid ends than for a plate or box girder to have open ones. In consequence of the unequal distribution of the load, and the point of maximum strain not occurring at the centre of the span, but at the point Y (see Fig. 3) it is here that the load may be supposed to divide, and be ultimately transferred to the supports, in the proportions previously described. The angle of inclination of the lattice bars to the horizon is 44 deg. 6 min. 3 sec., or nearly 1 to 1. The ratio of the strains upon the bars to the vertical strains is therefore as 1.44 to 1. The tie-bars, starting from the point of greatest strain, and proceeding towards the abutment from 1 to 7, are each 9·84 in. × 0·63 in., and since the girder is a double lattice, they are consequently in pairs, and the total sectional area of the pair is 12·38 square inches. The remaining ties completing the web on the same end are all of the same breadth, but the thickness is increased to 0·78 in. The total sectional area of the pair is therefore 15·36 square inches. Proceeding now from the same point towards the pier, all the ties, with the exception of the two nearest to the point of maximum strain, have the thickness of the bars increased to 1·10 in. The sectional area of the pair is therefore equal to 21·65 square inches. The two exceptions are of the same scantlings as the lightest section used at the other part of the web. The channel-iron struts have the same breadth as the bars, and vary in section in proportion with the ties they cross.

They are considered to be also strained to the same amount respectively, but as the nature of the strain is different, their sectional area is proportioned so as to be one-sixth stronger than that of the corresponding intersecting ties. The heaviest section of $\sqcup$ used in this girder is 9·84in. × 3·46in. × 0·98in × 0·51in., giving a sectional area of more than 12 square inches. The general formula for the strain upon a pair of end bars is $S = \frac{W}{2 \times N \times \text{sine } \theta}$ where W is the total load distributed, θ the angle between the bars and the horizon, and N the number of systems or series of triangulations in the web. As, however, the load in this instance is not uniformly distributed, and therefore not transferred in equal portions to the supports, we must substitute for $\frac{W}{2}$ its two values of R and R^1 already found. Following the same order with the strains as in describing the bars, and bearing in mind that the reciprocal of sine θ is 1·44, we shall find the strain upon the last pair of bars over the abutment to be 54 tons. Dividing this strain by the sectional area of the bars, it will be seen that they are strained a little less than the stipulated maximum amount, since we shall have about 3½ tons per square inch, instead of 3·82 tons. To find the strain upon the bars upon the other end, we must consider the position of the girder V^6, which is placed at about the distance of 1ft. from the pier. The weight brought upon the main girder at this point produces no effect upon the lattice bars, and, in fact, scarcely any at all upon that end of the girder, as the strain is practically taken by the pier. Referring to the table of weights, we find this load to be 140 tons, and it must be deducted from 350 tons, the value found for R^1, before that quantity be used in the formula for the end strain. Effecting this substitution, and solving the equation, we shall find the strain upon the pair of end bars to be 75 tons, and dividing as before by the area, the strain per square inch comes out the same as before, viz., 3½ tons. The bars in the web of this girder appear to be proportioned scarcely in so scientific a manner as one would expect, nor is that due attention to the varying amount of the strains in every bar sufficiently shown. For instance, there is no change made in the sectional area of the eight bars, starting from the point of greatest deflection and proceeding in the direction of the abutment. Again, when the section is increased, the remaining bars, six in number, are all of the same section. The principal point to be noticed is the excessive discrepancy between the two bars where the increase takes place. Thus, bar 7 has a sectional area of 12¼in., and bar 8 of 15¼ square inches, a jump of 3in. in area being made all at once. The discrepancy at the other end of the girder is still greater, the difference in sectional area of the double bar 1 and 2 being over 9 square inches. It would not be judicious to make the sectional area of the web of a lattice girder vary too closely with the strains, especially in a railway bridge, or whenever the rolling load is large compared with the dead weight, but it should be borne in mind that the web of a lattice girder constitutes its chief economy. If it is not designed in a correct and scientific manner, it would be better to put a plate girder instead, and there are undoubtedly numerous examples of lattice girders which would have cost more than what plate ones would have done in the same positions. The cause of the jumps in the section of the bars is mainly owing to the very unequal distribution of the weight, and we will consider the respective strains upon the bars of equal section. The minimum strain upon the first eight bars mentioned is about 3 tons, and the maximum 32 tons. Similarly, the minimum strain upon the last six bars towards the pier is 30 tons, and the maximum 75 tons. There is clearly a great loss of material in constructing these bars of equal sectional area. As the rolling load in this bridge is little or nothing, there is no necessity for making the bars at the centre stronger than what is required for a dead load.

(To be concluded in our next.)

MOSAICS: SOUTH KENSINGTON MUSEUM.

"Mosaic," said Ghirlandajo, "is the only painting for eternity." Some two thousand years ago it was practiced by Greeks and Romans, and now its revival is attempted by the Department of Science and Art at South Kensington. Processes which centuries ago were firmly established, revert once more to experiment, and an art all but lost has again to go through the successive stages of discovery. The mosaic pictures, eight in number, put up at Kensington, have received, for the most part, eulogy; and the experiment is so important and novel, that a critical description of the technical processes and the arts of design called into play may prove instructive. First as to process or material. The ancient methods are at Kensington revived with a difference. Early mosaics, the Roman for example, were composed chiefly of cubes of coloured stones or marbles. Our modern mosaics differ from the old in that they rely in no degree on natural substances. The cubes or tesseræ at Kensington are entirely artificial, yet in chemical composition and art aspect they are not identical. The terms used to designate the varied material are "glass," "enamel," and "ceramic," otherwise "earthenware." Dr. Salviati, whose name has been identified with the revived manufacture of Venetian mosaics, has (from cartoons) executed in the South Court, Kensington, the figures of Nicolo Pisano, Benozzo Gozzoli, Apelles and Giorgione, in materials termed "glass," and "enamel." An examination of the Salviati tesseræ, now before us, shows accordingly two distinct materials, a semi-transparent glass, used as the basis of gold, and an enamel as opaque as sealing wax. It would put the matter on a true scientific basis were a careful analysis made of these tesseræ. Will Salviati, Minton, Maw, or Powell do this for their several manufacturers? Glass and enamel, however, have this quality in common, that the surface glistens and gives off light, a quality which in turn has been deemed a merit and a defect. And here is the point upon which manufacturers diverge at the present moment. Certainly a polished surface gives greater brilliancy, and the picture when viewed at the right angle is seen at a further distance; for the same reason it remains visible in a low light approaching darkness. On the other hand, there are abundant disadvantages to which a dead or mat surface is not subject; such a surface is seen in the figure of Cimabue, wrought, both in figure and background, by Messrs. Minton, not in glass but earthenware. Certainly the picture is less obtrusive; it can be seen without dazzle at varied angles, and so far it approaches fresco. There is another figure, that of Hogarth, which makes a compromise between the two processes; the gold background is glazed, while the figure in material ceramic or earthenware is dead or mat. This discrepancy or contrast has been specially designed by Messrs. Simpson to give decorative brilliancy to the background, and at the same time to save the figure from distracting glare of surface. The experiment is believed to be novel in the history of mosaic art. Such improvements, indeed, as Constantine and his successors made in mosaics were all on the side of greater brilliancy; and specially is it recorded by Theophilus that the Byzantians discovered a cunning process of introducing a ground of gold under a surface of glass, whereby was shed over large mosaic works a splendour before unknown. This ingenious method, still to be observed in the mosaic pictures on the façade of St. Mark's, has obtained from Mr. Ruskin warm encomiums. And the delicate mediæval process is certainly skilfully imitated by Salviati. When the modern gold glazed tesseræ are placed side by side with cubes from the façade of Orvieto Cathedral, no material difference can be detected between them. An unbroken gold background is all but an untried decorative condition in this country. But the middle ages afford a number of precedents which may serve as guidance, such as the interior of St. Mark's, of Santa Sophia, and the ceiling in a stanza of the Vatican, painted by Raphael, in imitation of mosaics. In modern times, too, the Byzantine church of All Saints, Munich, shows a background blazing in brightest gold. For the direction of our own artists, it may be useful to recapitulate the conditions essential to the right use of gold backgrounds. Such backgrounds are obviously non-natural, conventional, and decorative; the colour of the gold is intense, and requires corresponding lustre in the surrounding ornament. Such treatment necessarily implies architectonic and monumental styles. And these considerations enjoin simplicity of composition, severity in line, breadth and firmness in modelling, and decision in relief of the figure from the plane of the background. Such canons, enforced by the earliest and best examples, place mosaics in an intermediate position between bas-reliefs and paintings; and it is evident that the compositions at Kensington have been chastened and restricted accordingly. Indeed, even that degree of pictorial treatment usual to bas-reliefs subsequent to Ghiberti, seems to have been deemed inadmissable. It is true that the later mosaics on the front of St. Mark's, allied to the school of Titian and Tintoret, are flowing and free; and it is said that in the Pope's manufactory in Rome, enamels of 10,000 different colours are used, so as to make the mosaics for St. Peter's *fac-simile* copies of the works of Raphael and the florid painters of the late Italian school. But such treatment, though not unpleasing to the popular eye, has been deemed out of keeping with architectural compositions. This judgment prevails at Kensington, so that only in some small accessory details is pictorial treatment seen in the cartoons, and the completed mosaics are in liberty further restricted, so that distance and perspective have been wholly excluded. In short, the treatment approaches that of the strict Greek bas-relief; in other words, the figure and action are limited to the one plane of the foreground. This is at all events safe; the practice is at least sanctioned by the best precedent; yet, in the words of Sir Charles Eastlake, the unflinching application of these strict principles to all mural decoration were an "extreme doctrine." Doubtless it may be possible to discover a just mean between opposite extremes. The cost of the Kensington mosaics has been stated at £25 for each cartoon, and £100 to £150 more for the finished work. It were interesting to ascertain what relation this cost, calculated at the square foot, bears to that of stained glass, fresco, distemper painting, and other modes of mural decoration.—*Journal of the Society of Arts.*

KRUPP'S STEEL WORKS, ESSEN, RHENISH PRUSSIA.

These works rank among the largest in the world, and are certainly the most extensive by far of any works devoted entirely to the production of cast steel and objects manufactured therefrom. They have gradually grown from a small factory, employing some 40 hands, and devoted then principally to making what are termed lace rolls, a speciality requiring rolls of extreme fineness of surface, as they are used for rolling out the gold wire for making bullion lace. The works have since then grown to an immense extent, and articles of a much greater variety are now produced, among which are specially tyres, axles, springs, plates, guns, shafts for steamships, rails, rolls, &c. They employ at the present time about 10,000 men, and occupy in workshops and melting-houses, &c., nearly 500 acres of ground, of which over 50 acres are under roof. The dimensions of the "centre shop" are 250 feet long, 72 feet broad, and 90 feet high. This shop is furnished with a crane capable of lifting 80 tons. There are about 20 miles of railway, on which four locomotives and 150 wagons are in daily use, bringing in the raw material and carrying away the finished products. In 1865, in the steel works alone, and exclusive of the blast furnaces and coal mines, there were employed 8,200 men. There were in operation in the same year 400 smelting, heating, and puddling furnaces. 160 steam engines, varying from four to 1,000 horse-power, in the aggregate 5,863 horse-power; 42 steam hammers from one to 50 tons weight, 110 smithies, and over 586 turning and other machines. There is in course of erection a 125-ton steam hammer; depth of foundation 90 feet; weight of bed-plate, 500 tons in one casting; its estimated cost, with appurtenances, is £175,000. The consumption of coal in 1865 was over 1,000 tons, water 200,000 cubic feet; and gas (8,000 burners), 280,000 cubic feet. The products are sent to all parts of the world, and, last year, exceeded 50,000 tons. The special work now going on at Essen is tyres and axles for railway use; and there is hardly a line in the whole world where these tyres are not running and their great durability and consequent economy experienced. This has been evidenced recently by a set of five feet tyres running on the Great North of Scotland Railway, under a 28-ton engine, over 109,000 miles, without being tooled since they came from the makers' shops. This is considerably more than the whole life of best iron tyres. These steel tyres are made without a weld, and by a method which insures that the steel is thoroughly well worked under the hammers. The wheels of the class exhibited at Dublin were cast in one piece, and are becoming very extensively used under wagons. These works have also turned out some very large ship's intermediate and cranked shafts for sea-going steamers, which are exclusively used by the steamers leaving Bremen and Hamburg for America, the Austrian Lloyds, and other continental companies, while they are also fitted in the City of Dublin steamers, *Connaught*, *Leinster*, and *Munster*, running between Dublin and Holyhead, and also in some of the Royal Mail Steam Company's vessels.

The gun department at Essen is very extensive, and embraces nearly a fourth of the establishment. The guns are made of all sizes, for field, naval, and heavy battery purposes; both muzzle and breech loaders. Two of the latter were shown in the machinery department of the Dublin Exhibition last year, one a nine-pounder field gun and the other a 110-pounder ships' gun. The field gun was rifled upon the French system, and the 110-pounder upon the Armstrong multigroove principle. The breech of these guns was closed by a system that was first submitted to the Ordnance Select Committee in May, 1860, and may be briefly described as follows:—The bore of the gun runs through the whole of the piece, and through the breech end; and at right angles to the bore is cut a slot, slightly tapered, and into this is fitted a wedge or valve, which is used for closing the breech when firing the gun. One of the chief difficulties to overcome in breech-loading guns is to prevent the escape of gas at the breech upon the discharge, and this was overcome by Mr. Krupp in two ways—first by means of a cup of steel, or copper, or even cardboard, that was inserted into the bore of the guns after the charge, or was attached to the end of the powder-bag. This cup, when the explosion took place, was expanded by the pressure, and completely filled out the bore of the gun, upon the same principle as the steam packing rings in pistons. This, however, involved the withdrawal of the cup each time the gun was charged, and therefore a second plan was proposed. In the face of the valve was turned a circular recess, corresponding exactly with the bore of the gun, and into this recess was fitted an angle ring, one face of which, when the valve was in its place, was in contact with the breech and the other face in contact with the side of the circular recess; so that when the gun was discharged, the gas entered the circular recess, and forced the two faces of the angle ring tight up against the breech and the side of the recess, and completely prevented the gas from escaping. The valve is kept in its place by a locking apparatus. This system has been very severely tested at Woolwich with perfect success, and has also been submitted to and adopted by continental governments, more particularly Russia. Guns up to 15 inch diameter of bore are made at Essen in very large quantities, but it would occupy too much space to enter into all the details of the experiments that have been carried on. Sir William Armstrong and Company are now lining a great many guns with tubes made by Mr. Krupp. The Prussians generally attribute to those guns their signal successes over the Austrians in the late war, particularly in the decisive battle of Sadowa. The ponderous masses that have to be handled at Essen have rendered it necessary that the dimensions of the tools should be proportionately increased, and, indeed, this has now become essential, from the large ingots that are being daily cast. A short time since an ingot of 45 tons weight was cast, to form the material portion of a 15-inch gun; and to properly forge this even the 50-ton hammer is considered too small, as it entails much longer time, and causes the ingot to be too often heated for profitable working. There is but little doubt that the steel-makers of this country are greatly indebted to Mr. Krupp for the energy he has devoted to the manufacture of steel, and its application to the variety of purposes. Steel is now entirely superseding the use of wrought iron in those parts of machinery where great toughness, elasticity, and durability of wear is required. There is hardly a locomotive used which is not running on steel tyres, and the introduction of steel rails is becoming daily of more consequence. The steel produced at Essen is all melted in plumbago crucibles, and formed into the ordinary ingot moulds. this process employing a large number of men. For the large ingots of 30 and 40 tons and upwards, from 1,000 to 1,300 men are employed at one time, occupying in the casting from eight to twelve minutes. The whole of the work, of whatever shape, that is turned out at Essen is made from these ingots, which are heated and forged until the desired density and form is attained.

THE RAILWAY SYSTEM OF GERMANY.*

By Robert Crawford.

(*Concluded from page 339.*)

Passing on to the next point for consideration, that of earthworks, it appears to be a general, although not a universal, plan, in the case of all main lines, to prepare the earthworks and masonry for a double way from the first, but not to lay the second line of rails, until the success of the undertaking makes itself apparent, and the requirements of the traffic demand the additional way. Some of the heaviest earthworks executed have been:—An embankment on the Southern State Railway of Bavaria, from Augsburg to Lindau, its greatest height being 172 feet, width at formation 33½ feet, and length 1,675 feet, requiring upwards of 2,900,000 cubic yards of material to make it up. On the same line also occur embankments of great importance, two of which are respectively 84 feet and 72 feet high. On the railway from Augsburg to Ulm, there is a cutting 2,390 feet long and reaching to a depth of 90 feet; also an embankment 53 feet high, and 5,755 feet in length. Between Elberfield and Dortmund occurs an excavation 86 feet deep, and upwards of 1¼ mile long; and on the same line there is an embankment 120 feet in height, with a length of 1,600 feet. Embankments from 75 feet to 130 feet high are to be found on the Westphalian railways. On the Bavarian State line, from Bamberg to Aschaffenburg, there is an embankment 100 feet in height at the highest point, and 1,743 feet long; besides two cuttings measuring in depth, the one 84 feet, and the other 71 feet, their respective lengths being 3,254 feet and 2,297 feet.

With regard to tunnels, the first executed in Germany was one 1,678 feet long, on the Leipzig and Dresden Railway. Besides the summit tunnel, 4,695 feet in length, on the Semmering Railway, already mentioned, there are many others worthy of notice, among which some of the most important are:—

A Tunnel 5,359 feet long at Konigsdorf between Cologne and the Belgian frontier.
„ 4,419 „ „ Heiligenberg between Ludwigshafen and Bexbach.
„ 3,600 „ on the Saarbruck, Trier and Luxemberg Railway.
„ 3,235 „ „ Railway from Gerstungen to Carlshafen.

and a tunnel 3,037 feet long through the Schwarzkopf between Bamberg and Aschaffenburg.

This brings the subject to one of the most interesting of its sub-divisions, that of viaducts and bridges, which it is proposed to treat under two separate headings,—First, Bridges composed altogether of masonry, and, secondly, Iron Bridges. There are instances of large timber bridges such as those over the branches of the Danube, at Vienna, on the "Emperor Ferdinand's Northern Railway," and that over the Elbe, at Magdeburg, whose superstructure only is of wood; but as these are cases of works executed in past years, and it being now laid down as a maxim by German Engineers, that timber is not to be used in railway bridges, it becomes unnecessary to devote space to the consideration of such works. To explain more fully these somewhat anticipatory remarks, it may be well to introduce here, the views of the Associated Railway Directors on bridge building, as expressed in their code of rules. These are—I. For bridges, arches of stone, or good bricks, are preferable to every other description of structure, except in cases which require very oblique bridges. II. Timber bridges are inadmissible. III. When iron bridges are made use of, the portion of the superstructure which sustains the roadway shall consist of either wrought, or rolled iron. Thus cast-iron bridges, as well as timber ones, are removed from the field of investigation. The former by negation, and the latter by direct condemnation.

Germany abounds in fine examples of stone viaducts and bridges of imposing dimensions and extent. It will be sufficient to adduce a few instances in addition to those already casually noticed, as occurring on the Semmering Railway. At the head of these stands the viaduct over the Goeltzsch Valley, on the railway from Leipzig to Hof. It consists of one central span of 93 feet, twenty-three spans of 46 feet in the clear, four spans of 39 feet, and two spans of 21 feet, one on each side of the large span through what may be called the abutment piers. Its greatest height is 255 feet, and extreme length 1,882 feet. The 93 feet opening has two arches one above the other, and on either side of it rise four rows of arches decreasing to one row at the ends. These additional arches are for the purpose of strengthening and supporting the piers, which carry the upper or main arches. All those in the upper tier are semicircular in form, as is also the lower arch of the central span, while the others are segmental.

There is also another fine viaduct over the Elser Valley, on the same railway. It is formed of six semicircular arches of 93 feet span in the clear, three openings of 20 feet, and one of 15 feet. Two of the lesser openings have four tiers of arches in height, and occur on both sides of the arch which spans the deepest part of the valley. Two of the 93 feet widths are strengthened by a lower row of semicircular arches, and two others by means of connecting walls. This viaduct is, at its greatest height, 223 feet above the stream, and is 914 feet long.

The Neisse Viaduct on the branch railway from Kohlfurth to Görlitz, in Prussia, consists of one row of semicircular arches, thirty in number, of which three spans have a clear width of 73 feet 1 inch, three of 61 feet 9 inches, five of 41 feet 2 inches, and eighteen of 30 feet 10⅜ inches. Its greatest height is 123 feet above low water, and its length, inclusive of abutments, 1,550 feet. This viaduct carries a double line of railway, and occupied about three years and a half in its construction, having been begun during the spring of 1844, and finished in the autumn of 1847. The masonry composing it amounted to 1,173,200 cubic feet.

The result of a series of experiments, for the purpose of ascertaining the best description of concrete to be placed round the foundations of the river piers, gave the proportions most suitable for yielding a quick setting, hard concrete, at

22 per cent. of cement
22 „ „ of sand
56 „ „ of small broken stone (2 inches diameter)
———
100

A stone bridge over the Elbe, on the Junction Railway, at Dresden, is well worthy of notice. It consists of twelve basket-handle arches of 93 feet span each. The width of the roadway is 50 feet, one half of which is applied to the purposes of an ordinary road, and the other half to those of the railway. Its height is 37 feet above the river at summer level. One approach to this bridge is formed by a viaduct of forty-four arches of lesser span.

A bridge over the Roeder, on the railway from Dresden to Görlitz, consists of one arch 148 feet 8 inches wide.

As a sample of an ordinary river bridge of handsome, although not very extensive, proportions, may be mentioned that over the Neckar, on the railway from Frankfort-on-Maine to Heidelberg. It is divided into seven equal spans of 88 feet 7 inches each, and carries a double line of permanent way at about 35 feet above the ordinary water level. Its building occupied from 1844 to 1848. The form of the arch is segmental, with a versed sine equal to one-eighth of the span. The thickness of the piers at the springing is 10 feet 4 inches, or between one-eighth and one-ninth of the span. That of the abutments is 39 feet 4 inches. The width of the bridge between the outside faces of the masonry is 31 feet 6 inches, and the depth of the key-stone is 3 feet 11¼ inches (1·2 metre). Comparing this latter quantity with the results to be derived from the different rules of eminent French authorities on bridge building, it appears that the depth of the key in the case of the Neckar bridge is somewhat over the minimum thickness required, both by Desjardin's formula and by that of Gauthey. On the other hand, it is so out of proportion with the huge thickness obtained from the method of Perronet, as to prove the total unfitness of this system for calculating cases similar to the one in question. Thus—

By Desjardin's formula for an arc of a circle $= 40°$,

$$E = 0{\cdot}02\,r + 0{\cdot}30 \text{ metre},$$

where E = the thickness of the key, and r = the radius of curvature of the intrados in metres, which in the present instance is approximately 42 metres. Supplying this value, the expression becomes

$$E = 0{\cdot}02 \times 42 + 0{\cdot}30 \text{ metre} = 1{\cdot}14 \text{ metre}.$$

By Gauthey's rule for spans of 16—32 metres

$$D = \frac{1}{24} S$$

* Read before the Institution of Civil Engineers.

where D = the depth of the key, and S the span in metres, and S being 27 metres,

$$D = \frac{27}{24} = 1 \cdot 125 \text{ metre};$$

whereas in testing the matter by the method of Perronet it stands

$$E = \frac{1}{24} D + 0 \cdot 325 \text{ metre} - \frac{1}{144} D,$$

in which E = the depth of the key, D = the span, in the case of semicircular arches, but in segmental or elliptical ones, D = double the radius of the intrados at the crown. Reducing this equation to a simpler form, it becomes

$$E = \frac{5}{144} D + 0 \cdot 325 \text{ metre}$$

and supplying for D its value, 84 metres,

$$E = \frac{5}{144} \times 84 + 0 \cdot 325 \text{ metre} = 3 \cdot 241 \text{ metres}$$

or nearly three times as great as the thickness required by Gauthey's rule.

By comparing the practical example with the three calculated results, the following is obtained:—

		metre.
The Neckar bridge, as actually built, has a depth of key	=	1 200
Ditto, according to Desjardin's formula, requires ditto	=	1·140
Ditto, ditto, Gauthey's ditto, ditto	=	1·125
Ditto, ditto, Perronet's ditto, ditto	=	3·241

In the case of wrought-iron bridges the arrangement most usually adopted, when the spans are wide, is that of a lattice construction, in some one of its various modifications.

