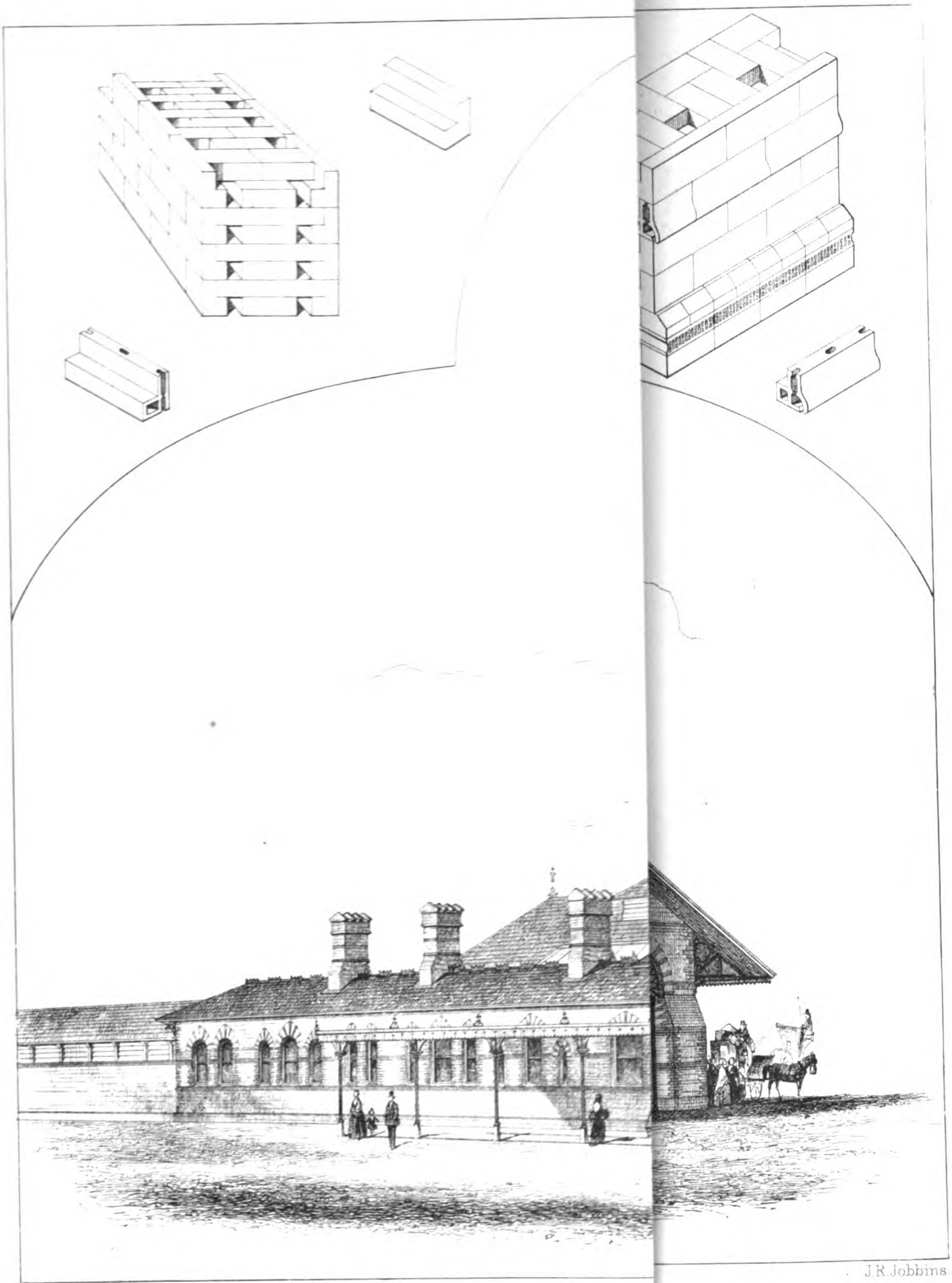

J. R. Jobbins

THE

CIVIL ENGINEER AND ARCHITECT'S

JOURNAL.

VOLUME TWENTY-FIFTH.—1862.

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

PRINTED BY W. KNOTT,
GREVILLE STREET, HATTON GARDEN, E.C.

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PLATE ENGRAVINGS.

W. KNOTT, PRINTER, GREVILLE STREET, HATTON GARDEN, E.C.

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THE

CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

ON THE "ECONOMIC ANGLES" OR PROPORTIONS OF FRAMED CONSTRUCTIONS.

ART 1.—To ascertain the most economical or best arrangement of the parts in any construction, we must, in the first place, determine what are the qualities chiefly desired in the particular circumstances. It may be that we have to attend to the consideration of cost alone, or weight of structure, or its bulk, or some particular combination of these qualities, and which is to be rendered a minimum.

Let, then, a represent the cost or weight, or bulk of such a quantity of any material as will be capable of conveying a unit of stress through a unit of distance; thus for example, a_2 may represent in some of these forms the quantity of material contained in a tie-rod measuring one foot long and capable of safely withstanding a working stress of one ton. In the subjoined table we offer some approximate values of a for various materials used for ties and struts, but these are given more for the sake of affording a clearer idea of the meaning of the symbol a than for any merit they may otherwise possess. These values are given under the heads of *cost*, *weight*, and *bulk*—those under the first head must be varied to suit the prices in different localities. When regard is had to more than one of these qualities, the value of a must be modified accordingly; thus, for instance, in the case of an elevated structure to be erected abroad, and where it will be exposed to gales, we must not alone consider the simple *cost* of the fabric in determining upon its proportions, but must also have regard to *bulk* on account of the greater resistance to the wind, and the greater expense for freight and painting.

Table of the values of "a" for Ties and Struts one foot long subjected to a working stress of one ton.

Material, &c.	a when *cost* is alone considered.	a when *weight* is alone considered.	a when *bulk* is alone considered.
TIES.	£ Sterling.	Tons.	Cubic Feet.
Wrought Iron	0·0060	0·00030	0·0014
Wire Rope	0·0075	0·00018	0·0009
Steel	0·0050	0·00012	0·0006
Rope	0·0090	0·00030	0·0104
Fir Timber	0·0013	0·00017	0·0104
Cast Iron	0·0100	0·00100	0·0046
STRUTS.			
Cast Iron, short	0·0014	0·00014	0·0007
Do. 20 diameters in length ...	0·0035	0·00035	0·0018
Wrought Iron, short	0·0075	0·00038	0·0018
Do. 20 diameters in length ...	0·0100	0·00050	0·0023
Fir Timber	0·0026	0·00035	0·0210
Do. 20 diameters in length ...	0·0040	0·00053	0·0315
Brickwork of moderate height ...	0·0060	0·00700	0·1400
Granite ditto...	0·0042	0·00105	0·0140

Again, the values of a given in the table are for the simple tie or strut without any addition for those joints and extra stiffening framings which *vary with* the length and stress of the piece. The correct value a_n to be used in the formulæ must be made to include an allowance for all such added parts. Those parts which do not so vary, but are of a fixed amount, do not affect the question of economic proportions, and are therefore excluded from the calculations.

2.—The standard of merit, in an economic sense, of any material when it has to resist longitudinal stress, or in other words, its relative value in framed constructions when it has to act as a strut or a tie, will be represented by $\frac{1}{a}$. And if in a strut or tie the total stress be represented by P, and the length by L, then the total cost or weight or bulk (whichever may be denoted by a), of the one strut or tie, in so far as that affects the economic angles, will be $=A=PLa$.

Now, the object sought in the following investigations is to reduce the sum, which we may put $=\text{A}$, of all the values of A for the several parts of a structure, to a minimum.

$$A = A_1 + A_2 + A_3 \text{ \&c.} = P_1 L_1 a_1 + P_2 L_2 a_2 + P_3 L_3 a_3 \text{ \&c.}$$

3.—To show more clearly the use of the table and symbols, let us take the example, Fig. 1, where w is a weight of 10 tons, supported by the mutual action of the wrought-iron tie wc 10 feet long, and the timber (fir) strut wb. The *cost* alone to be considered, and all parts beyond the points w, c, and b, to be constant, and therefore not taken into account in the calculation of the economic value of the angle β.

By the table we find the value of a_1 for the iron tie=£0·006, also, a_2 for the strut=£0.004. Now (in Art 9 following) we have this formula for the value of angle β

$$\tan\beta = \sqrt{\frac{a_1 + a_2}{a_2}};$$

substituting the above values of a_1 and a_2 we get angle $\beta = 57°\ 41'$.
and $\alpha = 32°\ 19'$ ∴

Stress on strut $wb = w \sec\alpha = 11.83$ tons, length of $wb = 10$, $\sec\beta = 18·71$
Stress on tie $wc = w \tan\alpha = 6·33$ tons. Therefore,

$$A = \left\{ \begin{array}{l} A_1 = P_1 L_1 a_1 = 6·33 \times 10 \times 0·006 = 0·380 \\ +A_2 = P_2 L_2 a_2 = 11·83 \times 18·71 \times 0·004 = 0·855 \end{array} \right\} = £1·265$$

Of course the total cost would require an addition to be made to this to cover the expense of fixing in the wall, the ends, and the connection at w; but this is not the subject of calculation here.

Should some other value than 57° 41′ be *insisted* on for the angle β, a more or less augmented value of A would result, as shown in this table:—

Angle β.	Cost, or A.
65° 0′	1·324
57° 41′	1·265
45° 0′	1·400
30° 0′	1·963

4.—Let *abcd*, Fig. 2, be the whole, or the half of a framing, and let its duty be to support the weight *w*. *ab* is a horizontal strut, *dc* a horizontal tie, *bc* a strut inclined at an angle $=\phi$ to the tie *dc*, and *bw* is a vertical tie or suspension rod.

Let the values of A for *dc*, *ab*, *bw* and *bc* be respectively $= A_1 A_2 A_3, A_4$

Let the values of *a* for the same be $= a_1 a_2 a_3, a_4$

Then we have:

$$A\begin{cases} A_1 = w \cot \phi \times (m+n) . a_1 \\ +A_2 = w \cot \phi \times m . a_2 \\ +A_3 = w \times n \tan \phi . a_3 \\ +A_4 = w \operatorname{cosec} \phi \times n \sec \phi . a_4 \end{cases}$$

Dividing by *w*, differentiating, dividing by $d\phi$, putting the result $=0$ for a minimum, and transposing, we get

$$\frac{ma_1+na_1+ma_2+na_4}{\sin^2\phi} = \frac{na_4+na_3}{\cos^2\phi} \text{ whence}$$

$$\tan\phi = \sqrt{\frac{\frac{m}{n}(a_1+a_2)+a_1+a_4}{a_3+a_4}} \quad \ldots \ldots \ldots \ldots (1)$$

When *a* for both ties is the same, we may substitute a_1 for a_3; and when *a* for the two struts is the same, we may substitute a_2 for a_4.

$$\tan\phi = \sqrt{\frac{\frac{m}{n}a_2+a_4}{a_4+a_3}} \quad \ldots \ldots \ldots \ldots \ldots (5)$$

And when $a_4 = a_2$, this becomes

$$\tan\phi = \sqrt{\frac{m+n}{n+n\frac{a_3}{a_2}}} \quad \ldots \ldots \ldots \ldots \ldots (6)$$

And if $m=\frac{1}{2}n$, and $a_2=a_3$, $\phi=40°\ 54'$ as in Fig. 8.

„ $m=\ o$, and $a_2=a_3$, $\phi=35°\ 16'$ as in Fig. 9.

When the framing is deprived of both the ties *dc* and *bw*, formula (1) becomes

$$\tan\phi = \sqrt{\frac{m}{n}\cdot\frac{a_2}{a_4}+1} \quad \ldots \ldots \ldots \ldots (7)$$

And if $m=2n$, and $a_2=\ 2a_4$, $\phi=65°\ 54'$,

„ $m=\frac{1}{2}n$, and $a_2=0{\cdot}8a_4$, $\phi=49°\ 48'$,

And when $a_2=a_4$, the formula becomes

$$\tan\phi = \sqrt{\frac{m}{n}+1} \quad \ldots \ldots \ldots \ldots \ldots (8)$$

which is identical with (2).

And when $m=\frac{1}{2}n$, $\phi=50°\ 46'$ as in Fig. 10,

„ $m=\ 0$, $\phi=45°\ \ 0'$ as in Fig. 11.

5.—If upon the same base line, having a length $= 2\,(m+n)$, we draw a series of frames given by the formula (2) of Art. 4, with a variety of values of *m* and *n*, we get such a combination as is shown in Fig. 12.