One of the earliest examples of importance is that of the bridge over the river Kinzig, at Offenburg, on the Baden State Railway. It is built for a double line of railway, with two projecting foot-paths on the outside, and consists of three main girders, one on each side, and one in the centre between the ways. There is but one span, its width being 206 feet 8 inches in the clear. The depth of the girders is 20 feet 7 inches, and they rest 13 feet 3 inches on each abutment. The top and bottom cross sectional areas of all three girders are the same, consisting of three thicknesses of iron laid one over the other, and forming together a plate $1\frac{7}{16}$ inch thick and 13 inches wide; in addition to which there are four angle irons $4\frac{3}{4}$ inches by $4\frac{3}{4}$ inches by $\frac{17}{32}$ inch to $\frac{21}{32}$ inch thick, and one vertical bar, $5\frac{9}{10}$ inches by $\frac{19}{32}$ inch, on the outside, running along the centre of the horizontal plates which form the top and bottom portions of the girder, to which it is attached by two of the angle irons, the other two serving to join the flanges to the bars which form the central web. This latter is composed of lattice-work, which in the case of the two outside girders, is formed with two sets of bars, $4\frac{1}{6}$ inches by $\frac{13}{16}$ inch, crossing each other at right angles, and inclined to the top and bottom at an angle of 45°, the distances of the crossings apart being 1 foot $5\frac{11}{16}$ inches between the centres of the rivets measured along the bars. The central rib of the middle girder, between the ways, is stronger than that of the outside ones, inasmuch as it consists of three sets of bars, two of which are $\frac{5}{8}$ inch thick and $1\frac{5}{16}$ inch, all having the same width as the other lattice bars. Along the whole length of each central rib there are two horizontal rows, formed of double rails of the bridge pattern, one on the inside and the other on the outside, and riveted to the lattice work. These rows occur at distances of 3 feet $11\frac{1}{4}$ inches and 7 feet $2\frac{1}{2}$ inches respectively below the top and above the bottom of the girders. The roadway inside and the projecting foot-paths are supported by transverse trusses, at intervals of 6 feet 3 inches apart, formed of ordinary flat-based rails, and the entire bridge is connected above and below by a system of cross and diagonal braces. The clear width between the outside and the central girders is 12 feet 8 inches. The abutments are surmounted by handsome ashlar portals in red sandstone. The weight of cast-iron in the bed plates is 23 tons, and of wrought-iron about 322 tons, distributed thus:—

Weight of central girder . .	= about	92	Tons.
Ditto, two side girders (together) . .	„	148	„
Ditto, cross girders and lower braces .	„	55	„
Ditto, upper connecting bars . .	„	20	„
Ditto, handrail for footpaths . . .	„	7	„
Total wrought iron in bridge .	„	322	Tons.

From this short description it appears, that the arrangement of the material is not a judicious one, considering the nature of the strains arising from the weight of the bridge itself and any superimposed load, since,—I. the dimensions of the iron-work are uniform throughout the length of the span.—II. Although a stronger lattice construction is adopted in the case of the central girder, still its top and bottom sections are of similar dimensions to the outside ones; and III. the cross sectional area of the iron has not been properly proportioned to its different powers to resist compression and extension, where these forces act.

Passing on from the consideration of the first of these undertakings on an extensive scale, the largest work of the kind yet executed in Germany naturally presents itself. This is the bridge on the Eastern Railway of Prussia, over the river Vistula, at Dirschau, consisting of six spans, each 397 feet $5\frac{3}{4}$ inches in the clear. The depth of the girders is 38 feet $9\frac{1}{3}$ inches, and the height of their underside, above the ordinary water level, is 34 feet.

The arrangement is for a single line of railway, but the width is 20 feet $7\frac{1}{2}$ inches in the clear, and the rails are laid along the centre, so that sufficient space is left on each side for ordinary traffic, to which the bridge is open except on the approach of trains. In addition to this, pathways for foot-passengers are suspended on cantilevers on both sides. The iron work of each two spans is distinct in itself, being fixed on the pier at its centre, and moving on rollers at both ends. The system on which the iron work is constructed is that of two girders, one on either side of the roadway, held together above and below by a series of diagonal and transverse braces, in both the vertical and the horizontal planes. The girder top consists of four horizontal tiers of boiler-plate 2 feet $6\frac{9}{10}$ inches wide, placed one above the other, at distances of 2 feet apart, and made fast to a central vertical web, by means of angle irons; and similar angle irons are rivetted below each of these horizontal plates along their outside edges. The bottom section consists of an ordinary boiler-plate girder 4 feet $1\frac{4}{10}$ inch deep, with two flanges 4 feet 6 inches wide; the bottom of which has two thicknesses of plates and angle irons along the outside edges, while the top consists of a single plate. The solid top and bottom sections of the girders are connected by means of a lattice frame, consisting of two rows of bars inclined at 45° to the horizontal, and crossing each other at right angles, at distances of 1 foot $6\frac{1}{3}$ inches between the rivets, measured along the bars. This is again strengthened by double angle irons $5\frac{1}{2}$ inches by $4\frac{1}{2}$ inches, and $1\frac{1}{2}$ inch by $\frac{1}{2}$ inch thick respectively, arranged vertically, one inside and the other outside, and rivetted to the lattice at horizontal distances of 6 feet $2\frac{1}{8}$ inches apart. At these points also are attached the cross-girders of lattice construction, which support the roadway at a height of 6 feet $2\frac{1}{5}$ inches above the underside of bridge. The thickness of the boiler plates in the top and bottom sections is about $\frac{1}{2}$ inch at the centre of the span. The lattice bars vary from a width of $4\frac{1}{8}$ inches at the centre to $5\frac{1}{8}$ inches at the sides, and $\frac{1}{2}$ inch thick at the centre of the span, increasing to $\frac{7}{8}$ inch at the moveable end, which rests on rollers, and to 1 inch on the piers where the girders are fixed. Over all bearings the vertical angle irons are only half the normal distance apart, and the ends of the girders are further stiffened by solid plates. At the bearings furnished with rollers —that is to say, both abutments and piers Nos. 2 and 4—the breadth and depth of the top and the bottom sections of the girders remain the same as at the centre of openings; whereas in the case of piers Nos. 1, 3, and 5, where the bearings rest immovably, the top is increased to 4 feet 4 inches in width, and all its horizontal plates are laid in double thicknesses of iron, while the bottom section, although retaining its regular width, is strengthened by doubling its depth by means of two corbels attached to the lower flange, the furthest of which projects about 40 feet from the face of the masonry and the other 8 feet 6 inches. The whole of the material in the superstructure was carefully proportioned to the nature of the strains to which it would be exposed. The foundations for the piers were prepared by driving a number of bearing piles into the sand, at the rate of one to every $18\frac{1}{3}$ square feet. The whole space was enclosed by a row of sheet-piling timbers 12 inches square, driven close together and reaching to a height of upwards of 10 feet above the tops of the bearing-piles. The area thus formed, being filled up level with the tops of the surrounding piles with concrete, furnished a bed of 10 feet in thickness on which the masonry rests. The foundations of the abutments were treated somewhat similarly to those of the piers, but they are not so deep.

The projections of the piers both up and down stream present sharp vertical arrises, or nearly so, from the water edge to the underside of the roadway. The facework masonry consists principally of basalt, with a small proportion of granite ashlar up to above ordinary water level. Above this hard sandstone is used, but only in the body of the piers. In the cutwaters the basalt masonry is continued for their full height. The blocks immediately under the ends of the girders are also of basalt. The backing and filling-in is formed of hard burned bricks, and partly with ashlar, where greater strength is required, the whole being laid in hydraulic mortar. The piers are 32 feet 11 inches wide at the underside of the girders, and 82 feet long in the direction of the stream. On each of the piers rise two circular towers, one on either side of the roadway, whose battlements reach to nearly 43 feet above the top of the girders. The abutments are surmounted by massive rectangular towers and a handsome connecting portal. The towers are all built with yellowish-white bricks, ornamented glazed ones, of a purple colour, being used in some of the mouldings. The copings and principal dressings are of gray sandstone.

The general effect produced by this bridge, when seen from a distance, is very fine. The great depth of the girders reduced to some extent, however, the impression which would otherwise arise from the magnitude of the spans, apparently diminishing them to much within their real limits.

There is one point in which the Author thinks the ornamenting of this beautiful bridge is deficient. That is the crowded state of the relief over the pointed arch of the Dirschau portal, in which the field is far too small for the subject, and the upper moulding is brought down so close to the head of the principal figure, as to give the appearance of the design having been originally intended for a totally different position to the one it now occupies.

About 10 miles nearer to Königsburg than Dirschau, and also on the Eastern Railway of Prussia, occurs the Marienburg Bridge, over the Nogat, which is in reality another arm of the river Vistula. The bridge consists of two spans of 321 feet $3\frac{1}{2}$ inches each, and two segmental arches in masonry of 53 feet $6\frac{1}{2}$ inches in width, one at either end of the bridge. The roadway is for a single way, with a footpath on both sides, and is arranged for ordinary traffic similarly to the Dirschau Bridge. The distribution of the iron in the superstructure is, however, altogether different. The Nogat Bridge may be described as a compound, the whole forming one girder, or tube, about 25 feet in depth, of which the top and bottom are composed of ordinary boiler plates, and the sides of lattice-work, similar in principle to that already described. The cross girders which support the rails are of lattice-work $24\frac{3}{4}$ inches in depth, and are placed at distances of 6 feet $2\frac{1}{2}$ inches apart. At these same intervals, attached to the upper portion of the vertical L irons, within 6 inches of the top plates, are transverse bars, something in form like the letter Z, stretching from the lattice on one side of the roadway to that on the other. These ribs, as well as the keelsons below, are more securely made fast to the vertical rods by gusset pieces, which tend to stiffen the bridge laterally. In the space, 6 inches thus left between the cross ties and the covering plates, six iron bars, also Z shaped, run longitudinally for the whole length of the girder, giving the top the appearance of a cellular form of construction in cross section.

As regards the nature of the foundations and the character of the masonry, they are similar to those at Dirschau. The towers on the central pier are, however, rectangular in form, instead of round as in the latter case.

Both bridges have arrangements for mounting cannon, and other military precautions, at their ends.

The next example selected is that of the bridge over the Rhine at Cologne. It consists of four river spans each $322\frac{3}{16}$ feet in the clear, and two equal land openings of 64 feet $10\frac{3}{4}$ inches in width over the wharf and street on the left bank of the river. Two distinct bridges, one 24 feet $8\frac{1}{2}$ inches in the clear, carrying a double line of railway, and the other, 27 feet $9\frac{1}{2}$ inches inside width, for the purposes of ordinary traffic, are placed parallel to each other, and close together on the same piers; that on the down stream side being used by the railway. The depth of the girders for the four large spans is 27 feet $9\frac{1}{2}$ inches, and they are formed in two separate lengths each extending across two openings. The clear height above low water is 50 feet.

The railway bridge is formed of lattice girders, double on each side. The cross section of the top of one side is that of two T's, placed one after the other, and close together, thus TT, and the bottom has a similar form, but reversed. The lattice frames which connect them are 2 feet apart, and are tied together and stiffened by diagonal braces, placed vertically at every 5 feet $1\frac{3}{4}$ inch. At the same intervals there are vertical angle irons, to strengthen the lattice, and keelsons to carry the roadway. Transverse angle irons and diagonal bars above are attached at every second one of these points. The lattice bars cross each other at distances of 2 feet $6\frac{7}{8}$ inches apart measured diagonally. They are about $3\frac{10}{16}$ inches by $\frac{1}{2}$ inch at the centre of spans, increasing to $4\frac{3}{16}$ inches by $\frac{29}{32}$ inch, the ends resting on rollers, and to $5\frac{9}{16}$ inches by $1\frac{3}{16}$ inch at the fixed bearings.

The principle of construction of the bridge for ordinary traffic is similar to that of the railway, with the exception that the top and bottom sections are in shape that of a single T, and the sides consist of a single lattice instead of double frames. Every second vertical rod is also composed of two angle irons, instead of one, laid together so as somewhat to resemble the letter E. The total weight of iron in both bridges is about 4,600 tons.

The foundations were formed of concrete, laid on the solid natural bed of gravel, which approaches close to the surface in the neighbourhood of Cologne. The ashlar masonry consists of basalt and sandstone, the former being used in the facework up to the underside of the girders, and where the greatest strength is required. The piers terminate in sharp upright cutwaters; their form on the down stream side being similar to the upper. Their thickness is 20 feet 7 inches at the level of the girders. The ornamental portion of the design only includes towers, which are rectangular in shape, on the centre pier, and on both abutments. The approach to the bridge from the Central Railway Station in Cologne is effected by means of a viaduct of segmental arches, in brickwork, upon a sharp curve, whose radius, as already mentioned, is 618 feet.

The next case to be alluded to is that of the bridge across the Rhine, at Kehl, close to Strasburg. In cross section this bridge is somewhat similar to the Kinzig one, comprising two lines of rails with a lattice girder on either side and one in the middle, all connected together, and two footpaths supported on the outsides. The main portion of the bridge is that to which the lattice system is applied, and consists of three spans of 184 feet $8\frac{3}{4}$ inches each. In addition to this there are two swing bridges of 210 feet in diameter, with solid wrought-iron plate sides, and opening a clear width of 85 feet 3 inches on each side of the river for military purposes rather than those of navigation. The depth of the girders for the three principal spans is 19 feet $10\frac{1}{2}$ inches, and the clear roadway in each case is 13 feet 9 inches. The lattice bars are inclined at an angle of 45° to the horizontal, and form a net work, the open spaces of which measure about 3 feet diagonally. They are secured at their crossings by two rivets. The top and bottom sections of all three girders are in form that of the letter T; but they, as well as all other parts, are carefully arranged, so as to insure uniform strength for the bridge throughout, in proportion to the effect produced upon it by a load. The keelsons occur at intervals of $3\frac{1}{17}$ feet, and are in direct contact with the rails, which are riveted to them. The lattice work is stiffened by vertical angle irons, fixed double on both sides, at distances of 9 feet $6\frac{1}{2}$ inches. The iron work in the whole of the three openings is in one length, and is tied together above and below by a system of transverse and diagonal rods. The entire weight of the wrought-iron in the superstruction is 984 tons, or at the rate of 328 tons per span of 184 feet $8\frac{3}{4}$ inches for a double line of railway. All the piers are surmounted by handsome Gothic ornamental work in cast-iron. Great difficulty was experienced with the foundations of the bridge, owing to the nature of the stratum of shifting sand which underlies the bed of the river at this point. They were eventually sunk to a depth of about 66 feet below the lowest water, by means of wrought-iron cylinders, in which the masonry was built and undermined; the method adopted being that of compressed air. The operation of sinking the foundations progressed at the rate of about 20 inches per day of twenty-four hours.

In addition to these two bridges there is another now in process of erection over the Rhine, at Mayence, which is expected to be completed during the present year. It consists of the following spans:—

							Feet.	In.
4	River openings	of	331	feet	$8\frac{1}{3}$	inches each .	= 1,326	$9\frac{1}{3}$
6	Flood	„	109	„	11	„	= 659	6
2	„	„	82	„	0	„	= 164	0
20	„	„	49	„	$2\frac{1}{3}$	„	= 984	2
32 spans in all, yielding a clear waterway of lineal measure.						.	3,134	$5\frac{1}{3}$

The total distance between the abutments is 3,372⅓ feet, and the heights of the underside of the girders above low water is to be 45⅓ feet. The foundations are, like those of the Cologne Bridge, formed of concrete. The face masonry consists of red sandstone and ashlar, formed from the granite boulders found in the neighbourhood. The ironwork in the superstructure, which is for a single way, is very similarly arranged to that in the Saltash Bridge, modified in some particulars as to the cross section, and the form in which the material is applied, according to what is known in Germany as the system of Professor Pauli, of Munich, which gives a rectangular top to the beam instead of an oval one. As a good example of Herr Pauli's system may be mentioned the bridge over the Isar, at Grosshesselohe, on the railway from Munich to Salzburg. It has four spans,—two of 191½ feet, and two of 95¾ feet, at a height of 101⅓ feet above low water. The Eastern Railway of Bavaria has also some fine lattice bridges, such as that over the Danube at Regensburg, having five river spans of 153 feet 2½ inches each, with iron superstructure for single way, and fifteen flood openings of segmental arches in masonry each 47 feet 10½ inches wide, of which three are on the left and twelve on the right bank of the river. The height of the underside of the girders is about 33 feet above low water. The bridge was finished in 1859, and the weight of the ironwork in the five openings is 563 tons, or 112⅗ tons per span. On the same railway, at the town of Passau, there is a bridge over the river Inn, with one span of 296 feet 10 inches measured on the skew, the angle between the axis of the railway and the direction of the stream being 71°; adjoining this opening there are six stone arches, five of 47 feet in width on the left bank of the river, and one of 38 feet 3½ inches on the right. The level of the rails is about 46 feet above low water, and the weight of iron in the bridge is 347 tons, for a single line of rails.

These few examples are sufficient for the purpose of illustrating the progress made in Germany in the construction of iron bridges on a large scale, and complete this portion of the subject under consideration.

Directing attention to the next branch, that of the permanent way, it appears that about seven-eighths of the rails in use are of the broad base or contractors' pattern; the remaining one-eighth being composed cheifly of chair rails, with a small proportion of the bridge-shaped ones. Fishplates, made fast with four screw-bolts, are now almost universally adopted, for connecting the ends of the rails, and the joints are always supported by a sleeper, generally 12 inches by 6 inches, a wrought-iron chair-plate being interposed between the rail and the timber. The modern English system, of leaving the joint free without any sleeper under it, has hitherto met with but little favour from German engineers. A trial of this arrangement has, however, lately been made, on a short length of the railway from Frankfort-on-Maine to Heidelberg, and the result has been so satisfactory, that it is intended to lay the entire permanent way of the new line about to be constructed from Gustavsburg (opposite Mayence) to Frankfort, on this plan.

With regard to the size of rails, the rule laid down is that they shall not be less than 4½ inches in height by 2¼ inches in width of head, and that their surface shall be curved to a radius of from 5 inches to 7 inches. The general weight of rails now adopted varies from about 66 lbs. to 76 lbs. per yard, both these limits being passed in a higher and lower direction according to local requirements.

The following Table of the dimensions and weights of some of the principal broad base, or contractors', rails in use on various lines will afford interesting information on the subject:—

——	Weight per Yard.	Width of Head.	Width of Base.	Thickness of Central Web.	Height of Rail.
	lbs.	inches.	inches.	inch.	inches.
Dortmund and Soesto Railway.	66·	2¼	3·86	0·65	4·65
Louise of Hesse ditto	68·25	2¼	3 85	0·65	4·70
Frankfort-on-Maine to Cassel ditto	70·	2¼	3·95	0·65	5·00
Ditto to Heidelberg ditto	70·	2¼	3·95	0 65	5·00
Vienna to Salzburg ditto	70 68	2¼	4·20	0·60	4·90
Frankfort-on-Maine to Wiesbaden do.	72·57	2¼	4·	0·70	4·93
Hanoverian State Railways.	72·	2⅜	4·	0·75	4·50
Bavarian ditto ditto	73·98	2⅛	3·95	0·75	4·65
Prussian ditto ditto	74·75	2⅓	4·	0·55	5·15
Baden ditto ditto	75·93	2⅜	4·40	0·80	4·70
Semmering ditto ditto	76·66	2¼	4·54	0 90	4·54

The almost universal system of supports is that of cross-sleepers. They are generally of oak, when it can be procured at a reasonable price. Different descriptions of larch and fir are often used, after being prepared by some chemical process to resist the tendency to decay. Various are the means adopted for this purpose, but the one which is now most favourably received is that of forcing a solution of sulphate of copper through the pores of the timber to be prepared. The most simple arrangement for carrying out this method is a tank erected on a wooden frame about 30 feet high, into which the solution is pumped from the tub in which it is mixed below. From the tank a main distributing-pipe descends, until reaching within a couple of feet of the ground, when it diverges into two horizontal branches, with a series of small feeders about every 3 feet at right angles to the mains, and 10 inches or 12 inches long. On these are tied flexible gutta-percha tubes 6 feet in length, furnished at the ends with brass nozzles, and having screw clamps attached to them, by which the supply can be cut off from each separate feeder, without interfering with the others. The timber to be prepared must be round, with the bark on, generally in lengths of, say, two sleepers. It is laid horizontally, on a rough supporting frame, and sawed across the middle, through about nine-tenths of its thickness. A wedge is then carefully driven under the middle of the stem to raise it up from the frame. This opens the saw-cut above, and admits of its being caulked round the outside edge with oakum. The wedge is next removed, and the cut closes up to a certain extent on the caulking, leaving a vacant space inside between its two faces. Into this a slanting hole is bored from above, and the nose of the flexible tube inserted. The clamping-screw is then loosened, and the solution allowed to flow into the centre of the tree, and acting by the hydraulic pressure from the high-level tank, it makes its way through the pores, forcing the sap out before it. When the wood has become thoroughly saturated, it is ascertained by applying litmus paper to the end of the stem. The clamping-screw is then made fast and the piece of timber removed, to make way for another. The most advantageous number of stems to prepare at the same time with one apparatus is about fifty, a similar number being always ready to supply vacancies as they occur. For success with this method, it is necessary that the timber should be cut down when the sap is in it, and prepared while green, as otherwise it occupies too much time. Also, that the bark should be whole, to prevent leakage, and that the stems should be in duplicate lengths, so as to admit of their being prepared from the centre. The average time of preparing a log 18 feet or 20 feet long, under favourable circumstances, is about twenty-four hours.

Square stone blocks are used to a considerable extent, as supports for the rails on the Taunus Railway, but this is only on the old permanent way, as they are not made use of on the new line of rails now being laid down by this Company.

In noticing ballast on German railways, there is a system frequently to be met with which can scarcely be passed over without comment: that is the filling up of the space outside the ballast to the level of the top of the sleepers with common earth, drains being cut through it at intervals, from the ballast to the outside slope, and filled up with broken stone. These drains, although at first answering tollerably well the purposes for which they are intended, after awhile become choked with the mud which is washed into them by heavy rains, and the free escape of water from the ballast is prevented. Add to this the mixing of the earth with the ballast, which is almost inevitable during repairs, and it becomes evident that the system has great drawbacks.

The stations on German railways are, as a rule, large and commodious, and in many cases display much architectural taste. They are generally close together.

The frequent absence of any description of fencing is also a marked feature on many German railways, the necessity for such a protection being done away with, inasmuch as cattle, except in some districts, are never allowed to stray at large without being attended by a herdsman. This latter arrangement is rendered imperative by the minute subdivision of land, which prevents the practicability of enclosing each separate property.

The quantity and description of rolling stock in use on different railways in northern and southern Germany varies greatly. The passenger carriages have principally six wheeles, but there are many lines on which four-wheeled vehicles are adopted. On the Würtemburg State Railways, the long eight-wheeled carriages on the American system are in use. As nearly as can be estimated, the quantity of rolling stock at the close of the year 1861 stood thus:—

Locomotive Engines	per English mile	0·414
Passenger Carriages (averaging 41·81 seats each)	„	0·807
Goods ditto (average load 6·91 tons)	„	7·040

Before any engine is permitted to be used, its boiler must be tested with hydraulic pressure to at least once and a half the maximum steam pressure which it is intended to sustain, and a similar test must be applied after the engine has run 46,109 miles, and subsequently repeated every time an additional 36,887 miles has been made, or whenever important repairs are required, should this be sooner. In no case, however, must the intervals between such testings exceed three years. On all such occasions the weighting of the safety-valves is also proved.

With regard to the proper proportion of breaks to any train, the rule laid down fixes the minimum number according to the following scale:—

—	For Passenger Trains.	For Goods Trains.
For lines with a maximum gradient of 1 in 500	$\frac{1}{8}$ of the entire number of wheels to have breaks.	$\frac{1}{12}$ of the entire number of wheels to have breaks.
„ „ „ 1 in 300	$\frac{1}{6}$ ditto.	$\frac{1}{10}$ ditto.
„ „ „ 1 in 200	$\frac{1}{5}$ ditto.	$\frac{1}{8}$ ditto.
„ „ „ 1 in 100	$\frac{1}{4}$ ditto.	$\frac{1}{7}$ ditto.
„ „ „ 1 in 60	$\frac{1}{3}$ ditto.	$\frac{1}{6}$ ditto.
„ „ „ 1 in 40	$\frac{1}{2}$ ditto.	$\frac{1}{4}$ ditto.

When the rate of gradient exceeds 1 in 300, it is ordered that the last carriage shall be supplied with breaks, and another rule in regard to the arranging of trains is, that between the engine and first passenger carriage there shall always intervene at least one carriage which does not contain passengers. It might have been well, when laying down such rules, to have gone still further, and ordered that the last carriage in every train, whether on a line with heavy or light gradients, should have breaks attached to it, and should not contain passengers. Where there are so few trains daily, and large quantities of small parcels and light goods requiring speedy transit, an arrangement of the kind might easily be carried out.

The rate of speed varies very much on different railways. For express trains it is usually from 27 miles to 35 miles an hour, exclusive of stoppages; the maximum velocity attained by trains while in motion being from 30 miles to 37 miles, and in some rare instances touching 40 miles. Ordinary passenger trains travel at the rate of from 20 miles to 25 miles, and goods trains at from 10 miles to 15 miles per hour, exclusive of stoppages. These comparatively low rates of speed, as might be expected, are most satisfactory in their results upon the wear and tear of both the permanent way and the rolling stock.

Mr. Vignoles said, he did not think the Paper should be designated as treating on the German system of railways, though it contained an interesting description of various railway structures, and there were a number of points which, when studied in detail, would be useful and instructive. Nothing was related, however, of which there were not good examples, long previously existing in this country, and of a character which, if examined, would, he believed, be found more interesting to the engineer. Many of the works which had been described he knew perfectly well; and while he gave due credit to the engineers of Germany for what they had done, he was obliged, in his own mind, to compare them with similar works executed here and elsewhere. The German system of construction was, in general, no more than adopting, in a greater or less degree, the plans which had been found successful in this country, with such modifications as the circumstances required; but their works would not as a rule bear comparison with similar ones in the United Kingdom. For instance, the viaducts built from the designs of Mr. J. Miller (M. Inst. C.E.), upon the Glasgow and Dumfries Railway, were still unequalled in Europe for boldness of conception and excellence of workmanship, and instead of following the old Roman fashion, of building tier upon tier of arches, as was the practice upon the continent, there was only one tier of arches, each pier being carried up to its full height without lateral support. With regard to the Dirschau and the Marienberg Bridges, it was unnecessary to analyse the principles upon which they had been designed, because even from the descriptions given by the engineers of those bridges, and from the diagrams published with respect to those works, it might easily be shown that their mathematical construction was faulty, there being a want of due proportion between the several parts. He had watched the progress of these works during their construction, and had ascertained that their cost had certainly not been less than £45 per ton. It must be understood that this was not said by way of depreciation, because, he thought, considering the struggles that had taken place in Germany, the results were most creditable.

He was exceedingly diffident in speaking on this subject, for he had so much to do in Germany many years ago, at the time of the introduction of railways, that it was impossible to allude to that period without saying more of himself than was becoming. When, thirty years ago, he laid out the railway from Brunswick to the foot of the Hartz Mountains, then almost the first after the Nuremberg and Fürth line, he introduced that particular form of rail, of which the Author had properly stated that seven-eighths of those in use on German lines consisted, which was known in this country as the contractors' rail, but was still better known in America and on the continent as the Vignoles' rail: it was a system which he studied very much, before finally recommending and adopting it. It was properly called the contractors' rail, because the contractors were the first persons who had the courage to use it, in the face of authorities who would not at that period recognise it. At the same time, he also strongly advocated the introduction, as many of his friends knew, of the system of fishing the joints of rails, which was first adopted in Germany.

The great principles, which he thought ought to have been insisted upon, as characterizing the German system of railways, were the simplification of the permanent way, and the perfection of their statistics. All the Companies were compelled, as in France, to give positive returns, under specific heads, of every detail of expenditure, and as these were published annually, the Companies were brought into a wholesome competition, for the reduction of the working expenses to a minimum. Each Company was held up "in terrorem" to the others, so that all were interested in the reduction of their respective expenses. A recent inquiry showed, that the expenses per train mile on two-thirds of all the German railways were within a fraction of each other. But notwithstanding this, he believed it was capable of proof that the average expenses per train mile were less in the United Kingdom than in Germany. Still he thought it would be a wholesome regulation if railway companies in this country were compelled to give that information, in the some way as farmers were asked to contribute agricultural statistics. If those returns were furnished, it would be possible to trace every item of expenditure to its source, so that it would readily be seen where economy might be effected. It had been stated that the average cost of the German railways, one-fourth only having two lines of way, was £16,400 per mile; that would amount to about £14,000 per mile of single line. Now when the cost of land, the Parliamentary and legal expenses, and a vast number of other items which had unfortunately swelled the expenditure in this country were taken into account, he thought that the average cost of the lines in this country did not very much exceed that amount, particularly when of later date, those items of construction which did not fall upon the continental lines being of course eliminated.

The principle of railway legislation in Germany, as on the continent generally, was this:—The Government granted a concession for a railway from the town of A to the town of B, and sometimes provision was made, that it should run by way of the intermediate towns C and D, but all the details were left to be decided during the progress of the works. The evidence of individuals, in respect to the direction the line should go, was not taken, but the line being granted from point to point, the details were decided on the spot, where they could best be settled; and although it sometimes gave rise to considerable delay and annoyance, it saved vast sums of money. The same might be said as to the land. There was more trouble, perhaps, in getting land on the continent, but then it was obtained at the mere agricultural or mere town value.

There were a number of matters to be considered in making a comparison between the cost of lines in Great Britain and on the continent. As a rule, neither the engineers nor the labourers were so well paid on the continent, and there were various contingencies besides; so that he really thought—and it was a question he had studied for many years—when all these were taken into consideration, if the quantity of work done and its cost were contrasted, that the expenditure was not greater in Great Britain than it was, in the end, on the continent. And he would lay it down as a positive fact, that in no part of the world could work be done so cheaply as in the United Kingdom, whether measurement or weight of material were taken as the standard of comparison.

With respect to inclines, on the line between Nuremberg and Hof, on the route eastward to Leipsic, there were about 7 miles of 1 in 45, with curves of 400 yards radius, worked by locomotives. The last returns of the Semmering Railway in Austria showed that the working expenses exceeded the receipts; so great was the cost of working over 22 miles, with gradients of 1 in 40 and 1 in 45, and curves of 10 chains radius. The railway itself had been constructed at a cost of nearly £100,000 per mile, and he might mention that the bricks for the viaducts were brought from Vienna, so that the expense was enormous. However advantageous the line might be politically, and perhaps in other respects, to the Austrian Government, commercially the speculation was a most unprofitable one.

In mentioning the railway between Cologne and Liège, the Author had not noticed the way in which the passage had been effected between the two countries. The principal works were in Belgium between Liège and Verviers, and up to the Prussian frontier. They were constructed at an early period in the history of railways, and abounded in rapid curves, and comprised an extraordinary series of tunnels and viaducts; and altogether formed one of the most remarkable examples of engineering on the continent.

He had laid out the Würtemberg State Railways, and he knew they had been executed according to his recommendations; but most of the rolling stock was founded upon the American fashion, and he thought had not turned out satisfactorily. In determining the gauge for the railways in Würtemberg, Mr. Vignoles was called on to decide whether the Bavarian gauge of 4 feet 8½ inches English, or the Baden gauge of nearly 6 feet, should be adopted. Though himself a warm advocate for a wider gauge, he felt compelled under the then existing circumstances, to declare in favour of the narrow gauge. It was then too late to adopt the wider gauge; and the Baden Railways being isolated from the lines of Germany on the east, France on the west, and Switzerland on the south, were, as the Author had remarked, compelled to alter their gauge, and change the under-frames of their rolling stock.

The Taunus Railways had latterly been relaid, in consequence of the failure of the rails. These were originally double-headed, and when worn, they were turned; but a few months afterwards they broke, as might have been expected, at a short distance from the point of support: and he saw hundreds of tons of those rails which had been broken, lying in stack. Since then a different kind of rail upon sleepers had been adopted.

Mr. T. E. Harrison said, it was stated that the average cost per mile of the whole of the railways in Germany amounted to £16,400. If this was contrasted with the cost of railways in England, undoubtedly it showed very favourably; but there were many causes which operated in favour of the German system, in respect of cost of construction. In the first place, they were exempt from Parliamentary expenses, which was a heavy item in this country; then, an exorbitant price was not paid for the land. Besides, the railways, when made, were not subject to the same competition as in England.

Allusion had been made, in the Paper, to the Semmering Railway. He had passed over that line, which was the work entirely of foreign engineers, and he would say that he knew no engineering work that would better repay the time and trouble of an inspection. It had been stated that, on the Southern State Railway of Bavaria, there was an embankment 172 feet in height, containing 3,000,000 cubic yards. The details of that embankment, as to the conditions under which it was carried out, were not furnished, but it was certain that in no part of England was there an embankment of that height. It appeared from the rules of the "Association of Government Railway Directors," formed in 1847, that the use of cast-iron was completely ignored. Now, he thought there were many cases in which cast-iron was exceedingly useful for bridges; and though that material might be open to some objections, yet, when employed in the form of segments, of which there were many admirable examples on railways in England, he could not agree in the conclusion which had been arrived at by the German engineers. The viaducts on the Semmering Railway were constructed with intermediate arches in their height. There were numberless examples of high viaducts throughout this kingdom—and those upon the Glasgow and Dumfries Railway had already been referred to; but in many parts of Lancashire, there were viaducts more than 100 feet in height, and he had built viaducts more than 150 feet in height, without a thought of introducing intermediate arches. Comparing the general designs of these viaducts, it appeared to him that those on the Semmering Railway contained more material than had been introduced into viaducts in England.

Captain Moorsom remarked, with reference to the small cost of the German lines of railway, that it appeared they were laid down generally with the earthworks and bridges to receive double tracks eventually, but almost invariably waiting for the double track till the traffic should justify it. He thought a useful lesson might be taken in that respect in this country. He had only a few weeks ago perused a report from one of the Government Inspectors, in which it was noted as a matter of unfavourable character, that land had not been purchased sufficient to lay down a double track on a railway branch where only four trains each way were run during twenty-four hours. The fact was erroneously reported by the Inspector, but still it showed one of the impediments thrown in the way of economy in this country, as compared with the German system. He was at a loss to understand why 'The Association of Government Railway Directions' in Germany should limit the radius of curves to 3,600 feet on level ground, 2,000 feet for hilly country, and never less than 600 feet. He was prepared to say, that curves of 300 feet radius might in some instances be desirable. Not that in England such were frequently found, but he should not hesitate to adopt a curve of 300 feet radius, if necessitated by the circumstances under which he was obliged to lay out a railway, as he believed it would be possible to work round such a curve, to the satisfaction of the locomotive superintendent, at a speed of 20 miles or 30 miles an hour. Some years ago, he laid down a curve upon a radius of 7 chains, or between 400 and 500 feet, which remained to this day on one of the great lines of the kingdom. The trains were calculated to travel on that curve at 25 miles an hour; but when the line went out of his hands, the Directors issued instructions not to exceed 15 miles an hour round that curve, by which instructions of course all the calculations for 25 miles were falsified. With respect to the limitation of gradients to 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountain lines, he remarked that the character of gradients must be guided by what the country would admit, as some countries seemed to be laid out for a certain class of gradient. Thus, in the West of England, the land was laid out for 1 in 60; and if 1 in 70, or 1 in 80, were attempted, serious difficulties would be encountered. In other parts the ground was suitable for gradients of 1 in 100. Therefore, as the country seemed itself to design the gradient on which the railway should be laid out, to limit these gradients by the dictum of book, or tables, appeared exceedingly undesirable.

The speed of the trains on these German lines appeared to be lower than was necessary. On the Semmering Railway the speed of the express trains was limited to 14 miles an hour in ascending, and to 16½ miles in descending, gradients of 1 in 40. He was satisfied that speed might be doubled with safety, from his experience in the working of the Lickey incline, of 1 in 37, on the Birmingham and Gloucester Railway, since the year 1839. The goods train at 9½ miles an hour might do very well, as high speeds were not required for goods, and it was expensive to have high speed for goods trains on heavy gradients. In descending such gradients, it was quite possible, with ordinary breaks, always to have the train under command, when travelling at a much higher speed; and the only limitation in descending upon heavy inclines was that which enabled the train to be held 'in hand.' When a train was obtaining the mastery, running ahead in fact, it was readily perceived, and there was a certain stage of progression which might be denominated the ultimate speed which a train attained, after the breaks had been got to a proper bearing; and this speed would not decrease, or increase, unless a greasy part of the line, or the falling of dews, intervened to give more sliding way. The late Mr. Robert Stephenson used always to complain of the cost of going up those heavy inclines; but Captain Moorsom believed that the cost of working up the Lickey incline, at 28 miles an hour, was practically no more than going up at the rate of 15 miles. From the year 1840 to 1845 the speed on that incline was 15 miles an hour with passenger trains of seven or eight carriages, at a certain cost per train mile, which he did not remember, but it was per engine about £700 per annum. From 1845 to about 1855, a material improvement took place, as regarded the traffic, which increased so much as to require ten or twelve carriages, instead of an average of seven or eight, and heavier engines were used. The result was that, from 1845 to 1855, the trains of twelve carriages used to run up that incline at 28 miles or 30 miles an hour, at no more practical cost than they ran in 1845 at the rate of 15 miles an hour. He referred to the accounts in verification of the correctness of this statement. He thought that embankments of 170 feet in height were dangerous to execute. He was laying out a line for the next session with 82 feet of cutting rather than have an embankment of 42 feet. The London clay or lias would slip at less heights than that, and he knew of no soil that could be trusted to the height of 172 feet. He had an embankment of 84 feet in the gritstone, but not higher than that. With respect to the bridge over the Rhine, at Cologne, to which allusion had been made, he thought it worthy of mention, that a member of this Institution furnished the design for which the Prussian Government gave the prize over sixty-one competitors of all nations. That design was for a lattice bridge of peculiar character, and very large spans. He was not certain whether the design had been carried out in all its details, but he was told that a lattice bridge had been constructed there. He mentioned this circumstance, as reflecting credit upon the Institution, that one of its members should carry off the prize as to engineering construction thus largely competed for, while the prize for architectural design was awarded to an architect of Berlin.

Mr. Mallet said, he felt unbounded admiration of German engineers, and he was satisfied that, as regarded sound technical education, the comparison between the English engineer and the German was much in favour of the latter, and increasingly so. With respect to originality of construction manifested in the German railways, no doubt the earliest lines in that country were suggested by the successful creation of the railway system in England. They were, he believed, not designed by military engineers, but by officers from the Bergampt (School of Mines), the first ideas of railways being taken from those of their great projector, George Stephenson; but the works were carried out in their own way from the commencement, and with striking originality in structural detail. So far from having copied English engineers, the latter had in several respects copied them. The lattice bridge in iron was in fact introduced from Germany. One of the earliest German iron lattice bridges was that across the Elbe at Magdeburg, the wooden lattice having been long previously known and adopted in America. Sir John Macneill, who was the first to employ iron lattice bridges in this country, took his earliest examples, in Ireland, from this and other early German bridges. Mr. Mallet would venture to say that he believed, in the end, the lattice bridge, in iron, in one form or another, would supersede all others for railway uses.

He had recently been over a new line of German railway, the Deutz and Giessen, which ran along the valleys of the Lahn and Sieg, through, in great part, a very uneven country, one very unlike the level plain of Central Germany, so commonly supposed to form the basis of all German lines. This line comprised a vast amount of heavy earthworks, and over bridges, and extensive lattice viaducts repeatedly crossing the Lahn a large navigable river, and it passed through a country more difficult than any he had seen in England. In one place, for 14 miles in length in one stretch, the gradient was 1 in 49, and nowhere less than 1 in 80; almost all this was in rock cutting and side embankment, and the line was obliged to take curves in the form, in some places, of the letter U. That line, he understood, had been made, nevertheless, at an expense of about £12,000 per mile. The bridges over the Lahn were on the lattice principle, and were beautiful examples of structural skill, and in some points novel. One characteristic of the German railways was well worthy of imitation; that was the care taken to prevent accidents, which seemed to be to a great extent neglected in this country. Some years ago, a brother of their member, Mr. Siemens, himself a German engineer by education, proposed a mode of telegraphing along all the lines, by which each train, as it started, telegraphed its approach to the station immediately in advance. That system was adopted on every line, he believed, and the result was an almost entire immunity from accidents on German lines. It was not correct to suppose, that the freedom from accidents on the German lines arose from their running few trains, or that these invariably travelled at a slow rate. In Westphalia, the grand centre of German industry, on the trunk lines, as many trains ran as on some of the English lines, and the speed of the express trains was 40 miles an hour, while the average speed of ordinary trains was 4 German, or nearly 21 English miles per hour. Repeated efforts had been made to get the same system introduced here, but the attempt had been nugatory, except in one or two instances. This inertness to improve in England might be illustrated by a smaller matter. Nearly all the railways in Germany had their axles lubricated with liquid oil, instead of solid grease, the imperfect material in universal use here; one loth, or ounce of oil, serving to grease an ordinary axle for a month. About fifteen years ago, he introduced a mode of oiling the axles of railway wheels which, although independently invented by him, turned out afterwards to be identical with that in use in Germany on certain lines. He endeavoured to get the method tried on some English lines, but was met by the statement, that however good it might be, grease was so generally employed that no change would be made. In Germany there was an admirable system at work for the technical education of engineers and others engaged in skilled and scientific employments, with which there was nothing to compare in this country, and it would be well to study it and to adopt it as far as possible.

Mr. Sheilds said, that in the north and north-east of Germany, everything in the way of railway works was so plain and simple, and so like what it was in any easy district of country at home, that there was not much to remark upon. The expenditure upon the railways had been small from a variety of reasons, one being that the population supplied an excellent industrious class of workmen, and the work did not appear to be hurried so much as was the case in this country. There was a less amount of work to be done, and being carried out more slowly, large bodies of workmen were not collected together, by which the price of labour was raised to an artificial height. The German navvy was paid about 1s. 6d. per day, and did a large amount of work, so that he believed throughout Prussia the cost of the earthwork did not exceed 8d. or 9d. per cubic yard. It was to be remarked, that but little contractors' plant was employed, the embankments being executed mostly from side cuttings, with barrow runs of much greater lengths than in this country, even up to 300 yards. This might account, in a great degree, for the excellence of the earthwork to which allusion had been made. The stations in Germany had been spoken of as being excellent; and he was surprised that the author had not noticed especially the station at Breslau, which was perhaps one of the finest in Europe, as regarded architectural effect. In his opinion, the German lattice bridges should not be taken as models of the best design and construction. The lattices were composed of flat bars, which were inherently weak in themselves, and which, however they might be supported at intervals, by vertical bracings, to keep the top and bottom flanges apart, were imperfect constructions. It was, he thought, far better to give the lattice bars the necessary rigidity in themselves, than to make them inherently weak, and supply what was deficient in them by additional construction. He had made such girders some years ago, when it was the customary practice, but he found their deflection to be very great; in consequence, he had since adopted the system of employing angle irons for the lattice braces, whether in tension or compression, or of using plate girders, which undoubtedly formed a good strong bridge. The rolling stock was of excellent construction, and the passenger carriages most commodious; but the trains were few in number, and in most cases several hours apart. Under such circumstances, he did not think that so much credit as had been claimed for them was due for their freedom from accidents. In fact, no fair comparison could be made in this respect between the German and the English systems; and he believed that if the trains ran as frequently on German lines as on those in England, it would be found that as great, if not a greater number of accidents would take place on the former than on the latter.

Mr. C. H. Gregory said, with regard to the alleged advantages of special education, without venturing to depreciate that which was a valuable aid to the labour of all classes, and very useful in assisting the engineer and the practical man, to the best way of attaining his object, yet he submitted that undue importance should not be attached to theoretical education, to the neglect of that practical experience and training which the engineer should always bring to bear upon his profession. The history of engineering in this country showed that the works which reflected the highest honour upon the profession had been carried out, to a great extent, by men who had not any large amount of special theoretical education, but who, being possessed of great natural powers, were enabled to take advantage of the national resources and peculiarities in such a way as to command for English engineers universal respect. He thought that this result would not have been attained, if they had relied upon a technical theoretical education, and systematized rules, cut and dried by others, instead of their own energy and originality of mind and action.

THE ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The monthly meeting of the committee of this Association was held on the 30th October, when the chief engineer, Mr. Fletcher, made his monthly report, from which the following is extracted:—

During the last month 473 engines have been examined, and 631 boilers, as well as two of the latter tested by hydraulic pressure. Of the boiler examinations, 506 have been External, 5 Internal, and 120 Entire. In the boilers examined 114 defects have been discovered, 5 of those being dangerous, thus: Furnaces out of shape, 4; fractures, 5; blistered plates, 2 (1 dangerous); internal corrosion, 12; external corrosion, 16 (2 dangerous); internal grooving, 2; external grooving, 1; feed apparatus out of order, 1; water gauges ditto, 17; blow-out apparatus ditto, 13 (2 dangerous); safety-valves ditto, 5; pressure gauges ditto, 4; without feed back pressure valves, 32.

Strengthening the Manholes of Boilers with Mouthpieces.—The importance of strengthening the manholes of boilers with mouthpieces is shown by the fact that nine explosions, by which fourteen persons have been killed and six others injured, have recently occurred to boilers in which this precaution has been omitted. In each of these explosions the primary rent has started from the manhole, and although in some cases the pressure of the steam has been considerably higher than it should have been, so that the explosions have been partly attributable to excessive pressure, yet they have been materially promoted by the weakening effect of the unguarded manholes, while others have been entirely due to that cause. Particulars of six of these explosions have been given in previous reports; while those of three others will be found below. The weakening effect of unguarded manholes is not produced solely by the amount of metal cut away, but to a great extent by the action of the covers. These are generally internal, and held up to their work by the pressure of steam, as well as by a couple of stout bolts and nuts, suspended from arched bridges; and as the surfaces of the plates at the joint are not dressed smooth, but left rough, a considerable strain is frequently put on the bolts to make the joints steam-tight, especially when the cover does not fit the sweep of the boiler. Thus the action of the steam, combined with bolts, tends to force the cover through the manhole and split the boiler open. This is just the action that takes place. In some boilers it has been detected in an early stage just in time to prevent explosion, while others have been known to burst shortly after the manhole covers have been tightened up, or the joints caulked. Nothing is easier than to strengthen these manholes. It is done in all modern boilers turned out by first-class makers, so that there is not anything novel about it. As, however, some of our members have old boilers to which this mounting is not attached, and which they are desirous of adding, while some makers continue to turn out new boilers without it—a practice from which so many fatal explosions, as just stated, have already occurred—it is thought that a description of this most simple but valuable mounting will not prove unacceptable.

The manhole mouthpiece is an external one, made of cast iron, and in the shape of a short cylinder, with a flange both at the top and bottom, the lower one being curved so as to fit the sweep of the boiler to which it is rivetted, while the upper one is flat, and fitted with a cover, secured with bolts and nuts. Both the cover and upper flange should be faced up true on their joint surfaces, while it adds a finish to the work to turn them up on the edge, as well as to face the cover on the outside for a width of about four inches, so as to give a true bearing surface for the nuts. For convenience in lifting the cover, a wrought iron eye bolt should be attached to it at the centre. The height of the mouthpiece should be sufficient to admit of the introduction of the bolts between the flanges for securing the cover, while the opening should be large enough to afford a man easy access, say 15 inches, which, however, is a liberal allowance, and might be slightly reduced in special cases should it be desirable to do so. The metal should be an inch and a quarter thick for steam at a pressure of 60lb., while the bolts should be an inch in diameter, and spaced about six inches apart. It is well to strengthen the upper flange by brackets, while the cover can be stiffened by ribs if required. By some makers the flanges are made as much as an inch and a half thick. For steam considerably above 60lb. on the square inch, mouthpieces are sometimes made of wrought iron, but those of cast iron are found to work satisfactorily up to that pressure. No hemp ring will be required for making the cover joint, but merely a little red lead and oil if the surfaces be properly got up, and provided that the lower flange be suitably rivetted to the shell, little or no caulking will be required to make it steam light.