Now it is evident that the curves $Pb_1b_2b_3$, &c., and Qb_1b_2, &c., forming the locus of the point *b*, are such that if *n* be taken to

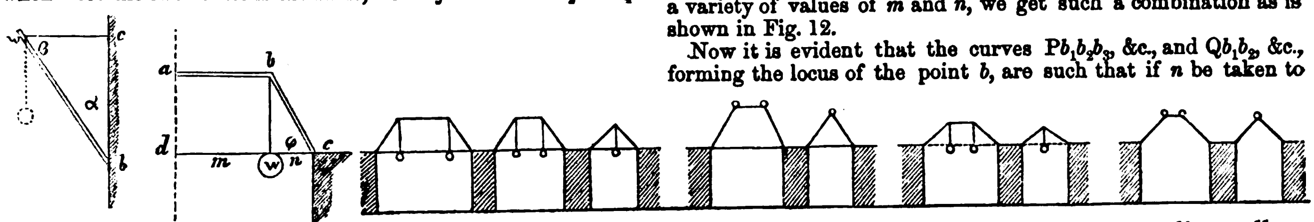


Fig. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11.

When such is the case, we have

$$\tan\phi = \sqrt{\frac{m}{n}+1} \quad \ldots \ldots \ldots \ldots \ldots (2)$$

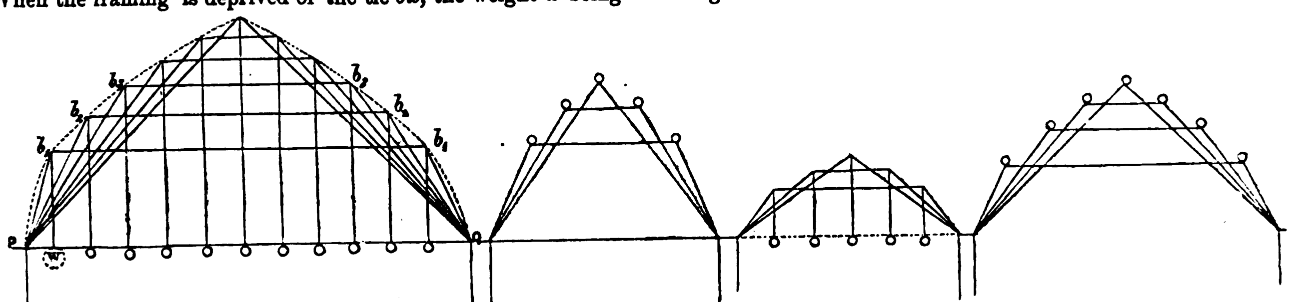
And if $m=\ n$, $\phi=54°\ 44'$ as in Fig. 3

„ $m=\frac{1}{2}n$, $\phi=50°\ 46'$ as in Fig. 4

„ $m=\ o$, $\phi=45°\ \ 0'$ as in Fig. 5

When the framing is deprived of the tie *bw*, the weight *w* being

represent the abscissa P*w*, then the ordinate b_1w will be$=n\tan\phi$, but by formula (2) this $= n\sqrt{\frac{m+n}{n}}$, squaring this and dividing by the abscissa *n*, we get $m+n$, or $\frac{1}{2}\overline{PQ}$. The curves are therefore parabolas having parameters $= m+n$, and their apices at P and Q. From formula (1) we get the parameter for the more general case



12. 13. 14. 15.

then imposed at the point *b*, formula (1) becomes

$$\tan\phi = \sqrt{\frac{\frac{m}{n}(a_1+a_2)+a_1+a_4}{a_4}} \quad \ldots \ldots \ldots \ldots (3)$$

And if a_4 be taken$=a_2$, this becomes:

$$\tan\phi = \sqrt{\left(\frac{m}{n}+1\right)\cdot\left(\frac{a_1}{a_2}+1\right)} \quad \ldots \ldots \ldots \ldots (4)$$

And if $m=\ n$, and $a_1=\ a_2$, $\phi=63°\ 26'$

„ $m=\frac{1}{2}n$, „ $a_1=2a_2$, $\phi=64°\ 46'$

„ $m=\frac{1}{2}n$, „ $a_1=\ a_2$, $\phi=60°\ \ 0'$ as in Fig. 6.

„ $m=\frac{1}{2}n$, „ $a_1=\frac{1}{2}a_2$, $\phi=56°\ 19'$

„ $m=\ o$, „ $a_1=\ a_2$, $\phi=54°\ 44'$ as in Fig. 7.

„ $m=\ o$, „ $a_1=\frac{1}{2}a_2$, $\phi=50°\ 46'$

When the framing is deprived of the tie *dc*, formula (1) becomes

$$=\frac{m(a_1+a_2)+n(a_1+a_4)}{a_4+a_3} \quad \ldots \ldots \ldots \ldots (1)$$

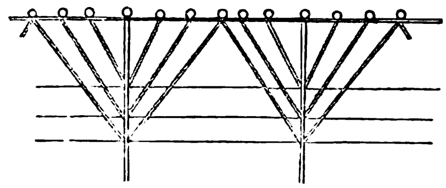
And the parameter for any particular case is obtained by squaring the expression for $\tan\phi$ and multiplying by *n*. Thus in the case having formula (4), the parameter $=(m+n).\left(\frac{a_1}{a_2}+1\right)$, and when $a_1=a_2$, this becomes $=\overline{PQ}$, according to which Fig. 13 is drawn.

The equation (6) gives parabolas having parameters $= \dfrac{m+n}{1+\frac{a_3}{a_2}}$

and when $a_3=a_2$, this becomes $=\frac{1}{2}\overline{PQ}$, according to which Fig. 14 is drawn. The equation (8) has the corresponding parameter $=m+n=\frac{1}{2}PQ$, as in Fig. 15.

6.—When the structure shown by Fig. 2 is inverted, it becomes that shown by Fig. 18; and the ties and struts are respectively changed into struts and ties.

All the formulæ already given might stand as they are, and be applicable to this new arrangement, if we changed the application of the symbols $a_1a_2a_3$ and a_4; for instance, making a_1, not the value of a for the tie *dc* in Fig. 2, but its value for the strut *dc* in Fig. 18. It will, however, be better to retain the symbols $a_1a_3a_5$ &c. for the values of a for ties, and $a_2a_4a_6$ &c. for struts. And all the change required in the formulæ will be the substitution of



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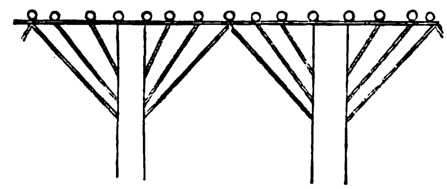

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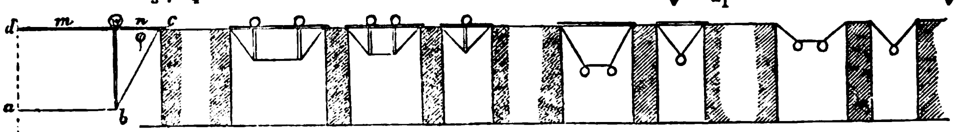
a_2 for a_1, a_4 for a_3, and *vice versâ*. We now then have the values of a for *ab*, *dc*, *bc*, and *bw* respectively, equal to a_1, a_2, a_3, and a_4, for these parts the values of A will also be respectively as A_1, A_2, A_3, and A_4. And the general formula (1) of Art. 4 becomes for Fig. 18

$$\tan\phi = \sqrt{\frac{\frac{m}{n}(a_1+a_2)+a_2+a_3}{a_3+a_4}} \quad \dots\dots\dots\dots (1)$$



18. 19. 20. 21. 22. 23. 24. 25.

And when $a_1 = a_3$, and $a_2 = a_4$, this becomes

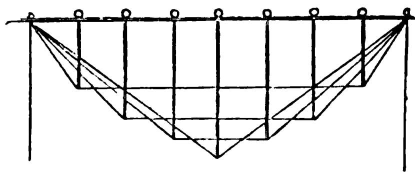
$$\tan\phi = \sqrt{\frac{m}{n}+1} \quad \dots\dots\dots\dots (2)$$

And if $m = n$, $\phi = 54°\ 44'$ as in Fig. 19.
" $m = \frac{1}{2}n$, $\phi = 50°\ 46'$ as in Fig. 20.
" $m = 0$, $\phi = 45°\ 0'$ as in Fig. 21.

The more general formula for Fig. 21 is

$$\tan\phi = \sqrt{\frac{a_2+a_3}{a_3+a_4}} \quad \dots\dots\dots\dots (3)$$

Making similar changes in the other formulæ, we obtain the particulars for such framings as Figs. 22 to 28. In Fig. 26, a_4 for the upright pieces is assumed three times greater than a for each of the other parts.



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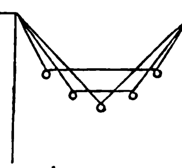

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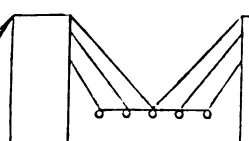

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7.—Given the bracket arrangement, Fig. 29, consisting of a tie *aw*, and a strut *wb*, to support a weight suspended from the point *w* at a given distance *cw* from the wall *ab*; required the values of the angles α and β which will render A a minimum.

The horizontal component of the strain in *aw* will be equal to the horizontal component of the strain in *wb*: let this = H. The vertical components of the strains in *aw* and *wb* will be respectively = H tan α, and H tan β. Let $p = \tan\alpha$, and $q = \tan\beta$, then

The weight $w = H(\tan\alpha + \tan\beta) = H(p+q) \dots\dots (1)$

$$A \left\{ \begin{array}{l} A_1 = H \sec\alpha \,.\, \overline{cw} \sec\alpha \,.\, a_1 \\ +A_2 = H \sec\beta \,.\, \overline{cw} \sec\beta \,.\, a_2 \end{array} \right\} = H\,\overline{cw}\,(a_1 \sec^2\alpha + a_2 \sec^2\beta)$$

$\sec^2\alpha = 1 + \tan^2\alpha = 1 + p^2$, and $\sec^2\beta = 1 + q^2$.

Substituting these values, and omitting $\overline{cw}$ as not affecting the question, we have

$$A\alpha H\,(a_1+a_1p^2+a_2+a_2q^2) \quad \dots\dots\dots\dots (2)$$

Differentiating (1), and putting it = 0, as not being variable,

$$(p+q)\,dH + H\,dp + H\,dq = 0,$$

Differentiating (2), and putting it = 0 for a minimum,

$$(a_1+a_1p^2+a_2+a_2q^2)\,dH + 2a_1Hp\,dp + 2a_2Hq\,dq = 0.$$

Let q be constant, and we have $(p+q)dH + H dp = 0$,

whence $\frac{dH}{dp} = -\frac{H}{p+q}$ and $(a_1+a_1p^2+a_2+a_2q^2)dH + 2a_1Hp\,dp = 0$,

whence $\frac{dH}{dp} = -\frac{2a_1pH}{a_1+a_1p^2+a_2+a_2q^2}$,

therefore $\frac{H}{p+q} = \frac{2a_1pH}{a_1+a_1p^2+a_2+a_2q^2}$, whence

$$2a_1p\,(p+q) = a_1+a_1v^2+a_2+a_2q^2, \quad \dots\dots\dots\dots (3$$

similarly $2a_2q\,(q+p) = a_1+a_1p^2+a_2+a_2q^2 \quad \therefore \quad \dots\dots (4)$

$$a_1p = a_2q,\ q = \frac{a_1}{a_2}p \quad \dots\dots\dots\dots (5)$$

Substituting this value for q in formula (3), we get

$$p = \sqrt{\frac{a_2}{a_1}}, \text{ and similarly } q = \sqrt{\frac{a_1}{a_2}} \quad \dots\dots (6)$$

We further have $\alpha + \beta = 90°$.

If $a_1 = \frac{1}{2}a_2$, $\beta = 35°\ 16'$
" $a_1 = \frac{3}{4}a_1$, $\beta = 39°\ 14'$
" $a_1 = 1\frac{1}{2}a_2$, $\beta = 50°\ 46'$
" $a_1 = 2a_2$, $\beta = 54°\ 44'$

8.—When the strut is made horizontal, q becomes = 0; making this change in (3) of Art. 7, we get

$$p = \sqrt{\frac{a_1+a_2}{a_1}} \text{ for Fig. 30.}$$

If $a_1 = \frac{1}{2}a_2$, angle $\alpha = 60°\ 0'$
" $a_1 = a_2$, " $\alpha = 54°\ 44'$
" $a_1 = 2a_2$, " $\alpha = 50°\ 46'$

9.—When the tie of Fig. 29 is made horizontal, p becomes = 0, and equation (4) of Art. 7 becomes

$$q = \sqrt{\frac{a_1+a_2}{a_2}} \text{ for Fig. 31.}$$

10.—When p or q has a given fixed value = p_1 or q_1, the value of the other, obtained from equations (4) or (3) of Art. 7, will be as follows:

$$p = \sqrt{\left(1+\frac{a_2}{a_1}\right) \,.\, (1+q^2_1)} - q_1$$

$$q = \sqrt{\left(1+\frac{a_1}{a_2}\right) \,.\, (1+p^2_1)} - p_1$$

11.—Given a weight w (Fig. 32) to be suspended by the two ties C*w* and D*w* from the parallel walls CA and DB. Required the angles α and β which will render $A_1 + A_2$ for C*w* + D*w* a minimum.

The following is an amplification of an unpublished solution of this problem by Mr. Sang of Edinburgh:—

Let A*w* = m, B*w* = n, tan $\alpha = p$, tan $\beta = q$, H = horizontal component of stress in C*w* or D*w*, a_1 and a_2 = the values of a for C*w* and D*w*.

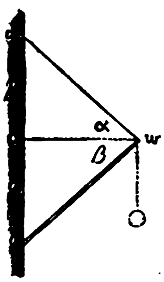
$$A=\begin{cases} A_1=H\sec\alpha\,.\,m\sec\alpha\,.\,a_1=Ha_1m\sec^2\alpha \\ A_2=H\sec\beta\,.\,n\sec\beta\,.\,a_3=Ha_3n\sec^2\beta \end{cases}=H(a_1m+a_1mp^2+a_3n+a_3nq^2)$$

$w=H(p+q)$.

Differentiating the values of A and w, we get

$$dA=dH(a_1m+a_1mp^2+a_3n+a_3nq^2)+2Ha_1mpdp+2Ha_3nqdq=0$$
$$dw=dH(p+q)+Hdp+Hdq=0.$$

When $m=\frac{1}{3}n$, and $a_2=\frac{1}{2}a_4$, putting $m+n=1$, we have AC=0·612, and BD=0·306 (see Fig. 33). When we make one of the **parts**, say Cw, horizontal, p becomes=0, and the formula (2) of **Art. 11** becomes, after reduction, and making the necessary changes in the values of a, $a_4nq^2=a_2m+a_4n$; $\therefore\ q=\sqrt{\frac{m}{n}\cdot\frac{a_2}{a_4}+1}$, as previously obtained, see (7) of Art. 4. And when any fixed value



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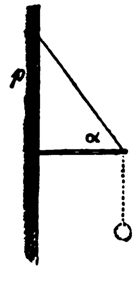

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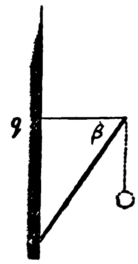

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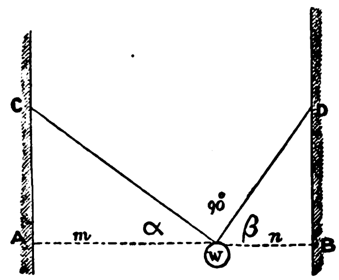

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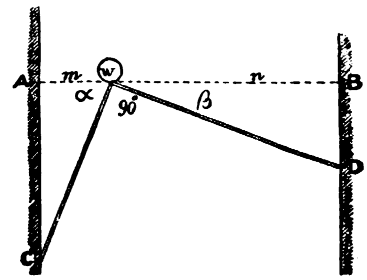


33.

Making q constant, we get

From the first $\frac{dH}{dp}=-\frac{2Ha_1mp}{a_1m+a_1mp^2+a_3n+a_3nq^2}$

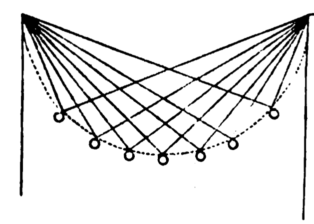
From the second $\frac{dH}{dp}=-\frac{H}{p+q}$

$$\therefore\ 2a_1mp(p+q)=a_1m+a_1mp^2+a_3n+a_3nq^2\ldots\qquad\ldots\quad(1)$$

is assigned to p or q, the economic value of the other will be obtained by substituting the assigned value in formula (2) or (1) of Art. 11 respectively.

13.—We will finish with this subject for the present by taking the example of a rigid suspension bridge, Fig. 38.

Let it be wholly of wrought-iron, and of such moderate span that the whole strain-producing load may be considered as con-



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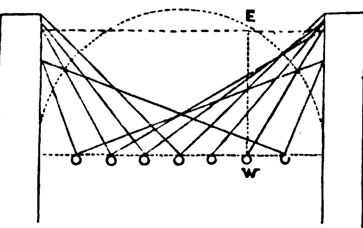

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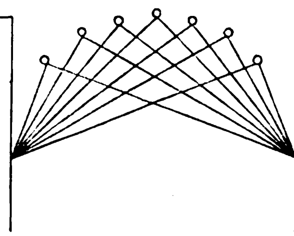

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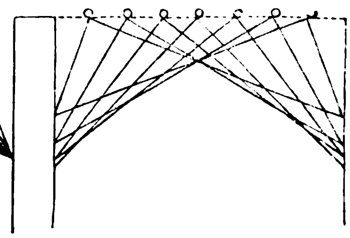


37.

similarly, $\quad 2a_3nq(p+q)=a_1m+a_1mp^2+a^3n+a_3nq^2\ldots\qquad\ldots\quad(2)$

$$\therefore\ a_1mp=a_3nq,\text{ and }q=\frac{a_1m}{a_3n}p\qquad\ldots\qquad\ldots\quad(3)$$

Substituting this value for q in equation (1), and reducing, we get

$$p=\sqrt{\frac{a_3n}{a_1m}},\text{ and similarly }q=\sqrt{\frac{a_1m}{a_3n}}\qquad\ldots\quad(4)$$

$$AC=mp=\sqrt{\frac{a_3nm}{a_1}},\ BD=nq=\sqrt{\frac{a_1mn}{a_3}},\ AC=BD\frac{a_3}{a_1}\quad(5)$$

When $a_1=a_3$, then $AC=\sqrt{mn}=BD$, $p=\sqrt{\frac{n}{m}}$, $q=\sqrt{\frac{m}{n}}$

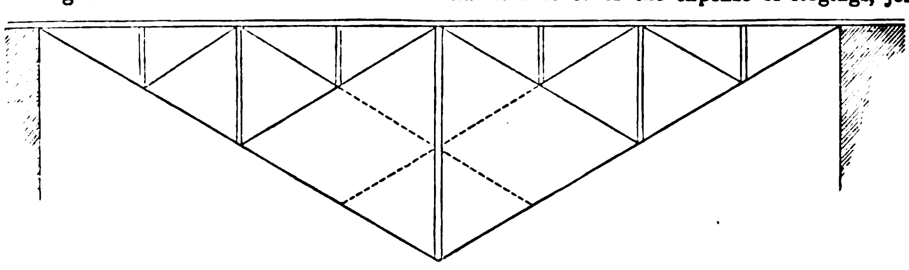
and as m : AC or BD=AC : n, the angle CwD is a right angle, so that i the points C and D be fixed, the locus of the point w will be a semicircle, as in Fig. 34.

centrated at the level of the roadway; let *cost* be the form in which the value of a is to be considered (the material being already determined upon).

Now this structure is simply a combination of framings such as shown by Fig. 21. It could indeed be constructed with framings of this form made to act independently of one another, except where the extremity of one frame transfers half the load to the centre of another of larger size. To obtain the general economic angle therefore, we must take the general formula (3) of Art. 6 for the Fig. 21, but in assigning the values of a, we must duly regard the circumstances of the complete structure

$$\tan\phi=\sqrt{\frac{a_2+a_3}{a_3+a_4}}$$

a_3 for all the ties may be taken from the table with only a slight addition to cover the expense of forgings, joints, &c., say a_3=



38.

And if the positions of w be confined to the same horizontal line, the parts will be arranged as in Fig. 35, the height of the points C and D being determined by the line wE drawn to the dotted semicircle.

12.—When the character of the arrangement in Fig. 32 is reversed, as shown by Fig. 33, the ties being converted into struts, the same conclusions are arrived at with the substitution of a_2 and a_4 for a_1 and a_3. There will however here be greater probability of a difference in the two values of a. When $a_2=a_4$ we have the structure regulated by the semicircle, as in Fig. 36.

£0·0066: a_2 for the horizontal top piece we will set down at £0·0080; it may be remarked that we exclude from this any consideration of the horizontal bracing, and the additional material to be added to the top to bear the transverse action of the roadway, as these are constant, and do not effect the value of ϕ. But a_4 for the upright struts must be liberally dealt with, and must be taken to include the transverse bracing to stiffen them; let a_4 therefore =£0·0150. We now then have

$$\tan\phi=\sqrt{\frac{\cdot0080+\cdot0066}{\cdot0066+\cdot0150}}=0\cdot8222,\ \therefore\ \phi=39^\circ\ 26'.$$

If the above values of a_2 and a_3 be retained and

a_4 be made $=0{\cdot}0200$, the angle $\phi=36°\ 33'$
a_4 " $=0{\cdot}0240$, " $\phi=34°\ 38'$
a_4 " $=0.0320$, " $\phi=31°\ 36'$
a_4 " $=0{\cdot}0372$, " $\phi=30°\ 0'$

The last value, 0·0372, given above for a_4 is 4·65 times that assigned to a_2 for the top piece; there can be little doubt, therefore that such a value of a_4 is in excess, yet with this value the economic angle ϕ is still so great as 30°. Fig. 38, which is drawn with $\phi=30°$, would be very generally pronounced as having far too great a depth in proportion to the span; the eye in this being misled by the commonness of the error committed by engineers when dealing with bridges of openwork construction, of making the depth too small. On this subject see vol. for 1855 of this *Journal*, p. 236.

To exhibit the increase of material in the structure, Fig. 38, (exclusive of the transverse girders, &c. of the roadway platform, and the horizontal bracing) which accompanies a wrong value of ϕ, let us take $a_4=0{\cdot}024=3a_2$; the corresponding economic value of $\phi=34°\ 38'$, then by assuming other values for ϕ, and calculating the corresponding value of A by the formula in Art. 4 properly modified,

$$A \div \cot\phi a_2 + \operatorname{cosec}\phi.\ \sec\phi a_3 + \tan\phi a_4,$$

we get the proportionate results given in this table:

Value of ϕ.	Span divided by Depth.	Proportionate Value of A.
34° 38′	2·895	100·00
30° 0′	3·464	101·61
25° 0′	4·289	107·82
20° 0′	5·495	121·24
15° 0′	7·464	148·29
10° 0′	11·342	208·63

The increase shown in the table gives a very inadequate idea of the extremely rapid increase on the value of A in the case of a bridge of great span, when the weight of the structure itself is taken into consideration, and becomes the chief part of the load.

R. H. B.

VENTILATION OF DWELLINGS AND HOSPITALS.

(*Continued from page* 326, *vol.* xxiv.)

THUS far all the examples we have given are of what is termed "natural" ventilation, that is to say, ventilation so arranged as to depend for its motive power solely on the expansion and consequent increase in lightness of the atmosphere when raised in temperature. The atmosphere around us is always, save under circumstances of unbearable heat, at a temperature much below that of the human body; consequently, air which has been taken into the lungs leaves the mouth, under ordinary circumstances, at a much higher temperature than that of the atmosphere into which it is discharged; the time during which it remains in the air passages and lungs being sufficient to allow of its being raised to a heat approaching blood-heat.

The expired air, commonly known as "the products of respiration," is in a very different condition in other respects, as well as in temperature, from that in which it entered the body. It is saturated with water, has lost a portion of its oxygen, is charged with carbonic acid, and is unfit if re-inhaled to support health, while if respired a few times it would become unfit even to support life. These changes in quality furnish the reasons why it is desirable the expired air should rapidly be removed from the neighbourhood of the person who has breathed it. The change in temperature is the circumstance which nature has so arranged as to afford, under ordinary conditions of atmosphere, a safe and certain means of effecting this removal.

In the open air, then, the breath (or the heated products of respiration) on leaving the mouth, rapidly ascends to a considerable height, and only parts with its excess of caloric at such a distance from the earth that it is quite out of the reach of human respiration. In a room perfectly closed the expired air, gases, and moisture ascend to the ceiling, where, finding no outlet, they gradually cool—the vitiated air by degrees sinking down into and mingling with the surrounding atmosphere, the super-abundant moisture being condensed in the form of a dense dew upon all the cool surfaces in the apartment.

In rooms furnished with any of the appliances described in our former article, the vitiated air ascends to the ceiling, and there finds an outlet channel, up which its own rarity causes it to ascend, while in many cases (such as that of openings into chimney flues) an already existing upward current stimulates the spontaneous action of the heated air; a second opening being in all cases provided which will afford an adequate supply of air to replace the amount drawn out.