This external manhole mouthpiece is not the only form adopted. Some boiler makers prefer an internal one. Either of them, if properly made, works well. The one described above is of a type very generally adopted and approved. Many hundred boilers are fitted with it in this neighbourhood. It has been found to work satisfactorily, and may safely be followed.

Mudhole Mouthpieces.—In double furnace boilers the mudhole—which is placed at the bottom of the front end plate, and below the furnace mouths—forms a second manhole, and should be guarded with a mouthpiece. When this is omitted, inconvenience is experienced from leakage at the joint, which not only disfigures the boiler, but induces corrosion, in many cases so wasting that the front end plate has to be cut away and repaired. With good mouthpieces, suitably got up, this danger is avoided.

The mounting for mudholes is very similar to that recommended above for manholes, but the position below the furnace mouths does not allow room for a cylindrical mouthpiece sufficiently large to admit a man's passing through it, and, therefore, instead of being cylindrical, it has to be oval. Like the manhole mouthpiece just described, one of the flanges is rivetted to the boiler, and the other fitted with a cover secured with bolts and nuts, both joint surfaces being faced, as well as the outside of the cover, for a width of about 4 inches from the circumference, in order to ensure the nuts bearing fairly. It is important that the joint surfaces should be well got up, and it is better to make the joint with a little red lead and oil, than with a spun yarn ring; while a case which has occured during the last day or two may be mentioned in illustration of this, in which the furnace crowns of a boiler were both laid bare and overheated at night time, in consequence of the water's wasting away from leakage at the joint of the mudhole cover, which was not made metal to metal with red lead and oil, but with a spun yarn ring. Metal to metal joints will of course sometimes leak if neglected, but they do not give way unawares, and thus rapidly drain a boiler as in the instance just mentioned, while the amount of discharge in all cases may reasonably be expected to be less, even should leakage occur.

Internal mouthpieces are sometimes preferred for mudholes to external, but either one, if well got up, will do good service. Perhaps the external ones are more extensively used, and, as stated above, with regard to the manhole mouthpieces, they are found to work satisfactorily, and may safely be adopted.

Explosions.—Before entering on the explosions of the past month, the particulars of two others, viz., Nos. 27 and 29, which were of prior occurrence, may be given, since they have special reference to the subject of unguarded manholes just alluded to.

No. 27 Explosion occurred at about half-past four on the afternoon of May 31st, at a small elastic braid manufactory, and resulted in the death of one person, as well as in injury to two others.

The boiler, which was not under the inspection of this Association, was most diminutive, its length being only 4 feet, and diameter 2 feet 5 inches. It was fired externally, and of plain cylindrical construction, with dished ends, the barrel being composed of two plates, which were laid lengthwise, and measured a quarter of an inch in thickness, while the ends were three-eighths.

The equipment of the boiler was most defective. There was a large manhole cut in the top of the shell, measuring 17½ inches long by 13¾ inches wide, which was not strengthened, as it should have been, with a substantial mouthpiece, while the hole was laid lengthwise on the boiler, so that it had a very weakening effect. There was but one safety-valve, an inch and five-eighths in diameter, loaded with a weight which at the end of the lever gave a pressure of about 150lb. per square inch, though it was stated that the boiler was ordinarily worked with the weight not at the end, bnt midway. There was no steam-pressure gauge, and no glass water-tube, the latter having been broken some weeks before the explosion, and the boiler worked on without it, while there was no feed-pump or injector for feeding the boiler, so that this could only be done by letting the pressure down, when the water was poured in through a pipe leading from two or three tubs placed three or four feet above the boiler.

When the boiler burst, it gave way at the unguarded manhole just described, five rents starting from it, which ripped the shell completely open along the top from end to end. The explosion reduced the house to a heap of ruins, the brickwork and timber being scattered in every direction, and an adjoining street strewn with the *débris*, while other portions were thrown on to the roofs of neighbouring buildings. The manhole cover is reported to have been blown to a distance of 160 feet, and the safety-valve 450, where it struck an adjacent chimney; while, in addition, the owners of the boiler, who were their own firemen, were both seriously injured, one of them fatally so.

From the evidence given at the inquest, it would appear that though the boiler was tended by its owners, this was done in a somewhat remarkable way. In consequence of there being no pump or injector, they were in the habit of charging the boiler with a whole day's supply at one time; and as the glass water tube was broken, they ascertained the amount of water in the boiler by tying an iron nut to the end of a string, and letting it down through the safety-valve, so as to take a sounding, stating that after twelve hours' work they still found water in the boiler up to the tap at the bottom of the disabled glass water gauge. A mechanic, who had erected the engine and boiler, said that when the steam got up to blowing-off point, the owners were in the habit of drawing the weight to the end of the lever, in order to confine the steam in the boiler, instead of allowing it to blow off. Two engineers, one of whom made an official report on the cause of the explosion at the order of the coroner, called attention to the weakening effect of the unguarded manhole on the boiler, the former stating that if the boiler had been intended for high pressure, the manhole should have been strengthened, and the latter, that he did not consider it safe at a higher pressure than 50 lb. per square inch. Both of them concluded, after examining the plates, that they had not been overheated through shortness of water, while one of them added that the boiler was laid down, in the first instance, for a much lower pressure than that at which it had been worked; and to admit of an increase, the original safety-valve had been removed, and replaced by the one upon the boiler at the time of the explosion. The jury brought in a verdict, "That the explosion was due to shortness of water in the boiler, and the generation of gas, which caused an over-pressure;" while, at the same time, they censured the owner for not having supplied the boiler with a steam gauge and water gauge; expressing, in addition, their disapproval of the practice of placing such boilers in thickly populated parts of the town, and entrusting their management to incompetent men, to the imminent danger of the surrounding neighbourhood.

There appears to be an inveterate popular habit of attributing all explosions to shortness of water and the formation of gases, and it would have done more to prevent the recurrence of similar explosions if the jury, instead of launching into theory, had confined their attention exclusively to the practical defects in the equipment of the boiler—such as the absence of any feed pump, steam gauge, or glass water tube, the very disproportioned load upon the safety-valve, as well as the weakening effect of the large unguarded manhole—and pointed out the importance of having boilers more efficiently mounted. It appears that the joint of the manhole cover had been caulked with red lead but a few days prior to the explosion, and as the boiler burst the first time it was set to work after the caulking, it would seem as if the manhole then received its finishing touch, which is in accordance with the view previously expressed, that the mischievous effect of these unguarded manholes is not due solely to the amount of metal cut away by the opening, but also to the strain put upon the plates in making the joint. It was not actually proved in the evidence that the weight was at the end of the safety-valve lever at the moment of explosion, and even if it had been, and steam had been up to blowing-off point, viz., 150 lb. on the square inch, it would not have led to the rupture of a shell of so small a diameter as this one was, had it been fairly made and suitably equipped; so that it would not appear correct to attribute the explosion simply to excessive pressure.

This explosion must, it is thought, be ranked among those due to defective boiler mountings, while it clearly affords an additional illustration of the danger of unguarded manholes, and the importance of having them all suitably strengthened with substantial mouthpieces.

No. 29 Explosion occurred on June 11th, to a small boiler of multitubular portable class, not under the inspection of this Association, and resulted in injury to two persons.

I have not had an opportunity of making a personal examination of the exploded boiler, but have been favoured with a photograph, as well as with particulars and sketches taken by an engineer on the spot, from which it appears that the primary rupture occurred at the crown of the outer casing of the fire-box, the rent running in a longitudinal direction, and through the manhole, which was not strengthened with any mouthpiece.

The explosion is extremely similar to another which took place to a portable agricultural boiler when at work driving a thrashing machine on the 9th of January, 1865, details of which were given in the report for that month, under the head of Explosion No. 3. Although there was no evidence in either of these cases of there having been excessive pressure, the question has been raised in both since the explosions occurred. Indeed, in the first instance, an action to recover damages was brought by the owner of the boiler against the party to whom it had been let out on hire, on the assumption that the explosion was due to his having improperly screwed the safety-valve down. The desirability of avoiding this uncertainty, apart from considerations of safety, appears to me a sufficient reason for adopting the recommendation already given on previous occasions; viz., that the spring balances with which the safety-valve levers of portable boilers are usually loaded, should be fitted with suitable stop collars or ferrules, which would render it impossible to screw the valves down beyond a pre-determined pressure; added to which, all these boilers should have two safety-valves, one at least of which should be of dead-weight construction, and not placed inside the boiler, where it would be out of sight, but outside, so as to be both above-board and accessible; while the constant recurrence of primary rents in boilers through unguarded manholes, of which the present explosion is an additional illustration, must be the apology for repeating the oft-reiterated recommendation, that all these manholes should be strengthened with substantial mouthpieces.

From September 22nd to October 26th, inclusive, the following explosions occurred:—September 25th—Ordinary single flue or "Cornish," internally fired, 7 persons killed, 2 injured. October 5th—Portable agricultural, internally fired, 1 killed, 7 injured. October 8th—Marine, 2 killed, 2 injured. October 9th—Portable vertical, internally fired, 8 killed. Total, 18 killed and 11 injured.

Not one of the explosions given occurred to boilers under the inspection of this Association. I have visited the scene of the catastrophe of the two that were most disastrous, viz., that which happened on September 25th, and resulted in the death of 7 persons, as well as in injury to 2 others, and also that which occurred on October 9th, and by which 8 persons were killed. I am not able, however, to give full details, but may state that neither of these explosions arose from shortness of water or corroded plates. The first was an ordinary Cornish boiler, 4 feet 6 inches in diameter, and failed in the external shell at a brittle plate. The boiler in the case of the latter explosion was a small vertical one, internally-fired, and most improperly equipped, having but a single safety-valve, whereas there should have been two, while the one with which the boiler was fitted was of a most dangerous construction. Also the manhole was not strengthened by any mouthpiece, and the boiler burst at that part. This is the second boiler of this class and by the same maker which has recently exploded with fatal results, so that it deserves serious attention. The details of both these explosions are important, and I hope to be able to give them at an early opportunity.

APPARATUS FOR SAVING LIFE.

The inundations that have recently taken place in France have shown how very necessary it is to establish a communication, by some simple means, between two points rendered inaccessible by the water. M. Gustave Delvigne has invented an arrow to carry a line that may be easily used to render assistance in such circumstances. There are everywhere a great number of guns available, either muskets of the soldiers, carbines of the gendarmerie, or fowling pieces. The average calibre is from 17½ centimetres to 18 centimetres. This arrow, for the purpose of carrying a line, consists of a rod of wood 1-10 to 1-20 metre in length, and 14 to 15 milimetres in diameter, of ash, or any other flexible and straight grained wood. At the end which rests on the charge a copper ferule is fixed with a small pin, 15 to 20 millimetres in height, and half a millimetre less in diameter than the calibre of the gun. This ferule thus forms a protection, a stop at the back of the arrow. In urgent cases this stop might even be made by a little pin driven through the wood. An arrow thus prepared would weigh 180 to 200 grammes. For a fowling piece, the barrel of which is shorter, the weight of the arrow is reduced by a third, and also the charge of powder. At the front of the arrow is placed a loop, formed by the end of a line of about 60 centimetres in length, firmly fastened by means of splice or a ligature. At the middle of this doubled line two strong ligatures are made with fine twine, so as to form a ring clasping the rod tightly. In this manner the doubled line forms two loops of equal lengths on each side of the ring. Below and against this fastening a noose is formed with the end of a line of the same size, with five or six turns tight round the rod. Finally the line to be carried is fastened to the loops. This line 100 metres in length, and from 2½ to 3 millimetres in diameter, is wound on a conical mandril, which is taken out when the ball of line is completed, and the end within the ball is that which always should be attached to the arrow. If necessary the balls of twine sold by the rope makers, and which are easily unwound from the interior, may be used. This done, the gun or musket is then loaded with a charge of from 2 to 2½ grammes of powder (about half an ordinary charge), then two good wads of felt are rammed in, or else a strong paper wad. The arrow is then put in (the wood of which should be first slightly greased), and is well pressed down to the wad. The gun is pointed at an elevation of 25 to 30 degrees in the direction required to send the line. In the firing, the fastening and the noose slide stiffly the whole length of the arrow as far as the projection or stop on the ferule. By this means the inertia of the line to be carried is gradually checked, and the shock that would be liable to break the line is prevented.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

OPENING ADDRESS BY THE PRESIDENT,

ALEXANDER J. B. BERESFORD HOPE, M.P., LL.D., F.S.A.*

Having by your kindness been for the second time called to the chair of this Institute, I have again to open the annual session, and to review the position of the Society in regard to the noble craft of which we are the accredited representative within this realm. My task is, under one aspect, more easy than it was last November, because, from having been personally engaged in all the work of the Institute during the past session, I can speak with the confidence engendered by personal responsibility. On the other hand, that responsibility makes the second year's address a more difficult enterprise to him who has the honour to deliver it; for when he makes his first appearance he comes forward with something of the assurance of an invited lecturer; the second time, he appears as an official, bound to show cause for what he may have performed in behalf of the Institute during the past period, and to plead indulgence for all that he has neglected.

To begin with a purely domestic matter, I have to congratulate you upon the doubt which may have existed as to our right to prefix the vocable "Royal" to our style, having been solved by Her Majesty's own gracious and direct permission to use the appellation. This session will be marked by certain alterations in our *personnel*, which are needed to give more efficiency to our

* Delivered at the Ordinary General Meeting, November 5th, 1866.

operations. It will not become me to say more upon this head than to assure you that, while fully convinced of the desirability of the change, I almost regret that we shall no longer show the world the example of so much done by a staff so nearly honorary in all its organisations.

Last November I referred to the relative functions of the Institute and the Royal Academy. The intervening year has been eventful for the latter body, for 1865 had not closed ere the chair of the Academy fell vacant by the decease at Pisa of its beloved and honoured President, Sir Charles Eastlake. Of the merits of that admirable man it is hardly necessary that I should speak to any who enjoyed the privilege of his acquaintance; but our transactions, I trust, penetrate beyond our own circle and island, and I should regret that this address did not contain our formal valediction of one whose name will long endure among the famous men whose praise is written in the history of British Art. The distinguishing characteristic of Sir Charles Eastlake's bearing, was a certain sweet and grave judicial evenness; kindly but firm, choosing with deliberation its time for speaking, and speaking then in the tones of one who claimed attention in right of his knowledge and forethought. A man so gifted, was of course eminently suited to be an efficient administrator in difficult times, and such were the latter days of the last President of the Royal Academy. Sir Charles Eastlake's place has, I am glad to say, been filled by the election of an Academician who has shown himself a vigilant sentinel of artistic independence, at a crisis which has put his courage to the proof. It is not many months since the attitude of art politics in regard to the Royal Academy and to the National Gallery was an object of anxious thought to all impartial bystanders. The late Government was desirous, to its credit, to terminate the long paralysis which had crept over the material future of the Royal Academy and National Gallery. It made its policy hinge on the expulsion of the Royal Academy from the building in Trafalgar-square, which was then to be transferred in its entirety, with something more, to the National Gallery. The administration had not very long before advocated a different policy, and proposed, while leaving Trafalgar-square to the Academy, to build a National Gallery in the garden of Burlington House. The sincerity of my regret at the failure of this scheme will not be doubted, because Lord Palmerston's Government was induced to reconsider the proposal by pressure from the party with which in political questions I am accustomed to act. But art ought not to follow suit to general politics. The edict of expulsion had gone forth, and a new position was offered to the Academy somewhere upon the site of Burlington House and of its grounds, on terms so lax as to involve either the destruction of its garden, which nobody wants to keep, or of the house and colonnade, which would have been a decided architectural loss. Happily, as events have proved, for the preservation of that monument of eighteenth century architecture, but at the same time somewhat inexplicably as far as its own interests are concerned, the Academy, after a little hesitation, declined the Burlington site. Then there spread a rumour that a large area at South Kensington was placed at the disposal of that body on advantageous terms. The offer was undoubtedly liberal, and there might have been reasons for closing with it; but the scheme was obviously unpopular, because its essential element was the removal of the existing exhibition of modern pictures from the centre of bustle and population to a spot which its best friends cannot deny is both suburban and exclusively inhabited by gentlefolks. An episode intervened of an unsuccessful attempt to induce the House of Commons to revoke the decision to which it had come in 1864, while, in the meantime, the Burlington House gardens site had been reduced by the cession of its northern frontage, lying between the Arcade and the Albany, to the University of London. Still between Burlington House itself and this proposed building, ample room existed, not perhaps for the construction of a National Gallery, but for the purposes of the Academy, while Lord Burlington's own mansion stood available for offices and vestibule. Accordingly, at the close of the session, the Academy, while finally declining to move to South Kensington, expressed itself willing to accept this space, subject to the retention and adaptation of Burlington House itself, leaving to the Government to keep and utilise the other buildings flanking the courtyard. The Academy galleries are in the hands of one alike honoured here and amongst our distinguished allies, Mr. Sidney Smirke, while the courtyard and flanking buildings are entrusted to the able manipulation of Messrs. Banks and Barry, who will have to consider the conversion for the uses of various learned societies of the two flanking wings, the curved colonnades, and the solid screen towards Piccadilly. The decision to which they may arrive is, of course, the business of the First Commissioner of Works. As to the treatment of the wings there can be but one opinion—namely, that those structures are the great blot of the whole composition, and ought under any circumstances to be rebuilt. On the contrary, the demolition of the colonnade would, I venture to say, be artistically a great misfortune; whether or not it be a necessary sacrifice to the Baal of economic retrenchment, this is not the time nor the place to settle. The screen towards Piccadilly being heavy, though symmetrical in composition, and physically obstructive, is unpopular with the public, and its removal or vital alteration seems settled. Against the expediency of freely handling this member of the group I have not a word to say; while I think it due to the taste of those who built it to observe that for their object, namely, the construction of a wall to serve as a complete screen between a private house and the street, it is a work of architectural merit. Our age is less exclusive, and the house is to become a public and not a private building. Nevertheless, if one of our contemporaries were called upon to build a veil-wall, it is quite within possibility that he would produce something quite as heavy as and less thoughtfully balanced than this often-abused screen. In spite of the physical proximity of the new University of London to the Burlington House group, it is impossible to conceive any two structures which it is more absolutely impossible to comprehend in the same view, and therefore our friend Mr. Pennethorne, to whom it has been entrusted, has wisely undertaken to carry out a totally independent design.

When the Royal Academy finds itself established in a mansion of its own, and master of its own times and actions, it will act with wisdom if it sets itself to consider seriously the position in which it annually places itself by adhering to the programme of an architectural exhibition which meets with so limited a response. I blame no one; I willingly admit that better success in Trafalgar Square might have been impossible; but we look for and claim other things at Burlington House. In the meanwhile, the Architectural Exhibition, which is our own co-tenant under this roof, having made a fresh start, with a new constitution, merits our best wishes and hearty co-operation.

I revert to the National Gallery. The result of the late Government's decision was to fix its permanent home in Trafalgar-square, and after the discussions of the past session, this result remains unchanged. Fortunately, there is but one opinion in or out of Parliament, that neither in size, arrangement, nor external appearance is the structure worthy of its destination, even after the appropriation of the half now used by the Academy. The one grand feature, Wilkins's double central hall, fell a victim some years since to an energy of patching emanating from Lord Palmerston's Government. The purchase of the workhouse behind the Gallery, of Archbishop Tennison's school, and of several houses, combined with the removal of the barracks, is a costly method of meesing the objection which exists against the physical capacity of the existing pile to contain a collection which our just national pride leads us to hope will not in the twentieth century be depreciatorily quoted after Rome, Paris, Dresden, and Berlin. However, we have met here to-night as artists, not tax-payers, and so we do not complain of this expenditure. It will be an outlay that will show results for the money spent, for with the addition of that area an ample space will have been obtained for the Gallery, with means of securing a magnificent façade towards Trafalgar-square. This opportunity of reforming the north side of Trafalgar-square, as I may notice by the way, is an advantage which would have been equally within the power of, and which would have been made compulsory on the Academy, had it been fortunate enough to have retained its present position. The mass of building behind will of course be a contribution to London interiors, but not to the artistic aspect of the streets. The late Government was sufficiently awake to the importance of the undertaking to determine upon selecting the architect by competition, and it further decided on a limited competition. I know too well the delicacy of the subject to risk making this the opportunity for raising a discussion on the comparative merits of limited or unlimited competitions. There is one stage in the discussion on which all who care for architecture must agree, and upon which this Institute made its formal stand when called upon to have an opinion in the course of the discussion of last session. Those who support and those who oppose competitions, those who wish competitions to be unlimited, and those who prefer that they should be limited, must all agree that when a competition exists and is not unlimited, there has arisen the necessity of a sufficient number of competitors being invited to secure the undertaking being alike advantageous to architecture, to the public, and to the object in view, both in the stimulus to art which such a competition is designed to give, and in the good results of a building of which the city in which it is to stand and the nation may be justly proud. The competition for the National Gallery was to be a double one, each competitor having to tender a project for the alteration of the existing building, and also for a completely new design, and the number of candidates originally named was six. It happened that in the other great competition of the year, that for the Law Courts, the number six had also been selected. The Council felt that in neither case was the number sufficient; but there were certain complications in regard to that for the Palace of Justice which did not exist in reference to the National Gallery, and we accordingly thought it wiser to limit our formal petition to the House of Commons (which I had the honour of presenting) to one in favour of extending the number of competitors for the Gallery, with, however, a manifest spirit of desiring to cover the entire controversy. Independent members of the House of Commons took the question into their own hands as regarded the Law Courts, and the broad result is that for either building a selected list of twelve eminent competitors was arranged; and that the double adjudication upon their designs will no doubt be the great architectural event of the coming session. I may observe, that in the course of the parliamentary discussion, I ventured to throw out, with all diffidence, the question of the possibility of the adoption, under certain circumstances, of a system of competition combining the principles of limitation and openness, by retaining a selected body of invited competitors, and yet permitting those architects who liked it, at their own risk, to enter the lists against the chosen few, with no claim for remuneration on account of work performed in getting out their drawings if unsuccessful, but with an equal one to be named if most deserving, for the actual construction. I do not here press the notion, though I have recurred to it as a subject which may be worthy of the attention of the Institute, guarding myself by the premise that I suggest it as for the present necessity, and not as theoretically and ideally just and desirable. I moved the House of Commons to reverse the decision of two years since, which closed Burlington House to the National Gallery. The success of that motion would have been fatal to the Trafalgar-square competition, and yet I had been working in your name and my own to make this competition broader. Still, I venture to plead that there was no real inconsistency in my proceeding. On general principles of art policy, I was led to the conviction that a certain scheme was faulty, and I opposed it accordingly. Faulty, however, as the scheme might have been in its broader aspect, it carried with itself the incidental benefits which might accrue from the competition. So long, therefore, as the scheme was a *fait accompli*, as it is now destined to be, it has been, and it will be, my duty to deal with the incidents of the new building in Trafalgar-square as a question to be treated within its own four corners with a single regard to the advantage of that building in itself, and in relation to the site which it occupies.

I was just observing that there were certain complications attaching to the competition for the new Law Courts. These were of an administrative character, and owed their origin to the fact that the Government had handed over no inconsiderable portion of the control, which in the case of most public buildings would have been shared between the Treasury and the Board of Works, to a Special Commission, created by act of Parliament, and comprising a large infusion of the legal element. These gentlemen set to work with a very sound principle strongly before them, and, as was not unnatural, rode that principle a little hard. They assumed that the successful architect (or architects) ought to have made himself practically acquainted with the working of the different courts of law, and the inference which they drew from this undeniable proposition was that it was needful for them to be excessively restrictive in the number of competitors chosen, in order to prevent the business of the courts from being interrupted by the frequent visits of curious investigators, and so they drew the line at six. This was palpably, in the eyes of all men except the Commissioners themselves, an extravagant application of their principle. Not to allude to any other objection, this restriction manifested considerable confusion as to the artistic obligation, contracted with the national honour, to produce the best attainable building. However, it required a vote of the House of Commons to overcome the reluctance of this most respectable Junta. The majority in favour of extending the number was decisive and totally devoid of party complexion, and the Commission of course capitulated. So the number was raised to twelve, while a parallel extension, indirectly occasioned by that division, enlarged, as we have seen, the list of competitors for the National Gallery to the same limit.