This then is a brief account of the nature of natural ventilation, and it will be perceived that two things are essential to it. The first being an exit at the upper part of the room—the second being an independent source for the supply of air.

That ordinary rooms in ordinary English dwelling-houses are not constantly overloaded with vitiated air is, we believe, due to the circumstance that a "natural ventilation" of a rough sort exists in them. The interstices between the floor boards, the joints of our windows, and the openings round our doors, supply the inlet channels—the upper part of the space over the fire opening forms the outlet. It is true that this outlet is not near the ceiling, and the products of respiration, after ascending to the ceiling, have to cool, and to descend towards the floor, mixing as they go with the unvitiated air in the room, and passing the level of the mouths of the inmates, before they can possibly reach the fire-place, but still a fair proportion of these products of respiration do perform this circuitous journey, and do actually escape up the chimney; and thus it is that a common open fire promotes so much the purity of the air of a room. It seems clear, however, that an opening at the level of the ceiling, especially if the channel into which it leads be in some way excited by the improved current in the chimney flue, or be itself that flue, will discharge the vitiated air more completely, and do the office of a ventilating outlet more perfectly, than any chimney opening. Upon this then all good practice in ventilating ordinary rooms upon natural principles agrees—namely, the propriety of an outlet at the upper part of the room.

On the question of inlets both opinions and practice differ. There can be no doubt that the place where the fresh air might most naturally be introduced is near the floor, and here accordingly it has often been attempted to bring it in, but there are practical difficulties in the way of any introduction of fresh air at or near the floor, which seem formidable. We are all aware how much annoyance is occasioned by the currents entering at the self-constituted inlet-channels to which we have referred—the crevices at and about the windows and doors of an ordinary room; how in cold weather the occupants complain of draughts, and how sedulously they stop up to the best of their ability every inlet for fresh air. Now it is hardly possible to devise any inlet at or near the ground level from which a current of air will not be perceptible, and from which, consequently, inconvenience will not be felt. The inlets recommended by the Barrack and Hospital Commissioners, whose report we have referred to, are accordingly placed near the upper part of the rooms, and at a considerable distance from the outlets, so that the entering current may have time and opportunity to mingle with the air in the room, may almost imperceptibly descend into the general atmosphere, and may gently mix with it.

To secure that the influx of air shall be imperceptible is to secure that it shall remain unchecked—and as even a Sheringham valve, or such a ventilator as we figured at page 324, is sometimes found to produce a sensible draught, we think the best plan yet proposed for inlets is that of Mr. Varley, already described, by which the incoming current is filtered through a large surface of perforations. It is also worth notice that a larger area given to the inlet will diminish draught, that is, will diminish the sensible rapidity with which air enters an apartment. Under no circumstances will the inlet admit more air than the outlet can carry off. If, therefore, the size of the latter be properly regulated, the former may safely be made pretty large.

It has been proposed to *warm* the air admitted into rooms before its admission, and several very ingenious methods of doing this exist; perhaps the best, as well as one of the most recently introduced, is a new stove, the invention of Mr. Taylor, in which air for the supply of the room enters through chambers of fire-clay which surround the grate.

Plans for introducing warmed air generally fail in avoiding the inconvenience of draught, for the air is not introduced, or at least ought not to be so, at a temperature at all approaching blood-heat, and consequently if thrown in a jet or current against any part of a human body, it, warm though it be, abstracts heat, and causes a sensation of cold, which is increased if it be at the same time abstracting moisture. Consequently it seems clear that even an inlet for warmed air ought to be carefully placed, so that the current admitted by it shall not be directed against any occupant of the room; and this being secured, an inlet for *moderately* warmed air seems in every way more desirable than one admitting air at a temperature much below the general warmth of a comfortable room.

Before leaving the subject of outlets and inlets, it may be right to revert to a simple method of introducing external air, which has been employed with good results in large rooms, such as schools, &c.

The air has been allowed to pass in through channels or apertures at the level of the floor, but in place of being allowed at that level to mingle with the air of the room, it enters vertical trunks of planed deal, some five or six feet high, and fixed against the wall. In these trunks it acquires an ascending direction, and leaving them at a level with, or rather above the heads of the occupants of the apartment, it mingles with the air of the room, and descends to the breathing level so far dispersed as not to be perceptible in the form of draught.

(*To be continued.*)

THE PATENT LAWS OF AMERICA.

The publication of the Annual Report of the Commissioner of Patents of the United States affords an opportunity of comparing the operation of the patent laws in America with those of England.

The form of the report presents a striking difference from the brief statement annually laid before parliament by the Commissioners of Patents in this country. It consists of two thick octavo volumes, one of them being entirely filled with engravings, and the other containing nearly 900 pages of closely-printed matter. The importance attached to this yearly report of the progress of invention in the United States is shown by the order of Congress for printing 10,000 copies of it for the use of the patent office, and 40,000 for the use of the members of the house of representatives. The preparation of a work of this kind requires no small labour, and it is not usually published until upwards of twelve months after the date of the year to which it refers. The report which has recently reached us is for the year 1859, before the breaking out of the internal convulsion that has now put a stop to improvements in manufacturing arts, but up to that period it exhibits an astonishing increase in the number of patented inventions compared with the years preceding.

So far as the activity of inventive genius may be considered a criterion of the activity of trade and manufactures, the commercial industry of the United States had progressed in a prodigious ratio, for whilst the number of patents issued in 1853 was only 958, in 1858 it had increased to 3710; and in the year to which the report refers no less than 4538 patents were issued. Nor do these numbers indicate by any means all the claims for new inventions, for it is the practice in the United States to submit all such claims to a preliminary examination, and in some years the number of applications for patents doubled, and even trebled, the number of patents granted. The practice in England is to grant patents to all applicants who pay the fees, the exceptions to the rule being so few as to be insignificant, and had the same practice prevailed in the United States the number of patents issued in 1859 would have been, at the least, 6000, or nearly double the number granted in this country. The greater number of patents applied for in the United States is, no doubt, principally owing to the comparatively small sum for which they can be obtained, which does not amount to one-twelfth part the sum that a monoply for fourteen years can be procured in England. Nevertheless, though the work in the American patent office must greatly exceed that of the patent office in England, in consequence of the preliminary examination of the inventors' claims, the receipts considerably exceed the expenditure, and in 1859 there was a balance of 35,664 dollars paid into the treasury.

The Commissioner's report specifies separately the number of patents issued to the subjects of the various states which, in 1859, constituted the Union, from which some idea may be formed of their relative manufacturing enterprise. New York is far above the rest, the number granted to the citizens in that state being 1237; Pennsylvania ranks next, with 532; then comes Massachusetts, with 492; Ohio, 390; and Connecticut, with 256. In the Southern States the numbers are comparatively few, those issued to the citizens of Virginia amounting to 65; to South Carolina, 15; whilst in Florida and Oregon there was only one patent issued in each state. An account is also rendered of the subjects of foreign states to whom patents have been granted, from which it appears that British subjects obtained 23; those of France, 16; and the subjects of all other foreign governments only 8.

Of the 4538 patented inventions in 1859, one-tenth part was for improvements in apparatus connected with agriculture; among which were 93 "harvesters," 61 "corn planters," 66 ploughs, 47 "cultivators," 22 "corn shellers," and 36 "seeding machines." Articles of domestic economy were abundant; and though it might be supposed there was previously a sufficient number of American churns, sewing-machines, stoves, and washing-machines in the market, a great number of each was considered by the examiners of inventions to possess sufficient novelty to warrant the grant of separate monopolies. Thus, in that one year there were added to the stock of patented inventions 57 new kinds of washing machines, 80 sewing machines, and 37 churns. Among the warlike inventions, 42 varieties of fire-arms were patented, including 12 new kinds of revolvers, and there were added to the number of destructive weapons two "centrifugal guns." Some of the inventions are for objects peculiarly American or tropical, such as "stump extractors," cotton-gins, four kinds of "automatic fans," and tobacco presses; and, to judge from the fact that there were nine kinds of "burglars' alarms" patented in 1859, it must be presumed that burglary is very prevalent in the United States.

The want of a preliminary examination of the claims of inventors is the crying evil of the patent laws of England, and it may be assumed, from the great number of patents issued in America for inventions having the same title, that the examination is not conducted there very rigidly. Indeed, the Commissioner admits that, in consequence of the great pressure of claims to be examined, and of the deficiency in the number of examiners, sufficient care was not given to the examination.

Another evil of our patent laws is the precarious nature of the protection which letters patent afford. If an invention prove profitable, the patent is generally infringed either directly or indirectly; and among the great number of protected inventions for effecting the same, or nearly the same objects, it is often very difficult to determine whether there is sufficient novelty in any one that may be disputed to give it a claim to be protected. The difficulty and the cost of establishing a claim in England tempt the invasion of patent rights, and an invention may be pirated because the true inventor cannot afford to be at the expense of defending it. This is a great grievance, of which English patentees have good reason to complain; but in America patent property is still more insecure, because it is exposed to fraudulent attacks that may deprive an inventor of his rights by the admission of prior claims to the "idea" of an invention. The original inventor, within the meaning of the patent law in America, is the person who first conceived the idea of the invention, and the admission of claims so vague opens the door wide to perjury and frauds. Even in ordinary course of the law, without assuming the adoption of such practices, great injustice is frequently practised. One man may conceive an invention, and years may elapse before he renders it practicable, and in the meantime another, conceiving the same invention, may reduce it to practice, and obtain letters patent for it before the first inventor has ever made a drawing or given any description of it. The first but tardy inventor, observes the Commissioner, by the aid of the very working machine of his more diligent rival, may finally succeed in reducing his invention to practice, and then obtain a patent for the same device, and thus render the well-earned property of the other perfectly worthless. The injury thus done to the true inventor by the preference of prior claims to the idea of an invention is often augmented by the absence of any provision to secure the testimony of witnesses in contested cases. Many persons whose evidence is of importance in such cases, knowing that they cannot be compelled to testify, either decline to appear as witnesses at all, or govern their conduct by the money offered by the contesting parties. "The result of this is, that in such cases the poor are completely in the power of the rich, the weak in the hands of the strong." Defective as are the present patent laws of England, they will bear favourable comparison with such a perversion of justice as may be thus perpetrated under the patent laws of the United States of America.

HIS LATE ROYAL HIGHNESS THE PRINCE CONSORT.

Seldom if ever in the history of this or of any country has any calamity of a public character seemed to each individual to bear so much the nature of a personal sorrow, as that sad and sudden event which it it is here our painful duty to record. The surprise and bewilderment of so unexpected a blow as the removal of the Prince Consort by sudden death has been felt by us all much as it would have been had death entered our own family circle; and we have hardly yet had time to take account of the loss to the country from a public point of view. That this has been the case is the highest testimony that could be borne to the personal worth of the Prince, to the tact with which he comprehended and discharged the requirements of a most difficult social position, and to the admirable way in which he has headed that domestic circle, till now unbroken, upon which every Englishman and Englishwoman has learned to look with mingled feelings of interest, affection, and pride.

The Prince possessed in an eminent degree the qualities of a true English gentleman, and as such, we, the most jealous nation of Europe, learned to respect him, forgetting—and this we ordinarily never forget—his birth beyond our own shores, and remembering only his unobtrusive courtesy, his unaffected interest in everything English which it was his duty to undertake or to support, and his loyal abstinence from all which circumstances rendered it undesirable he should engage in. The career of the Prince was singularly unostentatious; he abstained uniformly from any public share in political matters; and he avoided, with a sagacity and a constancy due to a rare prudence and a good heart, all the numberless risks which seem to beset one so situated. It is only now that we have been led to consider for ourselves the real nature and difficulties of his position,—facts of which hitherto no account has been taken, simply because the whole life of the Prince has been at once so natural and so unvaried that no one seemed able to suspect that it could have been—might easily have been different. To this personal excellence, and this unswerving discharge of a difficult duty, the present universal sorrow is a nation's tribute.

The loss which the arts and sciences of this country have suffered by the death of the Prince will not be at once comprehended; the benefit which they have derived from the exertions of his life will not be soon appreciated; it is, however, peculiarly appropriate for a journal devoted to those subjects which are pre-eminently cognate with the arts of peace to draw attention to the share which His Royal Highness has taken in stimulating the manufacturing, artistic, and industrial progress of this country.

Personally accomplished and practically familiar with literature, science, and art, the Prince was well prepared on coming to this country to take an exact account of our internal position, and to see in what directions aid could be given with advantage, and in what quarters it was needless. Well acquainted as he was with mechanical science, he must have early convinced himself that many of the staple branches of our industry were too perfectly understood and too thoroughly carried out to call for interference. Accordingly, the first, or almost the first subjects to which he devoted his time and the support of his influence were precisely those where we were most deficient, and where the influence of high position and the sanction of royalty might be expected to be of value—we allude to farming and cottage improvement. The model farm established by the Prince gave an impulse to that movement in favour of improved agriculture which is one of the most valuable of the present day; and the cottages built for the Prince near Windsor, and those subsequently designed for him, and exhibited in 1851, were equally valuable, as aiding, and that too at an early day, the important movement, only yet in its infancy, for the improvement of the dwellings of the poor.

How heartily the Prince concurred in the idea of the Great Exhibition of 1851, if indeed that idea was not actually originated by him, is well known. He acted as President of the Royal Commission which had the charge of that undertaking, and it was admitted by those who had the best opportunities of judging that, much as the Exhibition was indebted to the position and influence of the Prince, he was even more valuable as a thoroughly efficient working head, well informed upon every subject that had to be considered, and business-like to an extraordinary degree in his conduct of affairs.

It is probable that one of the objects which the Prince had in view in promoting the Exhibition was to bring before English manufacturers objects of a similar nature to those they produced, but superior in artistic merit. At any rate, from the year 1851 dates a vastly increased desire in this country for the introduction of genuine art into articles of ordinary manufacture. To foster this desire and to promote its fulfilment was the constant aim of the Prince during the last ten years of his life, and although his work in this respect is left unfinished, it has not on that account been barren of results. In a recent number of this Journal we had occasion to quote from an official document passages showing how remarkable a progress, in the opinion of French manufacturers, the arts of design have made in this country; and how excellent they considered that machinery for artistic education which has been here established; and we then took occasion to show how much of all this is due to the efforts of the late Prince. The forthcoming International Exhibition will no doubt exhibit the nature and extent of this progress most strikingly, and will give a new impulse to the work. It is a matter of heartfelt regret that he will be absent from this Exhibition who of all others would have taken the greatest interest in this undertaking, and to whom it would have afforded something of a public triumph, as it no doubt will bring with it that recognition of the value and the success of unobtrusive but strenuous and persevering efforts to advance British arts, as connected with British manufactures, which the English public has hitherto been more slow to award than have continental nations.

While, however, we deplore our loss, we do so with a regret not altogether unmixed. The death of a godly man, and such the Prince undoubtedly was, is never a subject for unmixed sorrow; the completion of a happy, useful, prosperous career, safely closed before it had been overshadowed by disease, bereavement, or any of the hundred forms of tribulation which might have embittered declining years, or enfeebled prolonged life, is almost a subject of congratulation; and while deploring that the summer which robbed Europe of her greatest statesman has hardly chilled into winter ere England has been called to part with her greatest citizen, we cannot but feel grateful that, like Cavour, Prince Albert, if he left his work incomplete, was able to labour till the last; that he fell at his post; that the image we shall ever retain of him will be as he was in his prime—and that the feeling which his death aroused was one of universal, unqualified regret.

THE BUILDING FOR THE INTERNATIONAL EXHIBITION OF 1862.

The rapid progress of this building has been such that it is now possible on visiting the works to judge pretty clearly of the actual effect of arrangements which, when we first noticed the work, were entirely perspective. We gave in April of last year the plan and an elevation, and in November last two sections and a perspective view of the west and south front; the illustrations which accompany this notice exhibit the south front and the interior of the nave or central passage. The greatest merit of the building is the remarkable clearness and simplicity of its plan. It rarely, if ever, occurs that a building of such vast size leaves so simple and intelligible an impression upon the mind of a visitor as the great structure now in progress at South Kensington. The main building occupies a space of ground forming a parallelogram, of which the sides have almost exactly twice the length of the ends—the greatest dimension being from east to west. The picture gallery—a structure of brick—runs along the entire length of the south side of this block, and parallel to it runs a great central passage or nave, having two transepts of similar width and height crossing it at the two ends; these main passages consequently taking the form of an elongated ⊢⊣, as will be seen by reference to the plan in this Journal for April last.

At the two points of intersection of the transepts and nave stand the two great domes of which so much has been said, these being roofed with glass, while the nave and transepts will have opaque roofs, but will receive light from a lofty glazed clerestory as shown in the accompanying interior view. The spaces north and south of the central passage or nave are roofed with glass in a very efficient manner; the roofs being at a level considerably lower than even the springing of the nave and transept roofs; and the distance apart of the supports is such that an almost uninterrupted space will be obtained for exhibition purposes. To complete the description of the building as it now appears it is only necessary to add—that to the north lies the great garden of the Horticultural Society, a quadrangle surrounded by arcades, and that, as this quadrangle is not of the full width of the plot of ground, two additions to the building, called "annexes," and forming sheds of great length in proportion to their width, are thrown out northwards, one from each transept, the gardens lying between them. In some respects the carrying out is fully equal to the splendid simplicity of this fine and comprehensive design, but in other respects it falls very far short. Nothing can be more successful than the design of the light wooden roof covering the annexes, or that of the more solid roofing of the nave. The general arrangement of the glass roofs in the courts north and south of the naves is also very good, and the diminished number of the points of support is very much in favour of this part of the new building as compared with the original one; these courts resemble a good deal the new and excellent roof of the Victoria Railway Terminus.

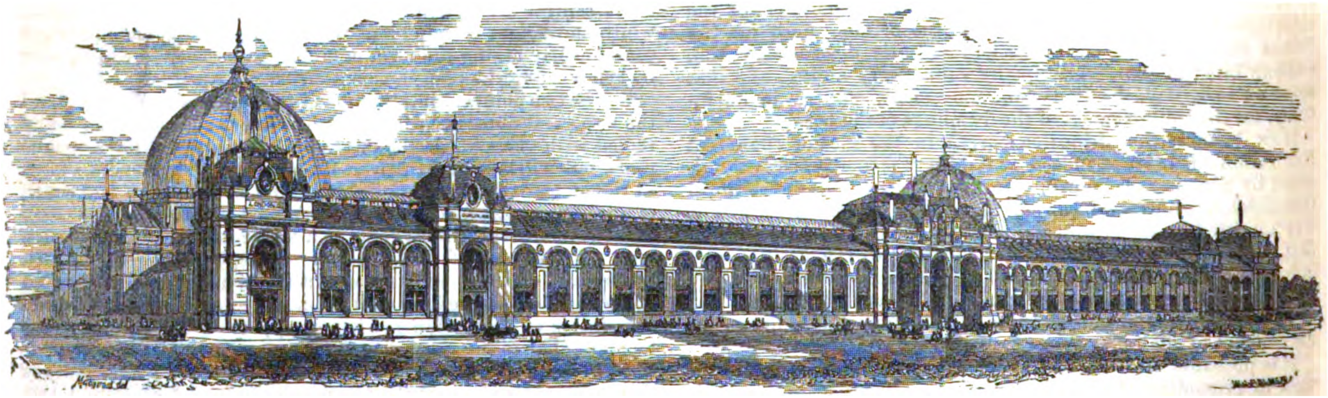
The most unfavourable contrast, however, between the new building and the original one, a contrast which the Sydenham Palace marks more strikingly, lies between the opaque covering of the nave roof at Kensington and the glass roofs of the two other buildings. There can be no question that, well proportioned and well built as is the South Kensington nave, it looks at present depressed and dark to a degree which is eminently unsatisfactory; and the idea suggests itself that a broad skylight along the ridge of the nave (such as exists in the smaller roofs of the annexes) would afford a wonderful help to the artistic effect of this part of the building. The great flood of light which will pour down through the domes, when they are fixed and the scaffolds struck, may redeem the central feature of the building from gloom, and will, without doubt, produce a magnificent and novel contrast of light and shade on a bright day; but we think this will not atone for the absence of that apparently boundless height to which we have become accustomed in the semicircular roof at Sydenham.

INTERIOR OF NAVE.

The ironwork, though generally well designed, does not display the consummate mechanical skill which marked Sir Charles Fox's work at the Hyde-park building. The mode adopted of supporting the girders by letting them rest on short brackets, or stubbs, cast on to the columns, is one which seems at all times dangerous, but appears doubly so in a building where rapidity of erection is of such importance, and the extent of which is so great, for it is hardly possible to secure a thorough inspection of every casting under such circumstances, and yet a single flaw in one of the little brackets we have referred to would be sufficient to produce the most disastrous results.

The exterior, too, does not show such a mastery over the best forms into which common brickwork and ordinary roofing can be thrown as would have been desirable. We hear of a proposal for decorating portions of the outer walls with mosaics, and an attempt has been made to introduce fresco. We trust neither of these plans will be carried out. One-tenth part of the cost of either of them expended on the brickwork as it was being carried up would have given nobility to what is now poor and meagre. Still, the exterior has the merit of simplicity, and its east and west fronts seem to promise something of dignity. Should either colouring or mosaic be introduced, the result will not be to add either beauty or richness; it will only be to destroy the simplicity which we admit to exist, and which in so great a structure becomes in itself, through frequent repetition, something akin to nobleness.

It is to be regretted that the building is placed so near the roads which surround it, and that the approaches are not more numerous and wider. The position of the building cannot of course now be altered, but the thoroughfares leading to it admit of improvement at comparatively small cost and little trouble. There is some ground to hope, we believe, that the roadway in front of Brompton-row will be widened; and should the suggested thoroughfare across the park be carried out, a great addition would be gained to the means of access to the Exhibition, and some portion of the inconvenience which must always attend the collecting together of large numbers of visitors to one spot would be obviated.



SOUTH FRONT, IN THE CROMWELL ROAD, AND PART OF WESTERN SIDE.

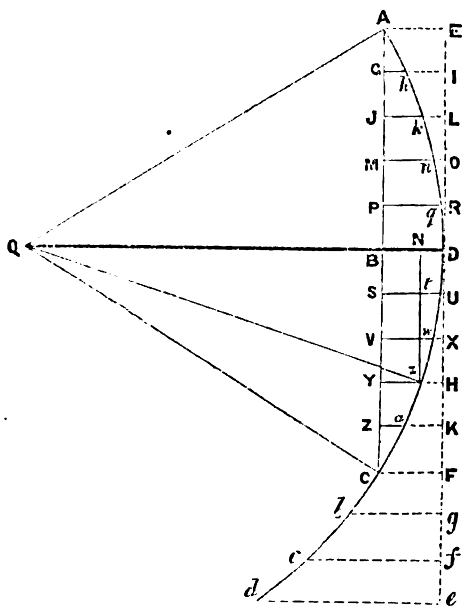
TO LAY OUT A RAILWAY CURVE

By means of Ordinates or Offsets in Rational Numbers from the Chord or Chords, without Calculation or Tables.

By Oliver Byrne, Civil Engineer.

Let AC=100 links, each a foot in length; a 50-foot chain of 50 links may be employed; then AB=BC=50 feet (see Fig. 1). AG=EI=IL=GJ=JM=LO=OR=MP=&c.=10 feet. Now, if squaring 5 be termed calculation, the heading of this article is

Fig. 1.

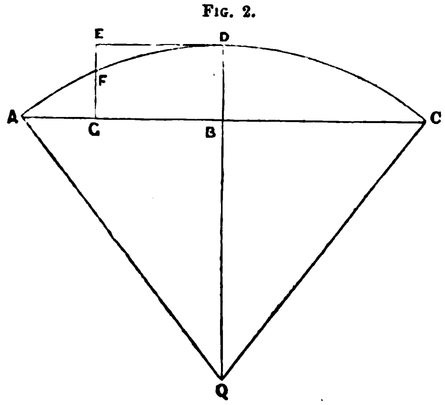


not correct; however, before any very extensive calculation can be undertaken, the common multiplication table has to be committed to memory, then it is known that 5 times 5=25;

$$\therefore\ 50 \times 50 = 2500.$$

The half of 2500 equals 1250, and the half of this is 625. These are

Fig. 2.



all the calculations to be made before setting down all the ordinates both inside and outside the circular arc ADC.

$$BD = AE = CF = \frac{1250}{6793} \text{ of a foot.}$$

$$Rq = tU = \frac{50}{6793} \quad \therefore\ Pq = St = \frac{1200}{6793}$$

$$On = wX = \frac{200}{6793} \quad \therefore\ Mn = Vu = \frac{1050}{6793}$$

$$Lk = zH = \frac{450}{6793} \quad \therefore\ Jk = Yz = \frac{800}{6793}$$

$$hI = Ka = \frac{800}{6793} \quad \therefore\ Gh = Za = \frac{450}{6793}$$

The numerators 50, 200, 450, 800, are set down without calculation, as 50 is half the square of 10, 200 is half the square of 20, 450 half the square of 30, and 800 is half the square of 40; which requires little more mental exertion than to recollect once 1, twice 2, three times 3, and four times 4. The results may be ordered thus:—

AG=10 feet,	$Gh = \frac{450}{6793}$ part of a foot.
AJ=20 "	$Jk = \frac{800}{6793}$ " "
AM=30 "	$Mn = \frac{1050}{6793}$ " "
AP=40 "	$Pq = \frac{1200}{6793}$ " "
AB=50 "	$BD = \frac{1250}{6793}$ " "
AS=60 "	$St = \frac{1200}{6793}$ " "
&c.	&c.