Last year I had occasion to express my anxiety that the coming Palace of Justice might be worthy of its destination and of the empire. This year I can confidentially say that the list of competitors gives the material guarantee that the building will fulfil the expectations of artistic patriotism, provided only the judges show themselves competent, and Parliament, in years to come, is wisely generous enough not to grudge the necessarily large sums requisite to bring so grand a work to its legitimate completion. I have, I feel, lingered somewhat long upon this subject. But it is one of so much importance, not only in regard to the buildings affected, but to the great question of the relations which ought to exist between architecture and the executive, that I have no reason to offer any apology for making it a prominent topic in this address.

I have now to call attention to the prospects of British architecture and of the cognate arts at the coming French Exhibition. You need not that I should repeat the history of that joint committee of this and other architectural societies which has, I believe, in some form or other, come before almost every meeting during the past session. You know that, after many incidents, mainly traceable to the tenacity with which the French authorities, who are, of course, supreme, have, true to their national character, clung to their own system for regulating the details of other countries, our committee has been recognised by the British Commissioners as the body on which it relies for accomplishing the Gallery of British Architectural Drawings in the Fine Arts Department (Group I.), and also (though with a less degree of official recognition) as organisers of a Court of Manufactured Productions referable to Architecture and the Cognate Arts to be comprised in Group III. Our committee was disapointed at finding that we could only have allotted to us a space of 1,000 square feet in this third group. However the Ecclesiological Society obtained 700 square feet more, and by the terms upon which the joint committee was constituted, this allotment was handed over to the common stock, while the authorities at South Kensington promised to forward our views by placing the two allotments so close together as to enable us to mould them into one court. More recently, however, we have learnt that in return for this facility, the joint space has to be reduced to 1,428 square feet. Remonstrance would be needless, and so we are exerting ourselves to make the best of what we have got. But out of these arrangements has grown a project, of which I am grateful to say that we owe the suggestion to Mr. Cole, which promises to be alike useful and full of interest. The tale of designs which we shall be able to exhibit at Paris will be comparatively small, while the number we should desire to send will be proportionately very numerous. In face of this difficulty the South Kensington authorities have undertaken to arrange for us a preliminary exhibition in London, commencing at the beginning of December, in the spacious range of galleries at South Kensington, which were during last summer, and will again next season, be occupied by the National Portrait Exhibition. The space is vast and the time convenient, and so we anticipate the opportunity of bringing together a mass of contemporaneous architecture such as has never before been put in the power of the English public to study. Those who hope to appear at Paris are invited to conform themselves to certain necessary and pressing regulations of size, but the committee desire it to be known that they do not regard this exhibition as a mere tasting trial for Paris, but as one possessing a national character and scope of its own, and which therefore need be only limited by the space at their disposal. It will, it is expected, contain many designs tendered for Paris, and it will also embrace designs sent to be viewed in London. A comparison of the list of the Institute, as it stood at the close of last session, with that of the year preceding, will show a considerable increase in the section of Honorary Fellows. I think we ought to regard this circumstance with satisfaction, not so much for the material advantage which it is to our body, but for higher considerations, on which I shall not be deterred from dwelling, because, when out of this chair, I myself belong to that order. What is an honorary fellow? Technically and literally he is the partner in a bargain, of mutual convenience to himself and to the Institute. Morally, however, we may, I hope, see in every new honorary fellow a fresh convert to the importance of our noble profession, a fresh pledge that in the construction of all and every building, science and art shall bear their due proportions. It is no doubt the duty, as it is the interest, of the architect to please his employer, so far as he can do so without sacrifice of self-respect. It is equally his duty to see that he is respected by that employer, in the same way and for the same reasons that the lawyer or the physician is, because the employer is convinced that the architect's technical knowledge carries with itself the guarantee of successful results unattainable by untrained cleverness. Now then, although a little learning is a dangerous thing where the half-taught empiric himself sets up as a practitioner, it is not dangerous in the hands of the man of sense, who is satisfied to appreciate and not to practise. On the contrary, it enables him to understand the value of things which are as sealed books to the wholly uninstructed. Applying this truth (I fear I should say this truism) to our own case, I contend that it is for our direct benefit that the knowledge of the general principles of architecture should be as widely diffused as possible among the educated classes. The time has as much passed away for our profession as for any other to be a mystery. We are constrained to live—and well it is for us to be under this constraint—in the broad daylight of general criticism, sometimes intelligent, sometimes prejudiced and ridiculous, but even when most prejudiced and ridiculous, far more tonic and useful to us than the ignorant silence of a careless and indiscriminating age.

This criticism—to use the word in its largest sense, as including oral no less than published opinion—we may make our own, or we may exasperate according as we show ourselves, on the one side proudly impenetrable or testily thin-skinned, or on the other, genial and tractable, but withal assured and tenacious of our principles. We build, it may be for our own fame, but also for the use of all that remainder of the world who are not architects; and, as those who use have a plain right to criticise, so it is far better for them to believe that their opinions will reach and be considered by the men on whom they are passed, than to imagine themselves prejudged to be gainsayers and malignants. On these grounds I congratulate this Institute upon the liberality of that provision in its constitution which admits the unprofessional element, and thereby truly makes us what we never should forget that we are, and what we should resolve never to cease to be—an academy of architecture as well as an institute of architects. The financial conditions which we impose upon the honorary fellowship, and the test of proficiency which we desire for honorary membership, if duly attended to, are sufficient to prevent the professional backbone of the Institute from being enfeebled by a liberal interpretation of the provisions of our charter, which leaves it at our discretion to replenish those two classes without any fantastic limitation of numbers. In one detail only I would wish the charter had been somewhat different. If the Honorary Fellow deserved from time to time to be called to the Chair, I regret that the same privilege should not also have been secured for our Honorary Members.

It will not be out of place, in reference to the co-operation of professional and amateur lovers of architecture, if I dwell a little upon the relations which have existed hitherto, and upon those which I should be glad to see established, between this Institute and the Architectural Museum, or else some organisation fulfilling the duties of that Museum. The Architectural Museum, as I am sure you will all bear me out in saying, grew out of a real and acknowledged want. It was founded, in 1851, to meet a necessity which was even then palpable and increasing, and which has in the few intervening years become even more urgent, owing to the growth of national wealth and of artistic literature, both of them combining in a remarkable manifestation of architectural luxury. Sculpture was then beginning to revindicate its rightful prerogatives as the first handmaid to architecture, and the need was pressing for a trained school of architectural carvers of a higher grade than mason's men, but still unencumbered with the usual apparatus which has grown up round the professed sculptor. Primarily no doubt, in the purview of the founders of the Institution, the demand was for a staff of carvers of Gothic stonework; but still, above all, of carvers who should show some perception of expression, and of anatomy, when called upon to place a figure upon a building, irrespective of the figure being draped in toga or whimple, or left to the light simplicity of nature. The necessity of an improved school of wood carvers was, of course, equally apparent, and came alike within the scope of the undertaking. Two things were requisite really to set up such an institution in working completeness—a good collection of examples, and systematic teaching. Of these the collection was the one which it was easier to provide; for its rudiments existed, partly in the specimens possessed by private hands, and partly in the facility with which the casts of desirable examples could be obtained. Systematic teaching, on the other hand, involved the organization of a staff of masters, while the class to be instructed was not one which it was very easy to bring to school. Accordingly, the new institution came into existence as the Architectural Museum, and not the Architectural Academy, with a great many casts, and a picturesque cock-loft wherein to store them. At the same time, as much teaching as could be drawn from the unsystematic friendliness of volunteer and often amateur lecturers was superadded; and prizes to art-workmen were set on foot. Out of all these elements the complete intended Architectural Academy of Art might have grown up, if only sufficient funds had been forthcoming. But the financial shoe never set quite easily upon the young museum, and, after a short though spirited period of independent existence, it succumbed to an arrangement which it would have been Quixotic, under all the circumstances, to have flouted, but which from the first has proved a source of numberless complications. You need not be told that this was the morganatic alliance which the Architectural Museum contracted with the South Kensington Museum, whereby, in return for house-room and certain privileges, personal and financial, the private made loan of its property to the public institution. Of this connection with the South Kensington Museum I have no desire (as an officer myself of the Architectural Museum) to speak in any other than grateful terms. There have been from time to time rubs, but we have met with a great deal of kindness and much material assistance. Still the alliance was one which carried within itself the seeds of failure, except upon one condition, in which indeed I never could see any antecedent or theoretic incongruity, but which, from first to last, through many accidents of negotiation, passed into every conceivable phase of practical impossibility. It seemed to us that—as the South Kensington Museum was expanding into a wide miscellaneous national collection of objects, both of scientific study and of art demonstration in its widest signification, divisible into many branches, and respectively capable of being independently administered—the Government (which assumed the direct control of the whole institution) might relax its bureaucratic grasp of one of those branches, and leave it to be administered, under due inspection, within the walls of the new Museum, by a private corporation. In the Council of the Architectural Museum a body of men existed, willing and able to become the curators and directors of a national collection of architectural art, while towards making up that collection both the South Kensington and the Architectural Museums were stakeholders of valuable materials. From the very first, however, my Lords of the Committee of Council turned a deaf ear to any such suggestion. They were anxious, as they told us, for an Architectural Museum, as an important component part of the great collection, whose name is borrowed from the suburb in which it has been placed, but the whole administration of that great and varied collection was to be, like the French Republic, one, indivisible and bureaucratic. They were ready to house the Architectural Museum casts, and to decorate those casts with a distinctive label of ownership, but in return we were to surrender them on loan. Of this condition of things, difficulty was of course, with the most friendly intentions upon either side, the inevitable result. The vital powers of the Institution—its capacity of growth—were smitten with paralysis; for how could it even procure fresh specimens, when on the one side we could not be sure whether those would be well received by our hosts; and on the other, whether those hosts might not themselves be intending to take the same casts, to the saving of our own private purse. The result was that while our individual casts continued, for many years, to do good duty as models for study at South Kensington, they did so not as a valuable and distinct constituent contributed by private enterprise, but as scattered fragments of the general amalgamation of noticeable objects. The hearts of its real proprietors were chilled towards the collection in itself, while with a genuine anxiety to do justice to their favourite study, and to those whose contributions they were inviting, they virtually resolved the museum, while still retaining its now somewhat incongruous appellation, into a committee for providing popular lectures at South Kensington on architectural subjects, and for stimulating the zeal of art-workmen by annual prizes. The lectures, many of them by persons of considerable eminence, were very miscellaneous in subject and treatment, and the audience comprised members of most diverse social classes. Accordingly they did much unsystematic good, in cultivating art-feeling, alike among the easy and the working members of the community. The prizes, also, which ranged over every description of art-workmanship, have, upon the whole, decidedly tended to raise the workman standard, and to consolidate personal intercourse between employer and employed, though more than once the particular result of the year's competition has been a disappointment. Such has been the so-named Architectural Museum, in the days of its intimate connection with South Kensington. That connection is now to be severed, as far as the collection goes, and the society has for itself secured an advantageous site whereon to build its own abode, close to Westminster Abbey. The lectures and prize giving may or may not be still continued at South Kensington, supposing the body to maintain its independent constitution; but for all practical purposes I believe that the Architectural Museum might advantageously abdicate a separate existence, if only some more powerful institution could be found willing to undertake the various duties which it has hitherto discharged. It is, I suppose, no secret in this Institute that a conference necessarily informal, was held during the late session between members of our Council and representatives of the Museum, to consider whether the Institute could not so far expand its organisation as to cover the ground from which the Museum might then gracefully retire. This conference did not meet with the intention of coming to any definite resolution; and it therefore deliberated with freedom, and broke up, I believe I may say, with the general idea that there was nothing impossible about the project—provided only that due care were taken not to hamper either the general funds or the chartered functions of the Institute by new and voluntary responsibilities. It would be clearly to our own credit and dignity, and to the advantage of architecture, if we were the possessors of a museum of architectural specimens, whether under this roof or in other convenient premises. All that would be needed would be some moderate distinct income from subscription or endowment sufficient to make it reasonably probable that no calls would be made upon our statutable revenue. We should, I am sure, be all of us glad to be the managers of some series of lectures of a more popular character, and appealing to a more miscellaneous audience than our formal course of annual papers, provided only those lectures did not starve or hamper the papers; and I think we should none of us refuse the trouble of adjudicating prizes for those art-workmen on whose proficiency we are so dependent for the satisfactory effect of our works, if only the donors of those rewards put it in our power to distribute them according to regulations made in concert with our Council. Why then not fairly see whether the time has not come for a popular development in these three directions? Each would have to rely for the sinews of war upon its own separate account; of which the lecture and the prize accounts, at all events, need not be very large, and that for the collection might, to a considerable extent, be self-supplying, through a system of moderate fees. Each might be worked by a separate committee, on which a certain number of our honorary fellows and honorary members might be invited to act, so as to give that portion of our body some share of administrative work, without trenching on the provision of our Charter which leaves the government of the Institute itself in the hands of its professional members. When I add that among the governing body of the Architectural Museum are found many of those whom we most honour and respect in this room, I have said enough to show how easily the change might be made. The Architectural Museum would, I believe, gladly, and without any haggling, hand over its collection to the Institute, happy to terminate its separate existence by so useful and so honorable a *euthanasia*.

You will, I conclude, have noticed the programme of prizes for the forthcoming year which the council has proposed. I beg briefly to direct your attention to two out of the lists of subjects. The first is the prize which we offer for the best design for a Gothic theatre. The affection which I bear for Gothic is a secret to no one, and I should be sorry to deny it, for I have striven not to let it interfere with the duty of equal administrative justice towards the wide world of architecture, irrespective of school and style. I may accordingly, without risk of being misunderstood, say that I shall look upon the responses which this proposal may elicit with peculiar interest. In the first place, I regard it as the assertion of the sufficiency (I do not say superiority, but sufficiency) of Gothic for any constructive need, secular as well as spiritual, recollecting, as we do, that men did not only pray but also did work, think, govern, and play, from the eighth to the seventeenth century. But in the second place—here speaking an individual opinion—I look upon the peculiar adaptability of Gothic to the modern theatre as a point which our modern Gothic architects have either overlooked or have not had the opportunity of developing. Everyone knows the type of the Classical theatre; a daylight place, with its receding rings of open benches, its official allotment of seats, and in Greece, its connection with stated religious festivals. The modern *salle de spectacle*, on the contrary, when true to its own type, is a chamber to be used by artificial and not natural light; in which the general community does not assemble at any stated times and in corporate array, but by person, or by family, when and as it likes. Now, then, what structure best responds to this demand out of the various forms in which the modern theatre has been cast? it is one in which the necessary tiers of boxes stick out like trays from the wall, or that in every lower story legitimately throws up its shafts to support the one above? No one who considers the question can hesitate to accept the latter, both for beauty of appearance and constructive excellence. Now, then, where do we find the nearest example of such curvilinear mid-air galleries? Not in the theatre of Bacchus, or of Pompey, but—let no man charge me with irreverence, viewing, as I am, the question from a purely constructive standpoint—in the triforium which encircles the asp of some cathedral of the thirteenth or fourteenth century! No doubt the shafts will most often be of metal, but a metal triforium is a development of which the idea may be more readily found in a stone triforium than in a semicircle of receding benches. For these reasons I venture, in the name of progress and eclecticism, to call on all here present to aid in vindicating the theatre no less than the church as a legitimate object for Gothic treatment; at the same time I conjure the competitors to consider seriously how they may reduce the risk of fire.

Another of our prize subjects was suggested by the proximate meeting, of which I shall have something to say further on, of the Archæological Institute in London. It is the restoration of old St. Paul's Cathedral. The materials for the competition will, as all our students are I trust aware, be found in the vigourous engravings with which Hollar illustrated Dugdale's History of that cathedral. In them enough is given to provide the key to every portion of the church, as it existed in the days of Charles I. and the Commonwealth, but no one feature is depicted with an attempt at what we recognise as architectural accuracy, while the structure itself that is exhibited is St. Paul's after generations of neglect, and the destructive restoration perpetrated by Inigo Jones. Enough, therefore, exists to give sure guiding, and not enough to reduce the work of the sagacious and erudite student to the servile labour of a simple copyist and compiler. It would be I am certain, a great satisfaction to the Institute, if any set of designs were sufficiently good to justify it in advising their author to publish the series, and thus bring back to the minds of our generation the details of a minster, which, as I believe, from its noble length, the solemn Norman of its nave, the developed and rich Gothic of its choir, and the majesty of proportion which the English system of a square east-end was carried out must have been more like Ely Cathedral than any other of our known great churches.

The recollection of old St. Paul's naturally leads to the general question of the conservation of ancient monuments, which we have wisely and boldly claimed as a portion of our stated mission by the appointment of a committee specially charged with this department. The case in which its exertions have come most prominently before the public during the past year has unfortunately not been one on which we can report a very successful issue. I mean the protest which, in common with other societies, we addressed to the authorities of Lincoln Cathedral against the deplorable scraping of their noble minster. Out of this protest, not from our fault, nor from the fault of those with whose judgment we coincide, has arisen an acrimonious personal controversy. I, therefore, refrain from entering further into the details of the calamity. But, without trespassing on the dangerous ground, I think we may profitably draw from it some general lessons of an encouraging character. Granted that Lincoln Cathedral has been spoilt, it is at all events some consolation to observe that so many sections of people have so intelligently observed, and so strongly protested against, the precise manner of its spoiling. No State-restored public building on the continent would have been so defaced by authority with the reclamation of more than a few uninfluential opposition archæologists. Thirty years since in England itself an outburst of indiscriminate scraping would have been accepted by clergy and commonalty and antiquarians alike, as a proceeding stamped by unquestionable good taste and reverence for antiquity. I am well aware that since the era of restoration set in, a suspicious and not always quite amicable feeling has some times been manifested between the archæologists and the restorationist school of architects. The archæologists looked upon the architects as somewhat destructive, and the architects treated the archæologists as rather obstructive. Happily the antagonism is now at an end, or I should not have alluded to it. There was, I fully believe, some room for either suspicion. Archæologists were at one time impracticable and architects reckless. Human nature would not have answered to its own identity had not these phenomena been observable. The formal recognition of the pacification came from the side which was originally the alarmist one—that of the archæologists, and it, therefore, carries with itself the elements of stability. The site was in the churchyard of Sherborne Minster, and the speaker was Professor Willis, at the Dorchester meeting of the Archæological Institute, in the summer of 1865. It is not an uninstructive illustration of this declaration that those who have most loudly protested against the Lincoln restoration have been leaders of the restorationists' party. In other places our intervention has been efficacious. The stone choir screen of Christchurch Priory, Hampshire, necessary as it is to the impressive and nearly unique choir of that fine church, has been saved, for which, in the first place, we owe our thanks to Mr. Ferrey. The church of St. John, Leeds, very noticeable as being in its structure a grandiose and picturesque example of the revived Gothic of the seventeenth century, and in its woodwork one of that English continuation of Cinque-Cento, which is usually known as Jacobean, has also been rescued from the destroyer, and will, I am sure, in the hands of Mr. Norman Shaw, present a true example of conservative restoration.

Another question, involving as it has done a matter of professional practice, as well as of the preservation of a very valuable ancient monument, has been taken in hand by the council. I mean the treatment by the Corporation of Bristol of the prize designs by Messrs. Godwin and Crisp for the new Assize Courts of Bristol, and for the preservation within them of the mediæval house known as Colston's. I believe that the best preservative against the repetition of such scandals as have discredited that and other competitions is that more general acquaintance on the part of the public with the principles of the architectural profession which I have already had occasion to advocate. So long as the arrogance or greed of the patrons of any competition finds itself supported by the uninstructed public opinion of persons who have never yet really learned to treat architects as gentlemen or men of sense, so long will the scandal continue. Let the world give the architect his true status, and then he will find himself the master of public opinion, not its enemy. Might it not be worth our while to publish some paper bearing the official mark of the Institute, short enough for the general newspapers to give it insertion, and clear enough for everyone to understand, in which we lay down certain general rules of competition, outside of which no architect can compete without losing caste, and no patrons institute a competition, and be able then to say that they had acted with fairness and generosity?

But I turn to a more agreable topic, and I invite you to record your gratification at the commencement of a work of restoration which, alike for the beauty and value of the structure itself, and for the national character of the enterprise, deserves especial commemoration. You will anticipate that I am speaking of the Chapter-house at Westminster, and will not require any description or encomium of the building. The cheerful unanimity with which the House of Commons recognised its responsibility towards the chamber, in which for more than half the existence of that august assembly, it had been wont to gather, must be noticed as an eminent example of that wise love for antiquity to which the English people hold fast. To Dean Trench, who originated, and Dean Stanley, who carried on the movement, must be accorded the tribute of our hearty thanks for their substantial good services. It was pleasant to observe that when once the squalid fittings intruded into the last century for the use of the public records had been removed, and the vestiges of the Chapter-house stood out again revealed, so much of the old work should have been found to be either still existing, or traceable from sufficient indications. Mutilated as the chamber was, it proved to be essentially the Chapter-house of Westminster, and not any modern trespasser run up within its walls. Accordingly the restoration is a matter of plain and easy architectural induction, while no doubt Mr. Scott will exercise a tender and conservative caution in his retention of the very stones and carvings of the thirteenth century, where the votaries of the French school of clean and perfect sharpness would have ruthlessly substituted that which we should have been compelled to accept as modern fac-similes of originals smashed up in the mason's yard. It is interesting to recollect that the Chapter-house was cleared out just in time to enable its appropriate house-warming to take place, in the meeting there of the Archæological Institute to listen to the lectures of the Dean of Westminster, and of Mr. Scott, upon the Abbey. I ventured last year to forecast the London Congress of the Archæological Institute as one of the matters which ought to interest our body in the course of the coming session. I am now rejoiced to report not only that the congress showed itself to be a most valuable incentive to the philosophical study of architectural archæology, but that it afforded the occasion for an extremely gratifying fraternization between our own body and the Royal Archæological Institute—two societies with so much in common that a close alliance between them was plainly a thing to be sought and effected.

I must not close without repeating the regret which we have already expressed at the sad and sudden death of our very distinguished honorary member, Dr. Whewell, late master of Trinity College, Cambridge. His is the only loss last year of a very eminent man within our own body, while English art has had to mourn the decease both of Sir Charles Eastlake and Mr. Gibson. The Pugin travelling studentship, intended to maintain, in memory of the great man whose name it bears, the study of mediæval architecture, is now, I am glad to say, firmly rooted. It has been twice adjudicated. The first time only one claimant appeared, and so Mr. Tavenor Perry won it without a contest, while by the paper which he produced as its fruit, he has shown himself full worthy of the distinction. This year we had several competitors, with such a good array of well-founded claims as to make the adjudication a question of substantive consideration.

I have mentioned some prominent questions affecting our pursuits, which came before Parliament during the last session. Other matters also engaged its attention in which we are more or less interested; among them the improvement of the dwellings of the labouring classes stands first. The wholesale demolitions perpetrated by different railways in London and other towns was the main cause which led the legislature to turn its attention to the subject. Let us trust that it will be one upon which the eyes both of the upper and the middle public and of the Government will be ceaselessly directed, for it is one in which, as a nation, we have as yet failed in our duty, both to our fellow creatures and to ourselves—to our fellow creatures as it is a matter of humanity, to ourselves as it is one of general health. I have also to notice the care taken for the protection of the integrity of the public parks and open spaces in and about the metropolis, noticeably shown as well in a general bill as in the resistance made to the erection of gasworks in dangerous proximity to Victoria Park. What remains of Epping Forest is also to pass into the category of public parks, from being transferred from the Office of Woods and Forests which only regards the financial value of its trusts, to that of Public Works, which deals with them for the general recreation and the decorative improvement of the ground.