6793 feet is the length of the radius QA, QD, or QC, when $\frac{625}{6793}$ part of a foot is added to it; this addition is not more than an inch and a tenth, while 6793 feet is more than a mile. Hence, 6793 feet may be taken for the radius of the circle.

The radius AQ (Fig. 2) of a circle is two miles and a half—13200 feet—and a little over half an inch more; AC is a chain of 100 links, of a foot each; AG=18 feet. Required, without calculation, the ordinate BD in the centre of the arc ADC, the ordinate FG on the chord, and the ordinate EF from the tangent ED.

$$\text{Ordinate } BD = \frac{1250}{13200} \text{ part of a foot,}$$

$$\text{The exact length of radius} = 13200\frac{625}{13200}$$

$$GB = ED = 50 - 18 = 32 \text{ feet,}$$

$$\frac{(32)^2}{2} = \frac{2^2 \times 16^2}{2} = 2 \times 16^2 = 512;$$

$$\therefore\ EF = \frac{512}{13200} \text{ part of a foot.}$$

$$GF = \frac{1250}{13200} - \frac{512}{13200} = \frac{738}{13200} \text{ part of a foot.}$$

To prove this rule, assume $QC = r + \frac{n^2}{r}$; $BC = 2n$; and $QB = r - \frac{n^2}{r}$. Now, if this assumption be true,

$$\left(r + \frac{n^2}{r}\right)^2 = \left(r - \frac{n^2}{r}\right)^2 + (2n)^2,$$

which when developed shows that $\left(r + \frac{n^2}{r}\right)^2$ and $\left(r - \frac{n^2}{r}\right)^2 + (2n)^2$ are identically equal; consequently QBC is a rational right-angled plane triangle.

$$QD - QB = BD; \quad \therefore\ BD = \frac{2n^2}{r}$$

Let $r=625$, and $n=25$; that is, AC=100.

$$r + \frac{n^2}{r} = QC = 625 + \frac{(25)^2}{r} = 625\frac{625}{625} = 626;$$

$$r - \frac{n^2}{r} = QB = 625 - \frac{625}{625} = 624;$$

$$\frac{2n^2}{r} = \frac{1250}{625} = 2 = BD.$$

$\therefore$ If QC (Fig. 2) equals $3763\frac{1250}{3763}$ feet, the number 3763 is taken at random; and if at the same time AC=100 feet, or BC=50, =2n, then the ordinate BD in the centre may be set down without calculation = in this case $\frac{1250}{3763}$ feet. The truth of the rule for finding the intermediate ordinates may be established as follows:—

Referring to Fig. 1, put $x = Qz$, $m = zN = DH$;

$$\therefore\ QN = \sqrt{x^2 - m^2}; \qquad ND = zH = x - \sqrt{x^2 - m^2}.$$

Now if m^2 be successively taken 1^2, 2^2, 3^2, &c. chains, the values of tU, wX, zH, aK, &c. will be respectively

$$x-\sqrt{x^2-1^2} = x-\left(x-\frac{1^2}{2x}\right) = \frac{1^2}{2x} \text{ nearly.}$$

$$x-\sqrt{x^2-2^2} = x-\left(x-\frac{2^2}{2x}\right) = \frac{2^2}{2x} \quad ,,$$

$$x-\sqrt{x^2-3^2} = x-\left(x-\frac{3^2}{2x}\right) = \frac{3^2}{2x} \quad ,,$$

&c. = &c.

Let the radius of the curve be 40 chains, each of 50 links, the link = 1 foot. Chain employed = 600 inches long.

$$tU = \frac{1}{2 \times 40} \times 600 = 7\tfrac{1}{2} \text{ inches}$$
$$wX = 7\tfrac{1}{2} \times 4 = 30 \quad ,,$$
$$zH = 7\tfrac{1}{2} \times 9 = 67\tfrac{1}{2} \quad ,,$$
$$aK = 7\tfrac{1}{2} \times 16 = 120 \quad ,,$$
&c. &c.

When the length of the curve exceeds $\frac{1}{4}$ of the radius, only five or six of the approximate offsets ought to be taken in this manner. Because

$$\frac{x-(x^2-8^2)^{\frac{1}{2}}}{x} = 1-\left(1-\frac{8^2}{x^2}\right)^{\frac{1}{2}}$$

Hence, if an arc to radius 1 be found, or angle, from a table of natural sines whose sine $= \frac{8^2}{r^2}$, the cosine of the same angle taken from the table, without calculation, equals $\left(1-\frac{8^2}{x^2}\right)^{\frac{1}{2}}$; hence the versine $1-\left(1-\frac{8^2}{x^2}\right)^{\frac{1}{2}}$ is found by subtraction, which, when multiplied by x, the radius, gives the de, the eighth ordinate; and so of other ordinates. The centre ordinate BD (Fig. 1) is always correctly determined by the foregoing rule, whether the chord AC be long or short compared with the radius QD.

Example.—For a radius between 6973 and 6975 feet, and a long chord of 300 feet or 3 chains, what is the ordinate in the middle at the concave side of the curve?

Take the radius $= 6973 \frac{5625}{6793}$ feet. $\left(\frac{300}{2}\right)^2 = \frac{90000}{4} = 22500$.

$\frac{22500}{2} = 11250$; $\therefore$ the required ordinate $= \frac{11250}{6973}$ feet exactly.

Take another example. Let the chord be 400 feet, and radius $68975 \frac{10000}{68975}$ feet. $\left(\frac{400}{4}\right) = 10000$. The length of the required ordinate will be $\frac{20000}{68975}$ feet.

It is clear that this rule may be applied to all circular curves, without mental labour. Any number, as 130, may be reduced to the required form, $x + \frac{625}{x} = 130$, by solving the quadratic equation, $x^2-130x=-625$; $\therefore x = 125$,

$$\text{and } 125\frac{625}{125} = 130 = \text{QD (Fig. 2).}$$

$$\frac{1250}{125} = 10 = \text{BD};$$

$\therefore$ BQ = 120. Proof: $CQ^2 = BC^2 + BQ^2$. $130^2 = 50^2 + 120^2$.

In a one degree curve (1°), that is, a curve in which a chord of 100 feet subtends 1° at the centre, radius = 5729·65 feet;

2° curve, radius = 2864·93 feet,
5° curve, radius = 1146·27 ,,
10° curve, radius = 573·66 ,,

Without solving a quadratic equation, these or other radii may be reduced to the form $x + \frac{625}{x}$, by taking the nearest whole number to x and dividing it into 625 (supposing the chord of the arc = 100 feet). Take a 10° curve, radius = 573·66,

$$\frac{625}{572} = 1{\cdot}09. \qquad \begin{array}{r} \text{From } 573{\cdot}66 \\ \text{take } \quad 1{\cdot}09 \\ \hline 572{\cdot}57 \end{array}$$

Then $572{\cdot}57 \frac{625}{572{\cdot}57} = 573{\cdot}66$. The middle ordinate $= \frac{1250}{572{\cdot}57}$ feet

Example.—In a 2° curve, radius = 2864·93 feet, what is the length of the middle ordinate, and the length of an ordinate 14 feet from the middle on both the convex and concave sides of the curve? as usual, measuring from the tangent to the middle point and from the chord = 100 feet.

$$\frac{625}{2864} = {\cdot}22$$

$$\begin{array}{r} \text{From } 2864{\cdot}94 \\ \text{take } \quad {\cdot}22 \\ \hline 2864{\cdot}71 \end{array} \qquad \therefore \text{ Radius} = 2864{\cdot}71 \frac{625}{2864{\cdot}71}$$

$$\text{Middle ordinate} = \frac{1250}{2864{\cdot}71};$$

$14^2 = 196$, $\therefore$ ordinate on the convex side, 14 feet from the middle, $= \frac{98}{2864{\cdot}71}$ feet; $1250 - 98 = 1152$, $\therefore \frac{1152}{2864{\cdot}71}$ feet, which is readily reduced to inches, gives the ordinate on the concave side of the curve.

ON THE CONCRETE USED IN THE LATE EXTENSION OF THE LONDON DOCKS.*

By George Robertson, C.E., F.R.S.E.

In the late extension of the London Docks at Shadwell, the point which appeared to me to be most worthy of and to afford the greatest scope for enlargement, was that of hydraulic lime. Firstly, because there were (in my mind at least) many unexplained difficulties and contradictory statements connected with its theory and practice; secondly, because the manufacture of the lias lime used on these works being in the hands of the Company's engineers, afforded advantages for investigation which might never occur to me again on such an extensive scale. An investigation into the theory of hydraulic lime, and its manufacture into mortar formed the subject of a paper read before the Institution of Civil Engineers in April 1858, to which the present one on Concrete is a sequel, completing the monograph on the lime used in this one work.

I also read a paper lately before the Royal Society here upon the "Solidification of Limes and Cements," which was founded partly on the London Dock experiments and partly on a continuation of them at Leith Docks.

The new works made by the London Dock Company consist of a new basin thrown into one with the old Shadwell basin, and two large locks 350 feet long and 60 broad, parallel with the former small ones; one to lock vessels up if necessary from the river Thames to the basin, and the other for vessels proceeding to the eastern dock, the water level of which is usually kept above Trinity high-water mark by a pumping engine.

Borings of the ground occupied by the new works showed how advantageously concrete could be used in their construction. Below the first eight feet of made ground and brick rubbish is a bed of brown clay some 6 or 7 feet thick; then a bed of peat averaging 6 feet, but often much thicker, full of remains of beech, oak, hazel, and other trees. The lower part of this peat was full of veins and lumps of sesquiphosphate of iron, native Prussian blue. This made an excellent pigment when ground up with gum water, of a delicate smalt colour, which I used in tinting working drawings. Below the peat is a thin bed of clay, the bright blue colour of which was very likely due to this colouring matter in the overlying peat. Under the peat and clay is a thick bed of flint gravel, Thames ballast, which extended nearly over the whole area of the new works. In some places it was fine enough to form sharp clean sand for mortar, in other places coarse gravel well adapted for concrete. The chief material for concrete was therefore on the very site of the works ready for use, and the whole expense was saved likewise of barging it up to Battersea Park, where we were permitted to shoot out the excavations. Under the gravel, at an average depth of 30 feet below Trinity high-water, lies the solid London clay, into which, of course, most of the foundation had to be carried. The bed of sand and gravel was more than 12 feet thick at the two locks, but thinned out completely at the north wall of the basin. The bal-

* Read before the Royal Scottish Society of Arts.

last was in sufficient abundance to supply all the concrete required for foundations and counterforts, and to leave enough over to make it worth while using it for the dock walls themselves.

The subject naturally divides itself into two divisions—the manufacture and the application of the concrete.

The Manufacture.—The great mass of the concrete was made with naturally hydraulic lime, blue lias from Lyme Regis in Dorsetshire, which requires no artificial mixture with pozzuolana or minion to render it capable of setting *permanently* under water. The word "concrete" in this paper implies, therefore, that made with blue lias lime, unless otherwise specified. The Dorsetshire lias was the only lime burned on the works; all lias from Warwickshire or Leicestershire was bought ready burned from the merchants. Lias requires much greater care in burning than richer limes, because any sudden or extra heat, which would do little harm to Dorking lime, greatly injures lias, by forming a glass between the silica and the lime in the stone, instead of only driving off the water and carbonic acid. The combination between the silica and lime, to which lias owes its hydraulic properties, ought only to take place in the humid way—*i.e.*, with the assistance of water, after the application of the lime as mortar or concrete. Lias comes from Lyme Regis in two different forms—the one with a clean conchoidal fracture, and the other of a shaly nature, approaching in appearance even to clay slate, but quite soft. The shaly lias, which contains so much clay as to have the properties of a cement, is not so desirable as the hard clean stone, because it carries less sand, and is therefore more expensive. The stone cost 4*s.* 3*d.* a ton when shipped at Lyme, but 10*s.* 9*d.* before it was stacked round the kiln at London, which is as much as the same stone costs delivered at the works of the new graving dock at Leith. Freight to London is always heavy, for there is no steady return freight like coal to be had. Notwithstanding the high price of the stone delivered at Shadwell, and having to pay freight on thousands of tons of water and carbonic acid to be afterwards driven off by the heat of the kiln, the engineer-in-chief of the Dock Company, the late Mr. Rendel, determined to burn the limestone in London, as the extra cost would be a comparatively small item in such extensive works. It was very desirable to have the best possible lime where concrete was to play so important a part.

Two egg-shaped draw kilns of bricks were therefore erected, of a total height of 43 feet from the floor to the top of the dome, and an extreme internal diameter of 14 feet, contracting to 5 feet at the fire bars, and 11 ft. 6 in. at 32 feet above the floor. The practical objection to having a less diameter than this at the top is the difficulty that would arise in charging the kiln with evenly distributed layers of coal and stone tipped in from barrows at the top through the windows in the dome. It has likewise been objected that a contracted top to a kiln prevents the escape of carbonic acid, although it has a counterbalancing advantage in confining the heat, and throwing it down with a reverberatory effect on the charge. This theoretical objection appears to be fanciful. It was found necessary, after these kilns had been working for a short time, to dome the mouth over with a brick arch to prevent stones from flying into the neighbouring streets. The chimney at the top of this was only 3 feet in diameter, and yet no difference was afterwards perceptible either in the time required for burning, or in the percentage of imperfectly burned stone. On the other hand, there is little doubt that the dome acted economically on the coal required, for the average of 7000 tons of limestone was little more than one ton of coal to 11½ of stone, the limits being 1 to 10 and 1 to 13. Carbonic acid came away freely after the kiln had been lighted for three hours, and it appeared to have ample room for escape. An average of 11½ tons of stone burned by one ton of coal is very high; but the coal was Welsh, and cost £1 1*s.* a ton. Newcastle coal, or bituminous coal in general, was inadmissable; for it was essential to have little or no smoke from kilns in the heart of London. At Leith, one ton of the coal of the neighbourhood appears to burn only 6 or 7 tons of lias; but the coal is only one-third of the price of Welsh coal. The barrows of coal and properly broken stone were lifted to the top of the kiln by a hoist worked by the mortar-mill engine, and were tipped in through three openings in each dome, as evenly as possible. After the kiln was lighted, these windows were kept closed with boiler-plate shutters. The cost of charging, including breaking up the stone and coal, was 1*s.* 6*d.* per ton of the two when mixed in the kiln. Unless the demand for quicklime was very irregular, the kilns were always kept lighted; but whenever they were allowed to go out, the charge of quicklime was left in the kiln, as the place most free from moisture. Whenever the fire is let out in draw kilns, the next charge is nearly sure to burn irregularly, and there is a considerable loss of heat in rewarming the kiln. Draw kilns are liable to irregularity from apparently slight causes, such as the direction of the wind, &c.; and in the Shadwell kilns there was also a permanent tendency to burn quickest down the side warmed by the adjacent kiln, for they were both in one block of building. But draw kilns are better suited for burning lias than flare kilns, as the heat is more uniformly distributed through the charge; there is therefore less danger of overburning the lower half and underburning the upper.

Each kiln held 100 tons of stone, and burnt 21 tons per diem. The two together produced 25 tons of quick-lime every day, a quantity sufficient for about 97 cubic yards of mortar, or 170 cubic yards of concrete; 9 tons of coal will burn 100 tons of stone, which produce 59·37 tons of quick-lime, or 1583 bushels of ground-lime, enough for 400 cubic yards of concrete, when the ballast is moderately dry. Drawing the lime from the kiln cost 1¼*d.* per ton of quick-lime. The total cost of the burnt lime amounted to 24*s.* per ton. When quite hot from the kiln, 26½ bushels of ground-lime went to the ton; but after keeping some time a ton swelled to 30 bushels, which is what bought lias usually weighs. A bushel of lime, ground when fresh burnt, contains therefore one-seventh more lime than a bushel of stale lime; and a cubic yard of concrete, of specified proportions, is so much the better when made with fresh lime.

Coke was used in the kiln for a short time, but it was found to be 8 per cent. dearer than Welsh coal; and, moreover, the heat given out by it was too quick and strong, casing many of the stones over with a vitrified silicate, which hindered the free escape of carbonic acid. When coke was burnt, therefore, the percentage of unburnt stone was raised much above the usual average of 1½ or 2 per cent.

The equally burnt and softest lumps, usually of a buff colour, were picked out for grinding; and the remainder, more of a liver colour, slaked for mortar in the manner described in my paper before alluded to. The lumps were first broken tolerably small by hand, and then crushed still smaller between iron rollers revolving in the hopper of the grindstones. These rollers were at first made fluted, but it was found that strong projecting cogs did the work more effectually. The hopper was fed with lumps of lime by an endless chain of small wrought-iron buckets worked by the engine. It was intended that these should be self-acting, and dredge the lime up from a well; but it was found necessary to have a man constantly feeding them with a spade, or the supply was not regular.

I may mention that a similar endless chain of cast-iron buckets was used very successfully for dredging a hole through the gravel, into which the piles of the cofferdam were dropped, and then driven into the clay. By means of these dredgers, fir piles were got down through conglomerated gravel like "Blackwall rock," in which it was found almost impossible to drive elm. The sides of a hole 20 feet deep stood quite perpendicular when there was a head of water on the hole, the hole being made large enough to take in about four piles in a row.

The lime was ground to a fine powder between two pairs of horizontal French burr millstones; the upper one revolving at a speed of 90 revolutions per minute. Each pair of stones was able to grind three tons of quick-lime per hour, at a total cost for grinding of 1*d.* per bushel when the consumption was 360 bushels per diem; less, if more lime was used. This is made up as follows:—Feeding and attending to the hopper and lift, ½*d.*; engine power, ¼*d.*; measuring the lime into bags for the contractor, and recutting the stones as the furrows became worn, the remaining ¼*d.* A bushel of lime ground fresh from the kiln weighed 84 lb.; and at this weight the total cost was 11¾*d.* In buying ground-lime from a merchant, if the purchaser buys by weight, he pays for the water absorbed from the atmosphere; if he buys by measure, he pays for the expansion caused by that moisture: the fairest way for both parties would be to specify the bushel to be of a certain average weight—say for lias from Lyme Regis 80 lb. This would allow for the lime not being quite fresh, but would prevent it from being too stale.

The grindstones were composed of burrs from the fresh-water beds of the Paris basin, set in two radiated rings in cement, and backed up with plaster of Paris and mortar. The "skirts" or outside burrs were 5 inches thick; the central or "high burrs" somewhat thicker, to allow for the "swallow," which is a slight depression in the centre of the upper stone, about 2 feet in diameter, and at most 3 inches deep. This acts as a kind of distributing reservoir for the lime as it falls from the hopper between the stones.

The face of the stones was divided into ten "quarterings" by "master furrows," each of them being tangential to an imaginary circle concentric with the stone, and called its "draft." The size of this regulated the quantity of lime passing through the stones in a given time. A radius of 5 inches was found to grind 90 bushels per hour of a sufficiently fine quality. The particles of lime, whirling round near the centre of the stone, by their centrifugal velocity pass towards the outside along the master furrows, being ground finer as they recede from the central depression. Each master furrow had two other distributing furrows leading out of it, parallel to the former master furrow. The furrows are shallow grooves, or rather nicks about 1¼ inch wide, with the cutting edge sharp, and the other bevelled.

The gravel found on the works was not always so free from clay as could be wished. It had often to be screened, to reduce the quantity of sand to the proportions necessary to form a good mortar with the lime used. Concrete is really minute rubble work of pebbles set in mortar, more or less perfect according to the care taken in mixing the ingredients. In theoretically perfect concrete, the mortar should be made, *first*, to insure a perfect matrix for the pebbles to be embedded in; but this is not the usual practice in this country. The great mass of the concrete was composed of one measure of lias lime to six measures of gravel; both being measured by boxes, and not by guess-work. Sometimes, however, a layer of gravel was spread out a foot thick, and then lime laid over it for a depth of two inches. This is not so good a way of measuring as by boxes, because the lime falls between the pebbles, and the concrete is richer in lime than the engineer intends, which is no advantage to the work, and is, of course, a loss to the contractor. When the ballast was moderately dry, 12 cubic yards of gravel and 2 cubic yards of lime made 11 cubic yards of concrete, mixed and deposited. The shrinkage from the dry materials was then 22 per cent.; but if the ballast happened to be very dry, the shrinkage was more, and the same quantities made only 10 cubic yards.

A cubic yard of concrete requires about 38 gallons of water to bring the dry materials to the requisite state of fluidity. Of this quantity nearly 8 gallons enter into chemical combination with the oxide of calcium in the lias, and 30 gallons are either absorbed mechanically by the pores of the lime, retained by capillary attraction between the grains of sand, or lost by evaporation. After the concrete has been mixed and deposited, a gradual expansion takes place from the chemical action of the lime slaking; the less of this swelling, however, the better, as it disturbs the setting of the mortar round the pebbles, and causes friability in concrete. Whenever concrete is made with quick-lime (as it usually is) there must be a certain amount of friability from this cause; and, therefore, when it is important to have no swelling, as in blocks of concrete which have to be lifted, recourse must be had to slaked lime, or else to cement, which contracts rather than expands in setting. In the one case the concrete is long in hardening, having more moisture in it than the lime can absorb; and in the use of cement more expense is incurred. Portland cement is, however, not so expensive as might at first appear from the cement being double the price of lime, because the proportion to the ballast may be considerably reduced.

Some experiments on the expansion of concrete proved to me that it varies a little with the season of the year. In hot summer weather the expansion of a cubic foot in twenty-four hours after mixing was as much as $\frac{1}{30}$th of its bulk, usually $\frac{1}{32}$d; but in frosty weather it rarely exceeded $\frac{1}{45}$th. The force exerted in the expansion was always sufficient to burst the box in which the concrete had been deposited; the amount might even be measured by the distance the nails were drawn out. Whenever the expansion exceeded $\frac{1}{30}$th of the bulk, I considered the concrete too rich in lime; and that there was more than would, when slaked, fill up the interstices of the sand and flints, and coat each grain with a thin pellicle of lime. More than this is not required, for too thick a coating of lime causes weakness, and not strength.

The gravel and lime were mixed together on a platform of planks, and were turned over twice in the dry state, and twice with water gradually added. The concrete was then wheeled in barrows, and shot into the required place from planks a few feet above. The idea that concrete should be thrown in from a great height is erroneous, for it then falls with too great force, and disturbs the setting of the mass below, causing unnecessary friability. This was particularly noticeable in the deep pits for the counterforts of the north wall of the basin, where the concrete had unavoidably to be thrown from a height of 30 feet. The force of the blow set the whole mass in motion for some feet down, even after setting had fairly commenced. Lias concrete sets slowly, and in this case it was impossible to wait long enough for each layer to become perfectly hard before depositing another, as the wall had to built with the utmost expedition, as will be seen hereafter. Anything gained in density by a fall of more than 6 feet is more than counterbalanced by the disturbances to the mass below. The grand rule in concrete is, not to disturb it after setting has once commenced. Wherever it is necessary to shovel it into corners, or pack it between stones, it should be done at once, and the concrete not touched again. The swelling of the lime during slaking causes enough natural friability, without increasing it by after-disturbance.

By arrangement in the contract with Messrs. W. Cubitt and Co., the contractors for the greater portion of the permanent work, ground lias lime was sold to them for 10*d.* per bushel; and at this price the cost of making a cubic yard of concrete was as follows:—

	s.	*d.*
3¾ bushels of lime, at 10*d.*	3	1½
Loading, waste, and bags for ditto.	0	3
Getting gravel.	0	6
Wheeling do. (say 5 runs).	0	4
Screening and selecting ditto.	0	3
Mixing and depositing.	1	1
Platforms.	0	1½
Total cost per cubic yard =	5	8

As the quantity of gravel fit for concrete was uncertain before the ground was opened up, for the sake of simplicity the whole excavation had been estimated as barged away; and for each cubic yard of gravel used as concrete, a certain deduction was made in the monthly payments.

The supply of water for mixing the concrete was obtained from pipes laid down to the various parts of the works, either from the street mains or from the launder of the pumping engine. In mixing large quantities the expense of laying pipes is soon saved.

The Application.—Concrete was applied on the works of the London Dock extension in several ways:—1st, In foundations for masonry or brickwork, as a means of spreading the weight over a large surface; 2nd, As the cheapest method of reaching a good foundation in the clay or gravel, whether for walls or piers of warehouses, &c.; 3rd, In the dock walls themselves, wherever the concrete would not be exposed to the alternate action of wind and water; 4th, As counterforts or buttresses, on which nothing was to be afterwards built, but where weight was wanted.

In all these cases it is to be noticed that it was applied as a mass, in the monolithic form, which is the true use and value of concrete. Whenever it is moulded into separate blocks, to be afterwards set in proximity to each other, concrete becomes an inferior substitute for stone, although often an economical and useful one.