At last the administration of the River Thames has been reformed, whether efficiently time will show, and also, I hope, rectify any improved efficiency. Beneficial as this reform is to the world at large, it carries with itself a special advantage to architecture, as it will render possible the vast system of metropolitan improvements which turns upon the quaying of the river, about which we have all no doubt thought so much, and will have no doubt still to think a great deal more. Let me in passing congratulate the Metropolitan Board of Works on having laid the first stone of the Southern embankment. One bill received the Royal assent, to which I should desire to call particular attention, as the first step towards the long-called-for opening between Whitehall and the Palace and Abbey of Westminster. This act only deals with the one wedge-like block, in front of the new Foreign and India Offices, whose apex is the Irish Office, but in this case the proverb about the point of the wedge will, I trust, receive its literal as well as its metaphorical interpretation. I refrain from recapitulating single buildings and monuments, however noteworthy, in various stages of progress; but the grandiose rebuilding of an entire quarter of the town by the Marquis of Westminster deserves especial commemoration. I gave reasons last year why I regarded our architectural future with hopefulness; to these reasons I am able to pledge my continued and increased confidence. True to ourselves let us only be, and no selfishness, or stinginess, or ignorance displayed by the world, which is so largely our debtor, can check the architecture of Great Britain in its onward course of great and rapid improvement.

Mr. M. Digby Wyatt expressed the great pleasure which he and all present must have derived from the President's admirable address, developing the features of the architectural movement going on around them. It was in the confluence of a multitude of different circumstances tending towards the general purification of taste in this country, that the professors and practisers of architecture might look forward with most confidence for the improvement of the art to which they were attached. On the part of some from congenital individuality, on the part of others from religious influences, and again on the part of a third section of devotees from dilettante or archæological promptings, there was an active, combined, and harmonious movement towards the general advance of art now going on in this country of the most auspicious character; and it was delightful to see by how many simultaneous impulses or efforts all these elements were conducing to the common end which they all had at heart.

Mr. James Fergusson, V.P., thought the President had dealt with the main subjects of interest of the day in a masterly manner, and that architectural art was attracting attention, not only amongst architects, but throughout the nation at large. People were no longer content with churches or dwelling houses of plain walls, pierced with holes, but ornamental art was demanded everywhere. They wanted men to think, men to appreciate, and men to demand, and when that combination took place progress was inevitable. With progress we would very soon be independent of Gothic, Greek, or any other style of art: the public seeing and learning to appreciate what was good would demand it and no longer be content with mere copies of extinct styles. He had no doubt the next ten years would witness such progress in architecture as would make it worthy of the nation and of the world. In that sense he felt grateful to the President for the able essay he had favoured them with.

Mr. George Godwin, F.R.S., was happy to re-echo one of the practical points which arose from the President's admirable address. It was with reference to the coming competition for the designs of great public buildings in London. He looked with the greatest anxiety as to the nature of the Committee which had to decide upon those designs. It was a most important point. Parliament would not meet before those designs were sent in: whether it would meet before the adjudication upon them took place he could not say. Therefore efforts through other channels ought to be made to obtain a proper court of adjudication. It was nonsense to expect three or four amateurs—whether noblemen, honourables, or simple members of Parliament—to judge of the merits of such designs as those which were going in. Such, of course, could only produce dissatisfaction, and it was to be feared bad results for the country. They had but to look at the constitution of juries on such matters in France. A certain number of literary men, a certain number of painters and sculptors, two or three men of intelligence representing the public, and a certain number of architects formed the jury. There was seldom any question as to the decisions of those juries; and with that fact before them, coupled with the further fact that almost every adjudication on public art-works here did disappoint the public, it should lead the ruling powers to appoint a proper jury in which the country would have confidence. He was therefore anxious that some course should be taken to appeal to Mr. Cowper. He believed Mr. Cowper was still a member of the Committee of adjudication, which was composed of a certain number of gentlemen for whom he had the highest respect, but to commit to them the final decision upon the plans for the National Gallery and the new Palace of Justice, could only ensure a failure. Therefore he thought some memorial should be addressed to the right quarter, asking for a proper jury to adjudicate upon this matter. On this subject he hoped he expressed the opinion of the members generally. Half a dozen other subjects of interest were embraced in the President's address: amongst others that of the Architectural Museum. That institution was parting from the Government; he regretted it, but supposed that it could not be avoided: they must not, however, part from the Architectural Museum. If the Government would not maintain it, the architects, the art-lovers, and the art-workmen of the country must do so. There was now an opportunity to put up a suitable building, and they must endeavour to find the money for it, and he favoured the notion hinted at of bringing this Institute to take charge of it.

A vote of thanks to the President having been passed by acclamation,

The President said he had received the greatest and highest reward that any author could do in feeling that what he had said had been acceptable to those whose good will and respect were so dear and precious to him. With regard to what had fallen from Mr. Godwin, he heartily echoed all which that gentleman had said as to the necessity for a proper tribunal to adjudicate upon the two forthcoming competitions. He would try to explain how the matter stood. He was afraid, unless some alteration were made by the present Government, those six selected names must be the stereotyped judges of the competition for the New Law Courts, as their appointment was part of a parliamentary arrangement. No judges, he believed, had yet been named for the competition for the National Gallery, but that the matter rested in the hands of the present First Commissioner of Works. He could assure them from what he knew of Lord John Manners, that the minister was fully alive to his responsibity, and that the most earnest and anxious care would be devoted by him in the selection of a proper tribunal of adjudication. At the same time Lord John Manners's hands would undoubtedly be strengthened by an expression of the feeling of this Institute such as had been suggested by Mr. Godwin—not worded as doubting his lordship's goodwill and desire, but as anxious to support him in appointing such a body of judges as would be satisfactory to the competitors and the public at large, and which would carry with it the earnest of a good building for the purposes to which it was to be devoted. The judges of the designs for the new Law Courts were nominated by Mr. Gladstone, Mr. Cowper, and Lord Cranworth. The Law Courts were to be carried out by a special commission named in the Act of Parliament.

Mr. Digby Wyatt suggested the propriety, upon the designs being sent in, of the lay judges so nominated procuring immediately a professional report upon them to assist the adjudicators in their labours. It was highly desirable that they should be put into possession of such information as an experienced architect could alone give them, not only before they should decide, but even, if possible, before they should commence their own examination of the drawings submitted.

Metallurgical Industry in Belgium.—The iron works in the district of Charleroi have for this year realised handsome profits, in spite of a slight augmentation in the price of labour, as well as in fuel. Great progress has been made in the manufacture of pig iron. Last year's production may be estimated at about 500,000 tons, of which scarcely 10,000 tons were exported, whilst on the other hand 25,000 tons were imported. Thus, the Belgian pig iron, which formerly served to supply the German and French iron works, is almost entirely used up in its own country. It is not now sufficient even for home consumption; and in general the trade has no cause to be dissatisfied with the reduction of import duties, that are now only 5 francs per ton. All the Belgian pig iron is worked up in the country, and it only goes out in the state of malleable iron. This is of considerable advantage for the blast furnaces, which in this manner are no longer tributaries to foreign markets. This indicates at the same time an extraordinary progress in French trade. Belgium, in 1865, exported 57,000 tons less, and imported 120,000 tons more than in the preceding year. Free trade and the facilities of transport have given an impetus to the mineral districts of France. The situation of the mineral industry of the Charleroi district would leave nothing to be desired if the low price of coal was maintained; but since the end of last year there has been a gradual rise, which begins to press heavily on manufacture. French markets for fuel are only obtainable with an augmentation of 20 to 25 per cent. on those of last year.

THE DESIGN AND ARRANGEMENT OF RAILWAY STATIONS, REPAIRING SHOPS, ENGINE SHEDS, &c.

By William Humber, Assoc. Inst. C.E.*

The rapid development of the railway systems in England and in other countries, has necessarily directed attention to the study of station arrangements; but the diversity of interests to be considered, the changes involved by a constantly increasing traffic, and the new and unexpected demands that have been made for accommodation, have prevented, in this instance, that general exchange of idea which has attended the progress of other branches of engineering. Hence the subject was not regularly brought before the engineering profession until a comparatively recent date: when, in 1858, a comprehensive Paper on railway stations was read at the Institution by Mr. R. Jacomb Hood, M. Inst. C.E.† So far as regarded terminal and intermediate stations, that paper touched upon most of the points of importance; but to one class—the arrangement of which is perhaps the most difficult of any that the engineer can be called upon to undertake—no reference was made. At New-street, Birmingham, there is a description of station neither entirely terminal nor entirely intermediate, but which may be termed "terminal-intermediate," as being a combination of both kinds. There is also another part of the subject requiring special notice, viz., that of goods and locomotive stations, which Mr. Hood was compelled to leave untouched. It will be the main object of this paper to supply information upon these heads, by submitting the details of the principal metropolitan and other railway stations, both terminal and "terminal-intermediate."

The classification adopted by Mr. Hood, viz., that of passenger stations; goods yards, wharves, and depôts; locomotive and carriage sheds; manufactories and workshops, will be adhered to. The latter classes will be illustrated by the goods station of the London terminus of the Great Northern Railway, the Battersea workshops of the London, Chatham, and Dover Railway, and the carriage and wagon factory of Messrs. Brown, Marshall, and Co., at Birmingham.

The leading principles to be observed in general, are—proximity to the town, or most popular part of the neighbourhood which the stations are to serve; facility of access; and available space for present and future requirements. Each of these is capable of being further subdivided.

With regard to the first two requirements, it is desirable that terminal stations should be as near as possible to the great central avenues of traffic, without being actually in them; for in the latter case, the traffic of the thoroughfare and that of the railway would become intermixed, and thereby impeded. For stations generally, a site should be selected where the surface of the ground is near to the level of the platforms, and if this be not practicable, inclines should be formed, and a sufficient space excavated or embanked, in order to carry on the works on a level with the platform. All steps, gangway ladders, &c., should be dispensed with; the use of them is only justifiable where no other plan can be adopted. Beyond the station, however, a variation of the surface will be an advantage, by enabling level crossings in the streets and roads to be avoided. The possible contingency of having to extend the line, or to enlarge the station, should also be provided for, by a careful inspection of the surrounding and contiguous ground, and by laying out the first plans in such a manner as to admit of this enlargement, without involving the destruction of any permanent building, or the disarrangement of the existing accommodation. Upon the observance of these conditions will greatly depend the power of limiting the expenditure of money, and of abbreviating the time required to carry out improvements.

Terminal passenger stations are usually arranged under one of three systems—that in which the booking-offices are placed on the departure side; that in which their situation is at the ends of the lines of rail, and transverse to them; and that in which the lines of rail diverge into a fork, having the offices between. Examples of these systems are to be seen at the Victoria Station, Pimlico, and at the Euston Terminus of the London and North Western. The Victoria Station may be regarded as illustrating two principles, that part of it occupied by the London, Chatham, and Dover Company having the booking-offices on the departure side, and that belonging to the London, Brighton, and South Coast having them at the end of it, and at right angles to the rails. There can be no doubt that the first plan affords, in the words of Mr. Hood, "facilities for giving the greatest length of setting down pavement," and is useful for a system of traffic in which the trains are very extensive, and arrive and depart at distant intervals. But though a large amount of platform accommodation is of importance, it is a question whether the length of the arrival platform should exceed that of the longest train. A departure platform, so proportioned, has the recommendation of readily admitting a second train behind the one about to start; yet, without great attention, the attempt to book for two trains at the same time will lead to confusion. Sometimes the platform is arranged in steps, with a view to assign a distinct line of rails for each train, but by this plan some of the trains become inconveniently distant from the booking-offices, and the portion of the line between the head of the last train and the departure end of the shed is comparatively useless. Where the traffic is of a mixed character, involving the despatch of trains to different parts in quick succession, the second system is no doubt the best; and is, indeed, perfectly fitted for any traffic, if the shed be capable of containing the longest train which the traffic will require. This system also secures a great width of frontage, and allows of the booking-offices being distinct, and opposite their several platforms. It is possible, however, that at terminal stations in large towns, a combination of the parallel and transverse systems might be employed with advantage. The third principal is illustrated by the Euston Terminus. The ample area of the great hall, with the booking-offices on each side, is conducive to the comfort of the passengers; but the plan of placing the departure platforms on either side, and starting the trains from both, seems open to the objection of causing confusion. The London Bridge Station of the South Eastern Railway, before the extension of the line to Charing Cross, may be cited as an instance of how an immense traffic can be worked in an inconvenient and a restricted space, by a combination, to a certain extent, of the three systems. Accommodation was thus provided for the South Eastern main line, and the North Kent, Mid Kent and Greenwich lines. Nowhere were so many trains despatched in the same time as from this station; and it is doubtful whether, except by the plan which was adopted, such an extensive and complicated traffic could have been conducted. It is not, however, intended to adduce this station as a pattern of arrangement, for its history is that of a gradual adaptation to successive requirements.

The through, local, and excursion traffic should each be distinct, so that a passenger, on entering the station, may at once see where to obtain his ticket and find his train. Every facility should be afforded for receiving, labelling, and despatching luggage. Too much attention can hardly be paid to this detail and also to the situation of the left luggage and cloak rooms. Those at the Paddington Station of the Great Western Railway are very convenient. Waiting and refreshment rooms should be of ample size, and readily accessible. It is well to separate the in and the out parcels offices from the general traffic; and this can mostly be done by placing them at the end of the platform furthest from the passenger and carriage entrances, as at King's Cross and at Paddington. The lamp rooms should serve both for the arrival and the departure trains, as at the Great Western at Paddington, where their position is below the platforms and lines, the lamps being raised and lowered by hydraulic lifts.

In the urinals, &c., for passengers, slate has been generally used, but it does not appear to be so well adapted for cleanliness as white enamelled slabs or glazed tiles. Both closets and urinals should be arranged to perform the maximum of duty with the minimum waste of water. The small glazed basins require less than half the quantity of water needed in the slate arrangement, besides being always free from bad odour. At the Knottingly Station, where the two plans are in use, the superiority of the former is obvious. Closets should flush on opening and shutting the door, and the walls should be lined with a material not easily defaced. Lavatories for the use of first and second class passengers might, at both terminal and junction stations, advantageously be provided, and would, no doubt, be largely used, even if a small charge were made. The platforms for passengers should be spacious. For through traffic, at terminal and junction stations, the width should not be less than 30 feet. For local trains, docks may be taken out

* Read before the Institution of Civil Engineers.
† See *C. E. and A. Journal*, vol. 21, 1858, p. 201.

of the extreme end of these platforms, as at King's Cross, leaving the wider part of the platform for the long trains. In order that the passengers may enter and leave the carriages easily and safely, it is essential that the platforms be level with the floors of the carriages, or certainly not below the upper step; many accidents have arisen, and the passengers in their ingress and egress are much impeded, by the neglect of this precaution. The stations of the Metropolitan Railway afford good examples of arrangement in this respect. Turn-tables should not be placed on the main line, or where engines or trains pass over them when not in use, as the ends of the rails and the rolling stock are injured by the constant hammering of the wheels. The use of traversers, especially when light and easily worked, cannot fail to conduce to economy.

At terminal, terminal-intermediate, and large junction stations, where there is space available, the greater portion may be roofed in, as that part not required for the traffic will be found useful as standing room for empty carriages. If it be not possible or expedient to construct the roof in one span, the intermediate supports should be placed in the centre of a wide platform, in order to be free from the danger of collision, in the event of an engine or carriage getting off the rails. An accident of this description occurred a few years since, at the Bricklayers' Arms Station, where the roof was, in consequence, to a large extent destroyed. The height of a station roof is of far more importance than has hitherto been supposed; when it is very low, no contrivance can secure a proper amount of ventilation. The general impression, that a building roofed with iron and glass must be exceedingly hot during the summer months, has probably arisen chiefly from the insufficient height which is sometimes given to such structures. Gas, throughout all stations, is preferable to any other means of lighting; and there are few places where it cannot be employed with economy. At road-side stations, or where there are no works in the neighbourhood whence a supply can be obtained, the cheap and simple apparatus manufactured by Messrs. Porter and Co., of Lincoln, may be advantageously used. At all terminal and terminal-intermediate stations, there should be a siding under cover for engines in steam, and every facility should be provided for coking and watering.

Terminal-intermediate and junction stations should have platforms, for through passenger traffic, on both sides of the main line, to avoid the confusion which results from having them on one side only, as at Taunton, Reading, and Perth. At the latter place, although it is a junction station for the Inverness, the Perth and Dundee, the North British, the Scottish Central, and the Scottish North Eastern Railways, the whole of the traffic of thirty-two trains per day, each way, is worked upon one through line, causing a great amount of inconvenience, which might have been avoided by placing the station upon one of the roads, instead of midway between them as it now stands. There are, however, two docks, one at each end of the platform, for those trains which commence and finish their journey at that station. The utility of this arrangement, as enabling passengers by local trains to alight on the platform for through traffic, and *vice versâ*, has been already pointed out. It will prove a great accommodation also at these stations to have two through lines in the centre, and sorting sidings for the mineral and goods traffic. At all stations these two latter departments should, if possible, be distinct.

At roadside or intermediate stations, the best site for the booking-offices is of course on that side of the railway whence the greatest amount of traffic may be expected. If the station, however, be at a point where the line runs in a deep cutting, it is then judicious to place the offices over the line, which may be done by widening the road-bridge. The platforms are most conveniently arranged when the lower end of the one serving the up line is opposite the upper end of that for the down line. No platform should be shorter than the longest train; nor should it terminate abruptly, but with a slope. At these stations the company will find it their interest to provide a residence for the clerk in charge; he will be near at hand in case of emergency, and his remaining on the premises will afford greater security to property.

The next part of the subject to be considered is that of goods yards, wharves, and depôts. A terminal goods station may either be attached to and form part of the passenger-station, though distinct from it, or it may be placed at a distance, and enclosed within its own fencing. It is important to take advantage of water carriage, and to locate the station where the easiest access may be obtained. Ample space for vans and wagons should be provided in the yards and sheds, and also at the entrance gates and in the roadway, to prevent crowding, and to diminish the risk of accident. The platforms for arrival and for departure should be distinct, and of ample width, with an abundance of hydraulic crane power, to facilitate the loading, unloading, and sorting of goods; whilst the clerk's office should be so arranged as to allow of easy supervision. The lines and turn-tables should be so disposed, that the trains may be made up with facility and economy, and that the necessity for shunting with engines may be avoided as much as possible. In some small terminal stations, and at road-side stations, it is found convenient, and conducive to a saving of cost and of time in working, to place the goods sheds close to the station, so as to enable the station-master to have ready access to this part of the traffic. In all cases the shed should be parallel to the line, that trains may be shunted into it, and the use of turn tables be avoided. The goods sheds, and the various buildings connected with them, should be arranged to lock up when not used; by this means the expense of a watchman is rendered unnecessary, and safety from pilfering is greatly increased. This plan is adopted with excellent results on the South Devon and Cornwall Railways. The other requirements of goods stations will receive more detailed notice in the description of the plans which have been selected as illustrations of the subject.

The development of the railway system has necessitated that all important lines should be provided with three classes of establishments—for manufacturing, for maintaining, and for storing the rolling stock, at one or more points. At the first, the locomotive and carriage shops, all the construction and renewal of plant is performed; in the second, the running shops, small repairs, such as are required by daily wear and tear, are carried out; and the third, or engine and carriage sheds, are for receiving the rolling stock when not in use. Great care and forethought are required in the selection of suitable situations for these offices; for if any error be committed, a constant, increasing, and unproductive expenditure is certain to be incurred. The most eligible locality for the locomotive and carriage shops is where labour and materials can be most cheaply and readily procured. Considerable study should also be bestowed upon their arrangement, so as to allow of the economic application of labour in the conversion of the material. It is obviously a great evil so to design them, as to necessitate unremunerative handling and shifting. The raw material should enter at one end of the shop, and pass on through its successive stages and processes, till it comes out complete at the other end. It is advisable, in all cases, for the District Superintendent of the locomotive and rolling stock to reside near the works, and to have them constantly under his supervision. Carriage running and repairing shops, when as close to the terminal stations as possible, are in the best position for avoiding waste of time, and wear and tear of stock. The disadvantage of placing them at a distance is exemplified by the Waterloo Station of the London and South Western Railway. The trains are made up at the terminus, where there is a small amount of standing-room, while the carriage sheds are at the Falcon Junction; in consequence of which nearly all the spare carriages have to be taken four miles, when emptied, and to be brought back again when required for service; and it is calculated that engines and empty carriages run in this way several hundred miles per week.

Engine and running sheds appear to be of three descriptions—rectangular, circular, and radial or fan-shaped. The circular shed is used by the Midland Railway Company, and the rectangular and radial by the Great Northern. The objections urged against the last are the length of line and the extent of ground occupied; but this is in a great degree obviated by placing the running shed in the centre, in front of the repairing shed, thus utilising what, without the running shed, would be a waste of space. Another objection is, that all the engines must pass over one pair of points; but this is not so serious as that of the single turn-table in the centre of the circular shed. In both cases, to guard against delay from accident, a few engines in steam should always be kept in covered sidings at the station. The accommodation afforded by the rectangular building in the centre of the fan is equal to that of the circular, though the area covered by the latter is nearly one-third more. There is no doubt, however, that the rectangular system requires a greater extent of permanent way; but this is partly compensated by the less costly nature of the building. The semicircular shed, on the fan-shaped system, can easily be compared with the others; the only superiority it possesses over the circular is, that of having but a portion of the radius covered. On the other hand, it involves a great length of extra road from the turn-table when one is used, as at Battersea, and should that get out of order, all the engines must remain in the shed until the defect be remedied. An engine shed should be lofty, well ventilated and lighted, and sufficiently spacious to allow the men to pass readily between the engines and the walls. Engine pits, properly paved, by the side of each line of rails in the shed, will afford free access to the machinery under the boiler when cleaning and repairs are needed. The best form for the bottom of the pits is convex; and the drainage should be from the sides, taking care so to construct the drains, that if any one pit should become choked, the working of those in any other would not be interrupted. For dropping and cleaning the fires, similar pits should be provided outside the shed, where the dirtier and rougher work can be performed. Plenty of water, with a good pressure, and accessible at suitable places by means of hydrants and stand-pipes, should be supplied, together with hose and conveniences for cleaning and washing the boilers. Lifting-shears, or overhead traversers, with powerful tackle, will be found of great service in every shed. By their aid an engine can be lifted and slung, so that the strain is distributed equally; they are therefore preferable to jacks, which concentrate the strain immediately over one point. The new shops at Nine Elms, of the London and South Western Railway, designed by Mr. Joseph Beattie (M. Inst. C.E.), and the engine sheds at the Bishop's Road Station of the Metropolitan Railway, by Mr. Fowler (President Inst. C.E.), are supplied with traversers worked by steam power. These effect a great saving of space. The employment of duplicate traversers, working from each end, to prevent delay in the case of a break-down, will no doubt, ultimately be adopted. The coke furnace should serve for the largest number of engines with as little movement of the lighted fuel as possible. The waste heat can be utilised for drying the sand to be used in the locomotive boxes, and for heating the sheds during the winter months. The coke platforms and the water cranes should be close to the lines leading into, or out of the sheds, so as to be accessible without shunting; and the stores in general should be adjacent to the repairing and running sheds, and planned with a view to prevent any material being taken in or out, without passing under the notice of the storekeeper.

The different kinds of stations belonging to the railway system of this country, their requirements, and some of the principles involved in their construction, having now been briefly described, it is proposed to refer in detail to the following existing stations, which are considered to embody most of the points touched upon:—The Victoria Station at Pimlico, for the London, Chatham, and Dover, and the great Western traffic, from the design of Mr. Fowler, President Inst. C.E.; the Victoria Station at Pimlico, for the London, Brighton, and South Coast, and Crystal Palace traffic, from the design of Mr. Jacomb Hood, M. Inst. C.E.; the London and North Western Railway terminus at Euston-square, by the late Mr. Robert Stephenson, M. Inst. C.E.; the New-street Station, Birmingham, belonging to the same Company, and the Stafford Station, also on the London and North Western Railway, both from the designs of Mr. William Baker, M. Inst. C.E.; the Newton Junction of the South Devon Railway, from the design of Mr. P. J. Margary, M. Inst. C.E.; the goods station of the Great Northern Railway, at King's Cross, from the design of Mr. Joseph Cubitt, V. P. Inst. C.E.; the London, Chatham, and Dover Railway workshops at Battersea, from the design of Mr. J. Cubitt and Mr. F. T. Turner, M. Inst. C.E.; and the railway carriage factory and workshops of Messrs. Brown, Marshall, and Co., Birmingham, from the designs of Messrs. Marshall and Ross.

At the Victoria Station of the London, Chatham, and Dover and the Great Western Railways, the booking-offices, &c. (at the entrance to which is a covered carriage-way), are on one side of the station. The waiting-rooms are conveniently placed near the booking offices, and the refreshment-rooms are large and well appointed. The parcels traffic is satisfactorily provided for, the out-parcels, in-parcels, and left-luggage offices being very commodious. The lines running into the station are of mixed gauge; and three trains can be prepared to start at the same time. There are two departure platforms (one of which is worked double), and two arrival platforms, with a cab-road between. On one of them is the Customs-office, for the Continental traffic. Connected with the station are sidings for spare carriages, a water tank, a coke platform, and an engine turn-table. The cab-road has only one point of ingress and egress, an arrangement which is objectionable, from its tendency to cause confusion. The roof is in two spans, and the supporting columns are placed between two lines of rails.

At the West End Terminus of the London, Brighton, and South Coast Railway, at the same place, the booking-offices and waiting-rooms are placed at the end of the station, and at right angles to the lines of rail. There are separate offices, platforms, &c., for the Crystal Palace traffic, to prevent crowding. Between the arrival platform is a cab-road, having a distinct entrance and exit.

At the Euston Station, the booking-offices are placed on one side of the large entrance hall, from which access is gained to the two departure platforms. A glass roof shelters the entrance to the station. The New-street Station, Birmingham, is terminal-intermediate;—intermediate for the London and North Western, and Midland Railways, and terminal for the Stour Valley line. It is in a cutting between two tunnels. The two main lines run through the centre of the station, and the platforms are approached by sidings, so that through trains are not stopped by the station traffic. The principal booking-offices are over the refreshment-rooms, and on a level with the bridge by which access is gained to all the platforms. The way is indicated by boards, at the top of each staircase leading from the bridge to several platforms, where fingerposts are placed to point out the destination of the several trains. An iron and glass roof, of considerable height, covers the station in one span.

The Stafford Station, recently erected, is terminal for the Trent Valley, and Shropshire Union trains, and intermediate for the London and North Western Railway. Two main lines run through the centre, the platforms being approached by sidings. There are docks and sidings for the arrival, departure, and marshalling of trains for the London, Birmingham, Trent Valley, and Shropshire Union lines. At the North end are the painting-shop, engine-house, and all the usual conveniences required at a terminal station. At a short distance from the passenger station are the goods station and the sorting sidings. These it is believed, were first introduced by Mr. W. H. Barlow, M. Inst. C.E., on the Erewash Valley Railway, near Derby. When a mineral, or goods train arrives at Stafford, composed of trucks going to Birmingham, or to stations on the Stour Valley, or to the Shropshire Union lines, the trucks are detached and put into their respective sidings until a sufficient number is obtained to form a train. This arrangement saves time, and enables thirty-six goods trains to be dispatched from this station in the course of twelve hours. There are in all five sidings, two on the up-side of the main line; but these are found insufficient to accommodate the traffic; two for the coal-trade of the town; and there is one to the cattle wharf.

The Newton Junction Station is terminal-intermediate for the South Devon Railway, and a junction for the branch to Torquay and Dartmouth. It is very conveniently arranged. The approach is by a single line of railway at one end; and there are three platforms—two for the main line traffic, and one for the Torquay and Dartmouth branch. Each platform is easily reached by means of a bridge over the rails. The principal offices are on the up-side; and there is a small waiting-room on the central, or Torquay platform. Near the station are the repairing-shops, engine-sheds, goods-warehouses, &c. The carriage repairing shops, are supplied with a traverser, by which the carriages are deposited on a short rail connected with a large turn-table at the end, and are then turned on to any line, when required for use.

The goods station of the Great Northern Railway at King's Cross, comprises coal depôts and wharves, potato stores, engine sheds, repairing sheds, stores, stables, and all the necessary offices, buildings, and appliances required for the goods and mineral traffic of the Company. A portion of this site is used by the Midland Company, who have their goods warehouse and running shed on one side. The goods shed of the Great Northern Railway is placed at the south end, nearly in the centre of the station yard. There are fourteen lines of rails running into it; and there is a platform on each side for the receipt and despatch of goods. On the outside of the rails, but within the building, space is reserved for the vans engaged in collecting and distributing the goods. The outer line of rails on the east side of the platform is used for unloading the trucks with the inward goods; and that on the west side for loading the outward goods. The inner lines nearest to these are used for the arrival goods trains, for empty trucks, and for making up trains for departure. The trucks, after being unloaded, are taken, by means of turn-tables and cross-roads, to the departure side of the station, where the business of loading and despatching them is carried on. The platforms are commodious, aud each have two rows of hydraulic cranes, of alternately one and two tons. The receiving-offices are on the platforms, but the general offices are adjacent to the main building. The stables are under the platforms; by which arrangement a great saving of space is effected. The granary is at the south end of the goods shed, through which it is approached by two lines running through the centre; two other lines, one on each side of these, being reserved for full trucks. When emptied, the trucks are removed by two lines, which run one on each outer side of the goods shed. The latter and the granary are supplied with water-communication through tunnels under the roads, to a basin on the south; and thence by the same means with the Regent's Canal, so that lighters can receive or discharge their freights directly under these buildings. On the west of the goods shed are the coal depôts and staiths; and a coal and a stone dock, also connected with the Regent's Canal. Adjoining, are numerous private wharves for bricks, &c. On the north are the engine, repairing, and carriage-sheds. There are eleven lines in the centre, at the extremity of the fan, in the repairing shed, with shops in the rear; seven lines on the south, in the locomotive painting-shed; and seven on the north in the carriage-shops. The running shed is placed in the centre of the fan, in front of the repairing shed, with which it communicates by through lines connected by means of a traverser. The potato-store and market occupy the eastern portion of the station, and are near the Midland goods shed. The whole is conveniently arranged, and the site is well chosen.

The locomotive workshops of the London, Chatham, and Dover Railway are situated near the Stewart's Lane station, on the Metropolitan extension of that line. The works proper are enclosed by a wall. At the entrance from the railway, there is a building on the right, for the timekeeper and police. A single line connects the works with the main line, by means of points and crossings. Two parallel lines, running east and west, are connected with the several buildings by turn-tables. On the north of these lines is a range of buildings, containing the engineer's offices, boiler-house, coal-store, grinding-shop, and turning-shop. On the south, under one roof, are the boiler-maker's shop and the lamp room. On the west is the erecting-shop, containing ten stalls on each side for engines, and a traverser which runs north and south. On the west of this building is a hooping and tyring shop, with a traverser connecting twenty lines near the north end of the carriage and wagon shop. Further west are the saw-mills; and near these at the extreme west, the engine for working them, and also a drying house and a boiler house. On the south of the several buildings just enumerated are the stores. There are roads for spare trucks, &c., connected with the main line, and having a separate entrance. Adjoining the works, but not within the enclosure, are the repairing shops, and a semicircular running shed, struck with a radius of 150 feet, only the outside 50 feet being covered. Within this building are twenty-one stalls for engines with their tenders. The turn-table in the centre is not covered, nor the forty roads radiating from it, each of which is sufficient for an engine and tender. It is connected with the main line by three separate roads. At the back of this shed is a shop for running repairs, with smithy, engine and boiler house, and engineer's and foreman's offices. A line of rails connects the above shed with the works, through an engine weigh-house.

The Britannia Carriage Works of Messrs. Brown, Marshall, and Co., of Birmingham, may be taken as successfully embodying the two great requirements of such premises, viz., suitability of site, and convenience of arrangement. The communication, by rail and water, is free and uninterrupted; for a level junction with the London and North Western line, with ample siding accommodation, beside large wharfage on the Stafford and Birmingham Canal, affords access both to London and Liverpool. Their position is also central in regard to the district from which the necessary materials are obtained, being close to the borders of the Staffordshire coal and iron fields.

On the left are two smiths' shops, parallel with the public road beyond. These are intended for the supply of iron-work only; this arrangement has proved advantageous, by obviating the necessity of interfering with the progress of the carriage work. To the right of the smiths' shops are the bolt shops and the fitting shops; in the former all bolts are forged and screwed, and plates bevelled. The saw-mill and log-mill adjoin; here all the wood-work is planed, tenoned, and mortised, before passing into the carriage and wagon shops. In each of the latter are eight lines of rails and a traverser communicating with the siding. The carriage painting shop is placed next the erecting shop, and communicates with it, but is sufficiently removed from the smiths' and the fitting shops to be free from dust or gases. It has four lines of rails, communicating with the traverser just mentioned; and has attached to it the paint stores and trimming room. The carriage-body shop and wagon repairing shops, are provided with a traverser through the centre, and communicating with the siding. The general stores stand in front of the wagon shop. A building in the yard is the shipping stores, where the packing and marking are completed. The packages and cases are run upon a tramway, to a crane placed by the inner siding.

The foregoing have reference only to systems and establishments now in undoubtedly successful working. It should be understood, that it is impossible to lay down rules which shall be applicable to all railway stations. The formation of the ground, the nature and extent of traffic, the capital to be expended, and the views entertained by the directors and the traffic manager, will inevitably modify the arrangements in each case. Some requirements, certainly, are common to all stations, while others are only exceptional; but even in those which are more or less indispensable, no absolute rule can be given. Much therefore, must always be left to the skill and adaptive power of the engineer. Yet the Author would remark, in conclusion, that if, in addition to the essential qualities of a station—spaciousness, cleanliness, accessibility, and light—the trains are frequent, the fares moderate, and even low, and if attention be paid to the comfort of the passengers, the results can scarcely fail to be satisfactory.

DEPOSITION OF METALS.

The following is the account given by Dr. Dullo, in the *Journal d'Industrie*, of the method adopted in Germany for covering cast-iron objects with copper. The surfaces are cleaned with a brush and hydrochloric acid, and the objects are then left in water slightly acidified; they are afterwards placed in a bath composed of 25 grammes of oxyde of copper, 170 grammes of hydrochloric acid, a quarter of a litre of water, and half a litre of alcohol. A regular deposit of copper takes place on the surface of the iron, the rapidity depending upon the proportion of the alcohol, which is the active agent, to the other ingredients. The iron may be coated with the aid of pure alcohol only, but in this case the deposit is very thin, and in the form of chloride of copper, which is converted in the end into metallic copper. The chloride which adheres to the surface should be carefully brushed off after the operation, and the surface dried. If iron thus coated with copper is placed in a bath consisting of 10 grammes of chloride of iron and 1½ litre of alcohol, in contact with metallic zinc, the surface is covered with a fine silvery deposit, which adheres firmly to the copper. Copper may also be covered with a layer of antimony by the following process:—Dissolve chloride of antimony in alcohol, and add hydrochloric acid until the mixture becomes clear, clean the copper well, and leave it in the bath for three quarters of an hour. The effect of the alcohol in the preceding processes is thus explained; it moderates the precipitation of one metal from its solution by another metal, and causes the precipitate to fall in an extremely divided state; when alcohol is used alone, without water, the coating of copper thrown down is reduced to the last degree of tenuity. It is recommended that when the work is finished it should be well washed, first in water, and afterwards several times successively with a solution of carbonate of soda, and with weak hydrochloric acid, and finally carefully dried in a warm place. The perfect silvering of vases, or plates of glass, is always a matter of some difficulty, and M. E. Reichardt recommends the following method:—Prepare four solutions—first, 10 grammes of nitrate of silver to 100 grammes of water; second, an aqueous solution of ammonia, of

0·984 density; third, 20 grammes of caustic soda and 500 grammes of water; and fourth, a solution of 25 grammes of sugar in 200 grammes of water, to which is added a cubic centimètre of nitric acid, at 36°; and let the whole boil for twenty minutes. When cold add 50 cubic centimètres of alcohol, and as much water as will make up the total quantity to 500 cubic centimètres; then take 12 parts of the first, 8 parts of the second, and 20 parts of the third solution, add 60 parts of water, and let the mixture stand for twenty-four hours; lastly, the solution No. 4 is added, when the whole becomes of a blackish tint, in consequence of the finely divided precipitate of silver which begins to fall. M. Reichardt has discovered that the deposition of the silver is greatly aided by motion, and that when the bath is continually shaken the deposit on the inner surface of glass vases is always satisfactory, and he recommends that in silvering plates of glass they shall be placed in evaporating dishes, or other vessels, so that the sides may give an oscillating motion to the liquor in the bath when shaken. In acting on large articles he recommends the glass plates, or other objects, to be fixed within tubs or vats, which may then be rolled or rotated pretty rapidly.

THE INSTITUTE OF CIVIL ENGINEERS.

November 13th—The first Paper read was on the "*Results of the Employment of Steam Power in Towing Vessels on the Gloucester and Berkeley Canal*," by W. B. Clegram, M. Inst. C.E.

It was stated that this navigation was 16½ miles in length, and level from end to end. The width at the surface varied from 80 feet to 100 feet, with passing places from 150 feet to 200 feet wide, and at the bottom from 13 feet to 20 feet, while the depth of water was from 18 feet to 18 feet 6 inches. Sea-going vessels up to 700 tons register, and drawing 16 feet, could by it reach Gloucester. Prior to the year 1860, these vessels were towed by horses, at a cost of about one farthing per ton per mile, and at speeds varying from 1 mile to 3 miles an hour. At the date named, three steam tugs, fitted with high-pressure engine and screw propellers, were purchased complete for the sum of £3,000, and were placed upon the canal to do this work. Two men and one boy were employed in each tug, and the consumption of coals in each was from 15 cwt. to 20 cwt. every twelve working hours. In the four years ending the 25th March, 1865, 1,059,137 tons register of shipping had been towed 16 miles, carrying 1,109,334 tons of goods, at a cost of £6,400, including 15 per cent. per annum on the price of the tugs, to cover interest of money, repairs, and renewals. Applying this outlay to the tonnage of the vessels towed, it gave 1·45 penny per ton for 16 miles, or ·0906 (about one-eleventh) of a penny per ton per mile,—being a saving of not far short of two-thirds as compared with the haulage by horses. In consequence of a larger and more regular trade in the six months ending the 25th September, 1865, the cost during that period did not exceed one-thirteenth of a penny per ton per mile. Applied to the goods conveyed in the vessels in the four years, the result was ·0865 of a penny per ton per mile. The vessels were towed either singly, or in a train, according to circumstances. Sometimes as many as nine, ten, and even thirteen laden vessels had been taken by one tug at the rate of from 3 miles to 3½ miles an hour. The heaviest load after any one tug had been 1,690 tons of goods, in three vessels, which were towed along the whole length of the canal at a speed of 2 miles an hour. For the smaller class of vessels, the speed, as a rule, was restricted to 4 miles an hour.

The employment of steam as a towing power had been found in nearly every way advantageous. The work was greatly economised. The vessels rubbed much less against the sides of the banks, the towing power being right ahead, and not on one side, as with horses. The wear to the ropes used in tracking was reduced; and vessels could be moved along the canal in weather which would have prevented horses doing the work. The speed also was increased; and owing to this, there was now no deposit on the sides of the canal, which formerly took place, and was difficult to remove. At present the deposit was entirely at the bottom, whence it could readily be taken out by dredging. The only disadvantage of this system, in a canal, the sides of which at the water's edge, were unprotected, was the additional wear at that part, caused by the constant passage of the tugs, and by the "run" of the water between the sides of the larger vessels and the banks. This action upon the banks was confined to a space of about 18 inches only, one-half of which was below, and the other half above the water line. On this canal, a band of good weather-stone pitching, 2 feet wide, had completely prevented the injury, presenting a face along which the water ran harmlessly. It cost about £180 per mile; but as a set-off to this expense, there was the diminished wear of the towing-path by the horses, which was considerable.

The second Paper read was "*On the Employment of Steam Power upon the Grand Canal, Ireland*," by S. Healy.

It was remarked that on this system of navigation, which was 160 miles in length, the locks were 60 feet long and 13 feet 6 inches wide; a depth of 5 feet 2 inches of water being maintained upon the cills, but the trading depth of the boats was limited to 4 feet 3 inches. The width of the canal varied from 60 feet to 80 feet, shallowing at each side, so as to admit of about 30 feet of navigable breadth in the centre. Upwards of 300,000 tons of goods are carried annually over this system, in and out of Dublin.

It was observed that steam power was applicable to canal navigation in either of two ways, and both had been attempted on the Grand Canal. First, by placing the machinery in the boats with the cargo; and, secondly, by employing steam power merely for towing boats or barges in trains. Trials had also been made with both a single and a double screw, but the latter was deemed to be unsuitable for canal purposes. In the first effort to introduce steam power, a vessel was designed to carry cargo as well as the machinery; but her carrying capacity was found to be so reduced, as to render the speculation unremunerative. Within the last two years however, a system of hauling boats in trains, by small but powerful steamers, had been successfully brought into use on a long level of the canal, 25½ miles. The screw which had been proved to be the best, had a width of blade at the circumference of 32 inches, cut away at the base to the extent that was consistent with strength; the pitch was an increasing one, varying from 5 feet 3 inches to 7 feet 9 inches. One of these steamers towed three laden boats, each carrying 40 tons of cargo, at the rate of 2¼ miles an hour; the pressure on the boiler being 60 lbs. per square inch, the number of revolutions 75 to 80 per minute, and the consumption of fuel, which was one part coal to three parts of slack, being 112 lbs. per mile. The boats were 60 feet long, and 13 feet beam, drawing when laden 4 feet of water. On that portion of the canal upon which steam power had been applied, horses had now been entirely withdrawn, and two steamers regularly performed a daily service both ways.

On the river Shannon, the steamers designed to carry their own cargo had to pass through locks, which limited their length to 72 feet and beam to 13 feet 3 inches. They carried 60 tons, with a draft of water of 4 feet 8 inches, and had been most successful.

In the course of the discussion it was observed that a fourth steam-tug was now at work on the Gloucester and Berkeley Canal, and that in three weeks during the month of September last, four tugs had moved 35,280 tons 16 miles at a total cost of £145 8s., being not quite one-sixteenth of a penny per ton per mile. On the Forth, and Clyde, and the Monkland canals, in the year 1856, a lighter, capable of carrying 80 tons of cargo, was fitted with small high-pressure engines, placed as close to the stern as possible, and a screw propeller. Having proved successful, engines were subsequently applied to a luggage-boat carrying 35 tons, to one of the canal ice breakers, to masted lighters, for canal and coasting trade, carrying 120 tons, and to a mineral barge conveying 60 tons on the Monkland canal, and 75 tons on the Forth and Clyde Canal. All of these had answered satisfactorily, and had been precursors of seventy steamers now at work on the Forth and Clyde navigation, and from the canal to the contiguous sea coasts. In reference to the screw tug-boat, 'Birmingham,' which had been employed, from 1855 to 1865, in hauling the barge traffic upon the summit level of the Regent's Canal,—where the sectional area of the waterway traversed as compared with that of the vessels navigating the canal was about 4 to 1, except through the Maida Hill tunnel, for a length of 270 yards, where these proportions were 2 to 1,—it was stated that the cost of working that vessel for the eight months ending 31st May, 1865, was £344 2s. The distance traversed was 3,519 miles, the number of barges hauled 2,023, the gross amount of cargo conveyed 59,738 tons, or with the weight of the barges 90,083 tons. The cost, including all charges, had been 1·96 shilling per train mile, 1·38 penny per ton of cargo, and ·916 of a penny per ton gross weight. On the River Severn steam-tugs had been used for ten years; but now the most efficient plan was considered to be that by which small direct acting engines were fitted in a barge capable of taking 40 tons of cargo, and of towing one, two, or three canal boats after her, according to the strength of the stream against which they had to contend. On the Weaver navigation, a canalised river, partly river and partly canal, the employment of steam power had been so profitable, that all sailing vessels and hauling by horses were being rapidly abandoned, when dependence would be placed upon steam barges alone. A series of experiments had been made on the Ashby-de-la-Zouch canal, for the purpose of determining whether the application of steam power would be injurious to the canal, particularly to the banks, when it was found that no prejudicial action took place, so long as the speed was limited to 3 miles or 3½ miles an hour.

Russo-American Telegraph.—Nearly the whole of the surveys on land and the soundings in Behrings Straits are completed. The following works will be completed this year, distributed amongst several sections. The line of telegraph will be lengthened 800 miles beyond the Port of Granley to Kvitchpok, and further in the valley of the Anadyr from its mouth to the Island of Anadyrik, from Okhotsk to Guijigumik, and, perhaps, to the junction with the Anadyr section.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

CERTAIN alterations having become necessary in the management of the affairs of the Institute of British Architects, it has led to the reclassification of its office-bearers, and particularly to the appointment of a paid assistant-secretary. For this post we understand that the applications are numerous, including the names of several good men and true, the consideration of whose claims will be brought under notice at the meeting on the 3rd instant. Without any disparagement whatever to the merits of other candidates, the list, so far as published, contains the names of at least two gentlemen who have special claims on the attention of the Institute, in consequence of their long connection with the Institution and the practical services they have individually rendered in furtherance of its interests. The name of Papworth is well known within the walls of the Institute, and the labours of Mr. John W. Papworth (one of the candidates to whom we refer) in conjunction with his brother, to improve and render more available generally, the accumulated treasures in the library, have been neither few nor unimportant. Mr. F. T. Dollman, the other gentleman to whom we allude, though his official connection with the Institute dates more recently than some of his brother officers, has, we believe, by the unanimous testimony of those best qualified to give an opinion, discharged in a very zealous and efficient manner the duties of librarian, to which he was elected some four years ago; being moreover an individual well and favorably known as an author, more especially in connection with his detailed and illustrated works, bearing upon mediæval architecture. Mr. Dollman may therefore naturally consider that the services he has rendered in both capacities present more than an ordinary claim to notice, and that his experience in the post just vacated will add not a little to other recommendations.

Among the candidates are Messrs. Edward Hall and C. L. Eastlake, both known in literary circles, and Mr. F. Warren, Mr. Snell, and Mr. Wallace.

THE PROGRESS OF ENGINEERING.

THE Institution of Engineers in Scotland commenced the Session 1866-7 on the 31st October last, under the Presidency of Mr. J. G. Lawrie, who delivered an introductory address, embodying an interesting sketch of the progress of scientific engineering. The proceedings of this Institution are of much interest and utility; some extracts from the President's address we append: —

Great as were the advantages derived from the original form of the steam-engine, in which the same vessel performed the duties of steam cylinder and condenser, it is nevertheless an instrument immensely behind the modern engine. The invention of a mechanical prime mover, which should be independent of the action of the wind, and which, not being fettered to situations where falls of water existed, could be placed anywhere and extended indefinitely, possessed plainly advantages wholly unattainable without such a prime mover, and was therefore fitted to produce an entire revolution in operations dependent on the exertions of dynamic force. Beyond the applications falling within the scope of a prime mover, such as the original form of steam engine, there existed even a wider range to which such a prime mover could not be profitably applied, and which, consequently, were as entirely shut out from that class of prime movers as if it had not existed. For these, the more perfect instrument in the modern steam-engine is peculiarly adapted. In steam navigation, for example, the improved steam-engine is rapidly becoming indispensable. For that purpose the difference betwixt an engine which uses 4½lbs. of coal per horse power per hour, and one which performs the same work with 2lbs., is so great that in many cases while the one is very much what the circumstances and conditions require, the other is absolutely worthless. With the former the expense of the fuel would alone in many cases be a bar to its use; but when to the expense of the fuel is added the incompatibility of burning 4½lbs. of coal per horse power, with the requirements for carrying cargo, the application of such a prime mover is wholly out of the question, and brings into prominent contrast the advantages of the latter. And these advantages are most prominently services rendered by science to the engineer. The advantages obtained by expanding the steam, the advantages of surface condensation, and the advantages of modern superheating, which constitute the improvements of the modern steam-engine, are due altogether to the scientific engineer. No one of the three has been the result of accidental observation, but has been due to elaborate and patient investigation. It is true that the amount of advantage derived from any one or all of these improvements has not yet been by common assent definitely ascertained, the experience of different engineers showing different results, arising, probably, to a large extent from inaccuracy of observation, and also to the different modes by which the advantages are sought to be arrived at. While, however, these different results are being discussed, questioned, and not unfrequently discredited among the doctors, the users of the steam-engine, the public, are plainly in practice answering all doubts by a steadily increasing demand for the improved steam-engines, showing that, although different forms may yield different amounts of advantage, they all, in every practicable form; yield results of sufficient advantage to induce their extended application. The progress made by these improvements points palpably to the time, and at no distant period—within, probably, fifteen or twenty years—when in steam navigation, for every work, except it may be the shortest coasting voyages, the injection condensing steam-engine will be entirely obsolete. On a vast variety of stations the question is not one with a consumption of 4½lbs. of coal per horse-power of more or less profit, but it is whether there is to be or there is not to be steam navigation at all, and the advantages of steam navigation compared with sail navigation are so tangible and so great as to ensure the unremitting attentions of engineers to the entire removal of the remaining difficulties in the way of the improved steam-engine. The great ocean race from China which has received so much notice within the last few weeks, will undoubtedly, in a very few years, lose its prominence, and be eclipsed by a race of far higher speed.

The great and prominent improvement in the steam-engine, as applied more particularly to steam navigation, is the economy of fuel, and without that improvement all the others that have been made would have been worthless, but with that improvement others have been of immense value, as in the change from the paddle wheel to the screw propeller. For many services, the paddle wheel was a most clumsy, inconvenient, and undesirable mode of propulsion. For all services, except, as yet, in shallow water, the screw propeller is nearly all that can be desired.

Recently, a method of propelling ships by the reaction of water issuing from turbine water wheels, now commonly called the Ruthven mode of propulsion, has been revived, and has lately been tried in one of her Majesty's ships, the "Waterwitch." This method of propelling ships is not without advantages peculiarly its own. For example, in many ships, and perhaps in all, the great power which a ship so fitted possesses in discharging an immense quantity of water, the result, it may be, of leak or injury, is of no inconsiderable importance. Probably, a facility of manœuvring a ship so fitted is another advantage. But there are no good grounds for believing that this mode of propulsion will be more economical in the application of dynamic effect or power, or in fuel, than the screw propeller, nor even that it will be so economical. In a comparison of the two modes of propulsion, there are three elements which fall to be considered:—

1st, The consumption of the power of the machinery due to the friction of the propelling instrument.

2nd, The consumption of the power of the machinery due to that part of it which is carried off by the water projected from the ship.

3rd, The consumption of the power of the machinery due to the propulsion of the ship, or that is developed in the propulsion of the ship.

To compare minutely the friction in the two methods, it would be necessary to know the surface, in each case, of the propelling instrument; in the one case the surfaces of the screw propeller, and in the other the surfaces of the turbine wheel and the surface of the water passages. Even, however, without these measurements, it is plain that the screw propeller has the advantage to a large extent in this respect. The surface of the propelling instrument itself is manifestly in favour of the screw propeller, and the loss arising from the friction of the water in the water passages with the turbine wheel has no counterpart at all with the screw propeller.

With regard to the consumption of the power of the machinery in that part of it which is carried off by the water that is projected from the ship, it is to be observed that with the screw propeller, if there be a sufficient number of blades, the whole water in the cylinder, of which the diameter is the diameter of the propeller, and the length the speed or space passed through by the ship, is driven off with a certain speed which measures the reactionary power obtained in that way for the propulsion of the ship. If this cylinder be reduced in diameter the water must be driven off with a higher velocity to maintain undiminished the reactionary power derived from that source; and, inasmuch as the power carried off by the water and wasted, not being developed in the propulsion of the ship, increases as the square of the velocity, plainly the higher the velocity with which the water is projected from the ship the greater the power carried off to waste. Consequently, in this respect the turbine wheel plan adopted in the "Waterwitch," in which the discharge orifices are of small dimensions, comparatively, and, therefore, the velocity with which the water is projected necessarily considerable, is inferior to the screw propeller.

With respect to the consumption of the power of the machinery due to the propulsion of the ship, it is to be observed that with the screw propeller the power of propulsion is derived from two sources—the one being the reaction due to the water which is projected backwards from the ship, and the other due to the reaction of the water in having imparted to it the velocity with which it is projected from the ship. For example, suppose the ship be propelled through the water by a propeller working in a solid, as it could be by having for illustration a propeller shaft of great length, then all the power of the machinery, with the exception of that required for friction, would be employed in propelling the ship, and none would be carried off by water being projected backwards from the ship, because none would be so projected. When, however, the propeller works not in a solid but in water, there is plainly reaction obtained for the propulsion of the ship, first from the inertia of the water in having velocity imparted to it, and then there is reaction corresponding to that velocity. The reaction due to the inertia of the water in having velocity imparted to it is measured by the rapidity with which that velocity is imparted, and is represented by a quantity proportioned directly to the velocity, and inversely to the time in which the velocity is imparted, or in other words, is represented by the expression the velocity divided by the time; and if, therefore, the time during which the velocity is imparted be reduced to one-half, or one-fourth, or one-tenth, or is infinitely reduced, then the reaction obtained from this source is increased twice, or four times, or ten times, or is infinitely increased—that is, if the propeller imparts the velocity to the water with great rapidity, the reaction will be equal to that of the propeller working in a solid. With the turbine wheel the reaction obtained from the inertia of the water in having velocity imparted to it is plainly much inferior to that obtained with the screw propeller.

In all the three elements the screw propeller appears therefore to have the superiority.

1st, In the friction of the rubbing surfaces.

2nd, In the quantity of power carried off to waste by the water projected backwards from the ship.

3rd, In the quantity of power which is developed in the propulsion of the ship.

And the extent of superiority depends upon the details of the manner in which the two methods of propulsion are carried out.

The "Waterwitch" has already been submitted to a trial on the Thames, and in the report on the subject which has appeared in the press, the performance has been greatly lauded. The method of propulsion has been lauded, and the machinery by which the method has been carried into effect has been also very considerably trumpeted. The facts, however, stated in the report do not afford the means of correct inferences respecting the result obtained, and the further experiments yet to be made are probably desirable to elicit in actual practice the true character of this method of propulsion.

Illustrations of the progress of scientific engineering could be multiplied to almost any extent. Within the last few years engineering has been rapidly changing character. Formerly engineering was not nearly so much as now a succession of scientific improvements. Then it was enough in a sense to be a hewer of wood and drawer of water, and to travel in a beaten path; but now it is far otherwise, engineering being in all directions full of novelties—the dictates of science. The mode of communication between distant places is, we have seen, entirely new, and is the result of laborious, patient, and keen investigation of the occult laws of nature. The mode of conveyance both by land and sea is full of the use of Nature's hidden laws. The material which the engineer employs is rapidly being changed, stone being superseded by iron, and iron in many applications being displaced by steel, produced in a manner entirely new, and due to principles far from obvious. Defining an engineer to be an artificer on matter, the scientific nature of his employment is apparent, whether we consider him as a fabricator of machines for transmitting intelligence or for transporting the fruits of the earth; whether he be considered as a fabricator of food in high agriculture, which is now in reality a manufacture; or as a fabricator of coverings to protect us from the inclemencies of the weather in the beautiful materials now constantly produced; or as a fabricator adapting everything around us, beneath us, or over our heads, to the wants and comforts of man. It is no longer sufficient for the engineer to know by rote the successive steps necessary in the various operations which fall to be performed by him, and which when known, may all be classed under the denomination of hewing wood and drawing water. He must be acquainted with the principles or laws of nature upon which these various operations depend; he must extend the applications of these principles in new developments if he would seek to keep abreast with the progress of modern engineering. It has been frequently alleged, and correctly so, that the task of deciphering Nature's laws, that is, of becoming scientific, is difficult of performance, and that any action taken upon a misapprehension of these laws is attended with disappointment and disaster. No doubt if erroneous steps be rashly made upon a misconception of the laws of Nature, the result will be disappointment and failure; and in proportion to the rareness of the capacity of correctly understanding these laws is the distinction of doing so, and the value of the reward due to success. These difficulties may furnish reasons for diffidence in undertaking the task, but they furnish no reasons for discrediting or under-valuing the labours of the successful explorers, which an inconsiderate view of the matter has not unfrequently encouraged.

THE ARCHITECTURAL ASSOCIATION.

The regular fortnightly meeting of this Association was held on the 23rd ult., Mr. R. W. Edis, the President, in the chair. The Secretary stated that the register for architects' assistants kept in connection with the Association, had hitherto been kept open free of charge to all comers. This was considered scarcely fair to members of the Association, and it was now proposed to alter the rule, so that while members continued to have their names placed on the register free of charge, non-members would be charged a fee for obtaining the benefits of the Institution. It was proposed to charge a fee of 1s. for registration, and 2s. 6d. to members of the profession who were suited with assistants. It was therefore proposed that the words "to be consulted free of charge" be left out from rule No. 17. Between eighty and ninety assistants had obtained situations last year by means of the register. The proposal was agreed to, and the rule altered accordingly. The following gentlemen were elected members of the Association:—Messrs. William Alexander, E. Skerritt, William Backhouse, Emile Brandau, James Winter, F. Piercy, P. E. Hart, — Gibbins, W. F. Walter, J. G. Taylor, W. Willis, M. Foster, Lewis Solomon Dale, W. L. Spiers, and Percy Oakden.

The Secretary read the annual report of the Committee of the Association, for the session 1865-66, which showed that during the session 78 members have been enrolled, and in the same period 23 resigned, making a total addition of 55 to the number of members. A summary of the papers read and of the business brought forward on each evening of last session was then given, and a unanimous vote of thanks was accorded to the officers for the past session.

The annual report stated that—"The library has increased in books and in the number of readers. A sub-committee was appointed by the Association, to consider the whole question and on their report, it was resolved that the present subscription be abolished, and the library thrown open to all the members, and that a voluntary subscription of small sums be instituted towards increasing the number of books. A sum of £5 5s. 0d. from the funds of the Association was voted to those of the library. The Committee hope that the members generally will make use of this important branch of the Association. The class of design continues to thrive, and the sketches and drawings contributed speak well for the ability of the members, but although a great number of sketches were sent in, there were but four gentlemen who were eligible for competition for the prizes; as having contributed the requisite number of designs during the session.

"The committee announce with regret that the voluntary examination class has ceased to exist, especially as the sole cause was the scanty attendance of members, and which repeated efforts have been unable to overcome. Whether the present unsettled state of the architectural examination question deterred members from joining, or whether the class was considered useless, it is impossible to say. The committee urge on the members, the younger ones in particular, the extreme importance of this class and the benefit to be derived from it, and they still hope that there will be sufficient spirit in the Association to resuscitate the class, or establish one for the stndy of practical subjects bearing on architectural art. The committee congratulate those of the members who successfully passed the examination in January last, and the members generally, that out of the four gentlemen who passed, three were members of the Association.

"During the session a letter was received from the Secretary of the sub-committee appointed by the Royal Institute of British Architects to consider the working of the examinations requesting to know whether any, and if any, what, change in the regulations was suggested, upon which a resolution was made suggesting that each gentleman passing the examination should be furnished with a certificate signed by the examiners, and bearing the seal of the Royal Institute of British Architects, setting forth the particular class in which the candidate passed. As the same request was sent privately to those members of the Association who had passed, many detailed suggestions were made, which, had they been carried into effect, would have tended to popularize the examination, but although the sub-committee recommended the greater part of them, the committee regret that almost the whole were thrown out by the general body; so that few alterations from the former scheme will be made. While deploring this, they would still say, "Go forward," as upon the spirit in which these examinations are taken up by the younger men must depend success. The committee urge on the members to present themselves as well for their own sakes, as for the profession at large.

"The class for the study of figure drawing which was established in the last session, has continued, and its progress in numbers, as well as the improvement of the members attending, has been satisfactory. This class differs from the others, inasmuch as it admits non-members of the Association, but the committee hope that some arrangement may be made whereby the subscription of the members may be reduced.

"A class for the study of water colour painting and sketching was organised under the direction of Mr. A. Penley. The class was necessarily limited in number, but the success has been very encouraging to all its members. The Committee remind the members of the rule that gives them the opportunity of forming classes for the study of various subjects. A good example having been set by the water colour class.

"Upon one subject the committee express their disappointment. With a view to stimulating the members to exertions, prizes were offered by the Association, the Architectural Union Company, and Messrs. Edis, Tite, and Goodwin, for competitions for essays and designs, but considering the large numbers of members, the offers have not been responded to in the proportion that might have been expected.

"In the matter of finance, the Treasurer announced the Association entirely out of debt, and with a substantial balance in hand; which would be materially increased if the members would pay their subscriptions as they fell due, by which means a great amount of trouble and expense would be saved, and the committee would know exactly what funds they had to enable them to extend the usefulness of the Association. During the past session the committee have met three times, and from the vote that was passed at the last meeting, believe they have gained the confidence of their fellow members. They would beg the liberty of expressing their thanks to the President, Mr. Robert W. Edis, for the unexceptional attention and interest he has shewn in all that concerns the Association, and they have pleasure in seeing the rules so altered as to render him eligible to again serve as President for the ensuing session."

The report concluded by stating that, "in looking back on the former years of the Association, it is almost wonderful to note the rapid progress that it has made, but while taking pleasure in this, it should be remembered that there is as much yet to be done. Our country is increasing in numbers and wealth, and with it our own profession, therefore it behoves every man (and especially the younger ones), for their own benefit as well as for their own profession, to qualify themselves for their future work, and in few ways can this be more pleasantly and readily accomplished, than by becoming *useful* members of the Architectural Association."

The PRESIDENT, in moving the adoption of the report, said he must first congratulate the secretaries upon the elaborate and successful report which they had prepared. On the subject of the library, he considered that the change which had lately been effected in making the library free, and the subscription a voluntary one, was most beneficial. It was the only voluntary lending library of its class in London, and the members ought to do their best to make it a good one. He thought if any members or their friends had duplicate copies of books, they ought to present one to the library, and if every member in the Association gave a small sum annually to the fund, they might be sure that such a collection of books would be amassed, as would do credit to the institution. It was not a matter of surprise that the voluntary examination class had ceased to exist. He was only sorry it had been discontinued, because it was a pre-eminently useful class to the members of the Association. It was a class which brought the members together for study of a varied character, and which engaged their attention in subjects which otherwise might not come under their notice. He hoped that a class with similar studies would be resumed, whether under the name of a voluntary examination class or otherwise it did not matter. It did not behove the President, as a member of the Institute, to say anything against that body, but he confessed he thought it a very short-sighted policy which had led them to treat the "Voluntary examination scheme" in the manner they had done. The Institute had asked for suggestions for improving the examination scheme, and when a large number of valuable suggestions had been sent in they had set them all, or nearly all, aside. The evils complained of were still in existence, and the examination was tantamount to a myth. He hoped that the question of architectural education would ere long be put on a more satisfactory basis, and that ultimately there would be a *compulsory*, not a voluntary, examination of all professional students. The members of the Association would require to continue their efforts in memorializing the "powers above," and if it was found that the Institute would do nothing in the way of granting a diploma or some other recognition, then it would be time for the Architectural Association to do something for themselves. The President next remarked that it was a matter of regret that out of nearly 350 members of the Association only twenty-two belonged to the figure drawing class. This was a most important study, and deserved a great deal more attention from students than was bestowed upou it. He hoped many more would join. It was necessary for a thorough artistic culture to have a knowledge of figure drawing, and it would be found a very pleasant knowledge to have when sketching, and one most essential and most important for the architect to possess. All things considered, he congratulated the Association upon its success during the past session. The number of members had largely increased, and in numbers and union lay the Association's strength. By increase of numbers they would obtain, he hoped, increased power, and be able to obtain for themselves many things which at present they could only look forward to as things "to be."

Mr. RIDDETT read the report of the library committee, which shows that during the past session, the number of books issued has considerably exceeded the number issued in any corresponding period. The annual payment hitherto of 2s. by every member using the library, had been remitted, and a general annual appeal to all the members for small sums is instituted, in order to form a fund for making some additions to the catalogue. Mr. Riddett in commenting upon the fact that the library was now free to all, urged the importance of contributing to the voluntary fund. Unless the fund was properly sustained the scheme of a free library could not be carried on. During the past year a number of new books had been added and the committee hoped to increase the library still further during the ensuing year.

Mr. E. B. FERRY read the report of the class of design, which showed that it had been very successful during the last session. The original system of giving a different subject for each fortnightly sketch has been returned to, the plan of a series of designs illustrating one subject (a large church) adopted during session 1864—1865, not seeming to meet with the approval of the members, as a comparatively small number of drawings were sent in during that period. The total number of designs contributed amounted to 185. The mode of proceeding adopted at the meetings has been improved. The Chairman commenced by passing round the drawings slowly to the members in rotation for their examination, each thus having an opportunity of deciding what criticism to make. After this, the chairman proceeded to criticise each design, exhibiting it to the members present to elicit remarks.

The PRESIDENT observed that there had been a marked improvement in the class during the past year, not only in the designs, but in the number of drawings given in, and he hoped the class would continue and increase, as its objects were most essential.

Mr. TARVER read the report of the figure drawing class as follows:—"The Secretaries report that, in spite of difficulties by defection of members, the class has successfully attained the end of a second session. This is much to the credit of a majority consisting chiefly of the original members of the class, who preferred paying a slight extra subscription (8s. instead of 7s. a month) rather than allow so useful an undertaking to fall to the ground; and it should be borne in mind that up to the end of this second session the subscriptions never reached the amount allowed for—namely, 10s. a month—when the scheme was originally proposed. The best proof, however, of the success of the class, lies in the fact that it has entered upon a third session. Much praise and many thanks are due to Mr. Poynter for the very efficient and explanatory manner of his teaching, and the class has great cause to regret his resignation. The Secretaries express their thanks to Mr. Macdonald Clarke, head master of the West London School of Art, who has always rendered them every assistance in his power. The number of members who joined the class between October and May was 40. Amongst these were a few artists and decorators, but the bulk of the members belong to the Architectural Association."

Mr. L. W. Ridge inquired whether the Institute had taken any steps towards the formation of a School of Art in connexion with architecture, as suggested by Mr. Geo. Gilbert Scott. The President said he believed that the Institute had not taken any action in the matter.

Mr. J. D. Mathews, the Treasurer, read the balance sheet for the past session which showed the total receipts from all sources to be £176 0s. 2d. and the expenditure £160 18s. 10d., leaving a balance in hand of £15 1s. 4d. He said it was a matter of privilege to say that the Association was out of debt. The committee had made a grant of £5 to the library, and had voted 25s. per month to the figure-drawing class.

The President, in proposing the adoption of the balance-sheet, proposed a vote of thanks to the Secretary (Mr. J. D. Mathews), for the able and earnest manner in which he transacted the business of the Association.

The balance-sheet was adopted, and the vote of thanks to Mr. Mathews was unanimously carried.

The President read the report of the delegates to the Architectural Alliance Meeting on 3rd July, 1866, as follows:—

"Two only of your delegates to the Alliance, Messrs. Thos. W. Rickman and Robert W. Edis, attended on the 3rd July last at its meeting in Conduit-street, and the meeting was occupied throughout the day, first in the consideration of the various resolutions of the allied societies relating to the propriety of making the bills of quantities part of the contract, with regard to which question, although it was generally admitted that it was one of much importance, and deserving of the attention of the profession at large, it was not considered at present desirable for the Alliance to take any action thereon, involving—as any change in so important a matter must needs do—a very considerable amount of alteration in the present system; but, at the same time, it was a question which, without doubt, was receiving great attention, and one which was deserving of the serious discussion and consideration of the architectural societies throughout the country.

"Subsequently, attention was turned to the consideration of the form of contract promoted by the Birmingham Society. The position of the architect as regards the builder and his client, is one of so much complexity that it was felt that no conclusion could be at present arrived at which would enable the architect either to obtain a greater control over the builder than at present, and which might also take away from the architect all responsibility as regards questions of dispute between his client and the builder after his certificate of completion had been given; and it was considered by several of the delegates that it would be undesirable for many reasons to make the bills of quantities form a part of the contract, inasmuch that any error therein on the part of the surveyor would necessarily cause unpleasantness between the architect and his client, and, in reality, much power would be taken out of the architect's hands by such addition. It is only fair to add that, in the case of each of these proposed alterations, those who had actually tried them were in their favour. But in both these questions, your delegates have considered them as eminently worthy of consideration and discussion by the several societies."

The President observed that on the question of whether bills of quantities should form part of the contract, the Association delegates (Messrs. Rickman and Edis) held different opinions. At the meeting opinion was about equally divided, and the question was left in an unsettled state.

The reports above quoted were in each case adopted.

RUSSIAN RAILWAY CARRIAGES.

Russian railway carriages are thus described by the correspondent of the *Times*:—"The distances travellers have to perform in this country are so immense, and the weather is frequently so severe, that the idea of giving a sort of domestic arrangement to the cars naturally occurred to a people labouring under such disadvantages. Russian railway carriages are little houses on wheels. In the first, and partly also in the second class, their interior may be described as a saloon, with all the necessaries, and some of the elegances, of such an apartment. It is furnished with looking-glasses, heated by porcelain stoves, and lit by lamps and candles. Along the sides soft divans are ranged; the middle is occupied by a mahogany table, and double windows with red curtains exclude not only the rude touch of the Russian air, but also the aspect of the winterly sky. The company sits or lounges about, chatting, reading, or playing cards, chess, or dominoes. The day passes pleasantly enough, and as night comes the passengers betake themselves to rest almost as comfortably as at home. By a simple process the divans are made into beds, and supplied with pillows by the attentive guard. In the first class the carriages are also provided with second stories, so to say, reached by an elegant staircase, and fitted with complete beds; in the second, if there are too many passengers to be accommodated on the divans, part o them are lodged in berths, which take the place of the rack provided in England for hats and caps. At length everyone is snugly ensconsed, the ordinary good wishes are exchanged, and it is night in the car. The guard and the driver only keep awake. During the twenty hours a passenger is whirled along between St. Petersburg and Moscow, the train stops twenty times at least. The stations are elegant buildings, painted red, with broad white facings round the windows and along the eaves. Without, the very picture of cleanliness—they are well-stocked receptacles of the good things of this world within. The passenger enters a large vaulted hall, scrupulously whitewashed, and paved with flags. On long tables a sumptuous repast awaits him, every plate over a lighted lamp to maintain the warmth equally necessary in this country for taste and wholesomeness. The wines and beers of every clime are represented in numerous bottles, alternating on the neatly covered tables with steaming plates. The hall is in the bare, cold style so often met with in this country when pomp is not intended; but the viands are good, the waiters ready, and their white gloves unexceptionable. I need not say the whole affair is dear. Such luxuries as these are still regarded and paid for as exotic in this distant latitude. The station is an oasis. Round about, the aboriginal race of the country lives in wooden cottages, including the whole family and their quadrupeds too, in a single room."

THE ROYAL ACADEMY.

The new regulations, long under deliberation, having received the needful sanction of her Majesty, are printed and circulated, and will forthwith come into operation. They relate primarily to the number, nomination, election, and power of associates. The concession is made that the limit of twenty Associates may be exceeded; the minimum is fixed at that number, but the maximum is left undefined. Under this law, it will be possible to widen the area of the Academy, so as to make it commensurate with the art talent of the country. As to nomination of Associates a change has been effected. The old ordinance, which required a candidate to inscribe his name in a book, was regarded as needless and humiliating. This condition to election is now abolished, and in its stead a candidate will be proposed and seconded in writing by some friend in the Academy. The elections will be then made from the printed lists of all the candidates, and the votes and names of the voters may be known on demand of the majority. Associates are now, for the first time, endowed with votes, and thus vested with power. The election of associates will take place in January, and of Academicians in June and December, of each year. Though the number of Associates may be indefinitely multiplied, the prospective right to a pension can never be vested in more than twenty at a time. This safeguard will remain for long superfluous. Other reforms already resolved upon await the accession of space which the new building will afford.

Coast Semaphores and Telegraphy.—The semaphores erected on the coasts of France have just been placed at the service of the commercial world. These semaphores being in relation with the whole telegraph system of the empire, captains of ships may now make known their wants, sends orders, and receive instructions and news without the necessity of entering ports or harbours, or even of quitting their course for shallow waters. Elaborate instructions have been drawn up by the Ministers of the interior and of the marine, and sent to all the ports and chambers of commerce in France, for the regulation of the working of these coast telegraphs, the signals used being those laid down in the code of commercial signals for all the world, drawn up by a commission appointed by the English and French Governments conjointly, and approved and adopted by Belgium, Italy, Spain, Portugal, and some other powers. A system and code which, when completed, will place the ships of all the world in direct communication with the territory of every nation, is certain of universal adoption. The English Government is now establishing semaphores along our own coasts on the same plan, and in connection with the same system of signals.