The whole of the side walls of the two locks rested upon a bed of concrete, of a thickness varying very much with the level of the clay, from 3 feet to 6 inches. The invert of the lock chambers was laid on concrete, and the spandrils of the arch filled up with it. The high chimney of the pumping-engine house stood on a square of concrete of considerable thickness, the pumping engine itself resting on beech piling. As this chimney was very close both to the pumping well (18 feet in diameter) and to the excavation for the lower dock, there was some risk of unequal settlement. A plumb-bob was therefore left suspended in the chimney, which at once would give warning of any inclination either way. Some time after the chimney was built the plumb-bob showed that the shaft had inclined several inches towards the excavation. A quantity of limestone was at once stacked round the base of the chimney on the opposite side, which brought the shaft back to the perpendicular.

Concrete was used as the cheapest means of reaching the clay, in the foundations for the lattice swing-bridges over the locks; the bridge pits resting on arches, the piers of which were of concrete up to a certain height. Columns of concrete were built up likewise in the proper places, upon which carnes and capstans might be placed when required. The whole of the walls and iron columns of the new warehouse rested on trenches of concrete about 8 feet wide, and averaging perhaps 8 feet in thickness, from the top of the natural gravel to the level of 17 feet below high water. As the concrete here was not to be exposed to the direct action of water, it was made of Dorking or grey stone lime, in the proportion of 1 of ground lime to 8 of ballast. This lime carries more sand than lias; is but feebly hydraulic, and, indeed, not permanently so at all. It is the lime used in London for building purposes, and by some engineers even in dock work when mixed with pozzuolana.

By far the largest quantity of the gravel found in the excavation was used up in the construction of the walls of the basin, in which everything below the level of 17 feet from high water was of concrete, faced with two feet of Kentish rag-stone, to protect the surface from the disintegrating effects of water. At this low level there was no fear of vessels rubbing against the rough faces of the rag-stone. The general type of the basin walls was much the same as that of the West India Junction Dock walls, where Mr. Rendel used concrete of 1 part of Portland cement to 9 parts of gravel.

The concrete portion of the basin walls was 17 ft. 6 in. broad at the bottom, and 11 ft. 6 in. at the top, the face being curved at first to a radius of 11 feet, and then carried up with a batter to the bottom of the brickwork, which was perpendicular. Whenever concrete is faced with rag-stone, it should be built with a batter, and the layers slightly inclining away from the face. All danger of the wall bulging out, or of the face-work peeling off, is then avoided. The Kentish rag-stone facing was hammer-dressed on the joints for a specified distance in, and care was taken to have at intervals long wedged-shaped stones, with the broad end inwards, tailing well into the concrete, which was carefully packed between the joints when first deposited. About two feet high of face work was first set, and then the concrete deposited in two layers of about one foot thick each. The first layer was allowed to harden for at least twenty-four hours before the second was deposited, and they were always arranged so as to break joint. A layer of concrete does not thoroughly incorporate with a previous one unless the meeting surfaces be kept rough, and free from sand. But, by sweeping off all sand, and, if necessary, picking the face in furrows, and by breaking joint with the layers, all danger is avoided of either a vertical or horizontal run of water through a mass of concrete. The brickwork of the upper half of the wall, with its counterforts, was not laid on landings, as in the lock walls, but was for three feet set in superior mortar, with hoop-iron bond every three or four courses.

The above description applies to the east, west, and south walls of the basin; but the north wall varied materially from the general section, and was altogether very instructive, from the difficulties encountered in building it. The east end of the wall had been commenced in the usual way, by taking out the excavation of the basin in front and of the wall to the natural slope of the earth, when alarming cracks appeared in the churchyard of St. Paul's, Shadwell, and the whole ground on which the High-street and this church, with its handsome steeple, were built, appeared to be slipping into the works, for a length of 800 feet. Any one who witnessed the fall of the terrace at Ramsay Gardens some months ago, will understand, on a small scale, the result of such a catastrophe. The excavations were at once stopped, and borings made in the churchyard and adjoining streets, outside of the parliamentary boundaries of the dock company. The surface of the London clay was found to rise suddenly in a slope of 1 in 10 from the basin to the High-street, so that the whole prism of earth, resting on an incline, was only kept up by the weight of the earth in front. It was necessary, therefore, to alter the character of the wall, and to stop the excavation of the basin till the wall was completely built, and ready to take the thrust of the ground behind. For the better protection of the church, which was in more danger than the houses, a perfect forest of piles was driven into the clay in front of the churchyard. These were in four or five rows deep, several feet apart, and connected by walings at right angles to the basin wall. The ground was next taken out in pits, in the line of the wall, 50 feet centre to centre, 20 feet wide, and 40 feet back from the coping. These were carried well down into the clay, and the bottoms cut in steps, sloping away from the basin. The pits were filled in solid with concrete, up to the level of 17 feet below high water, the face being protected by two feet thick of Kentish rag as usual. Brick arches were then turned from pier to pier, to support the upper half of the wall, which was of the ordinary character.

To prevent the ground between the piers from falling through into the basin, vertical brick arches, 3 feet thick, were turned from counterfort to counterfort, and backed with puddle or concrete. These arches were founded in the clay, on the top of a strong slope of concrete, faced with a foot of puddle, to protect the surface from water. The wall carried at the back of it a culvert four feet in diameter, for keeping up the water level in the eastern dock or the new basin if required.

After the counterforts were finished, and the arches turned, the ground in front of the coping line was excavated, and the toes of the slopes and piers put in with Portland cement concrete, in the proportion of 1 of cement to 9 of gravel. This sets faster than lias concrete, and is heavier, a cubic foot of each weighing 139 lb. and 129 lb. respectively.

Before the water was let into the basin, the north wall resembled a massive viaduct more than a quay wall for ships to lie against; but after the water was admitted the arches were not seen, as their crowns were eight feet below high-water level.

The use of concrete by Mr. Rendel in the London Dock Extension is an excellent example of what good engineering ought always to be; viz., the application, in the best and most economical form, of the material closest at hand, so long as that is consistent with strength and durability.

THE IRON-CASED SHIPS OF THE BRITISH NAVY.*

By E. J. Reed, Sec. Inst. Naval Architects.

The construction of iron-cased ships of war is engrossing so much of the attention of scientific men at the present moment, and is manifestly fraught with such important consequences in financial respects, that this Association could not well be expected to assemble, even in Manchester, without taking the subject into consideration.

With the view of best fulfilling the intentions with which the gentlemen of the Mechanical Section made this the chief topic of to-day's deliberations, I propose—

1st. To glance briefly at the circumstances under which the British Admiralty resorted to the construction of iron-cased seagoing ships of war.

2nd. To state as compactly as possible the principal features of the ships which the admiralty are building and propose to build.

And 3rdly. To bring to the notice of this Association the great increase of dock accommodation which iron-cased ships have rendered necessary.

Early in 1859, the secretary to the admiralty, the accountant-general of the navy, and the secretary and chief clerk to the treasury, together reported to the government of the day (Lord Derby's) that France was building "four iron-sided ships, of which two were more than half completed," and that these ships were to take the place of line-of-battle ships for the future. "So convinced do naval men seem to be in France of the irresistible qualities of these ships," said those gentlemen, "that they are of opinion that no more ships of the line will be laid down." In another part of their report they said, "The present seems a state of transition, as regards naval architecture, inducing the French government to suspend the laying down of new ships of the line altogether." At the instance of Sir John Pakington, then first lord of the admiralty, this report was immediately presented to parliament, and thus obtained universal publicity.

From that time forward, then, we have all known perfectly well what the plans of the French government in this matter were, and we have known equally well that the only mode of keeping pace even with France in the production of iron-cased ships was to lay down four of them to match the four which she at that time possessed, and to build as many more annually as she saw fit to add to her navy. In pursuance of this very simple policy, Sir John Pakington at once had designs of a formidable class of iron-cased ships prepared, and ordered the construction of one of these vessels, the Warrior.

The present board of admiralty shortly afterwards succeeded to power, and ordered a second of these vessels, the Black Prince, and after some delay also issued contracts for the Defence and Resistance. No other vessel of the kind was actually commenced until the present year; so that in the beginning of 1861 we had

* Paper read at a Meeting of the British Association, Manchester, September 1861.

only just attained the position which France held in the beginning of 1859, having "four iron-sided ships, of which two were more than half completed." Meantime France had been devoting the bulk of her naval expenditure for two whole years to the production of similar vessels, and is consequently now in possession of an iron-cased fleet far more considerable and more forward than ours.

At length, however, our sluggishness has been overcome, and we have set ourselves earnestly to work to repair our past deficiencies. The Hector and Valiant have been laid down, and are being urged rapidly forward; the Achilles, after a year's preparation, has been fairly commenced; the Royal Alfred, the Royal Oak, the Caledonia, the Ocean, and the Triumph are in progress; and contracts have just been issued for the construction of three out of six other iron-cased ships, the building of which has for some time been decided upon. The peculiar features and proportions of these vessels I shall presently describe; but I will first state some of the causes which have led to delay in this matter, and set forth the circumstances under which we have at last been compelled to advance.

We have heard much in various quarters about the invention of iron-cased ships, the credit of which is usually accorded to his Imperial Majesty Napoleon III., although there are scores of persons, both here and in America, who claim it for themselves. But the truth is, very little invention has been displayed in the French iron-cased ships. Their designers have almost exclusively confined themselves to the very simple process of reducing a wooden line-of-battle ship to the height of a frigate, and replacing the weight thus removed by an iron casing 4½ inches thick placed upon the dwarfed vessel. It was not possible to produce a very efficient ship by these means; so they have contented themselves, in most cases, with vessels like La Gloire, which carry their ports very near to the water when fully equipped for sea, and are characterised by other imperfections that it would be easy to point out. The reports of her efficiency which have appeared in the French newspapers prove nothing in opposition to what I here state. The writers in those papers have systematically exaggerated the qualities of the French ships for years past, representing that they could steam at impossible speeds, and carry as much fuel as any two of our ships. But these are statements which can be disposed of by scientific calculations of the most elementary kind, and the untruth of the French accounts has been so demonstrated over and over again. With the drawings and other particulars of La Gloire before us we could tell with the greatest precision what fuel she can stow, how fast she can steam, and at what height her ports are above the water. We have not, it is true, all the details of the ship before us yet; but we have enough to demonstrate her real qualities with sufficient accuracy for my present purpose, and I confidently assert that she is seriously defective as a war-ship in many respects.

Now, from the very first our admiralty has been averse to the construction of such vessels as La Gloire, and to the rough-and-ready solution of the iron-cased ship problem which she embodies. Whether their aversion was wise or not, under the peculiar circumstances of the case, I shall not presume to say; but that they could speedily have produced a fleet of ships in every way equal to La Gloire, had they pleased, there is not the slightest doubt. Instead of doing this, however, they have asked "How do we know whether a plated wooden ship, or a plated iron ship is the better? How do we know whether the plating should extend from stem to stern, or not? How do we know whether the side should be upright or inclined? or whether the plating should be backed with wood or not? or whether it should form part of the hull or not? or whether it should be made of rolled iron or of hammered? or what its thickness should be? or how it should be fastened?" and so forth. And while all these questions have been asked, we have pretty nearly stood still.

It is only fair to Sir John Pakington's board of admiralty to say however, that, without waiting for answers to them he ordered, as we have seen, the Warrior, which is now afloat on the Thames. Those of you who, like myself, proceeded to Greenhithe in this vessel on the 8th of August, or have visited her there since, will doubtless concur in the praise almost universally accorded to her. In all the yacht squadrons of the country there is not a handsomer vessel than the Warrior; yet there are few iron-cased ships in the French navy that will bear comparison with her as a vessel of war. She has been so often described in the public journals, and particularly in the 'Cornhill Magazine' for February last, that I need not stay to describe her here.

It is also to the credit of the present board of admiralty, that on their accession to office they hastened to order the Warrior's sister ship, the Black Prince, which I doubt not is in every respect her equal. But why they soon afterwards built the Defence and Resistance, ships of 280 feet in length, 54 feet broad, and 3700 tons burden, of only 600 horse-power, and plated over less than half their length, I cannot conceive. I am aware that these vessels are primarily designed for coast defence, and that their draught of water is more favourable than La Gloire's for this purpose—theirs being 25 feet, and hers 27 ft. 6 in. But with engines of only 600 horse-power their speed must necessarily be low, and with so small a portion of their sides coated with thick plates they will be unfitted to stand that continued "pounding" to which a low-speed coast-defence vessel would be more exposed than a fast sea-going ship. The same objections hold to a certain extent against the Hector and Valiant class, which are of the same length and very nearly the same draught of water as the Defence and Resistance; but their increased engine-power of 800 horses (which has led to an increased breadth of 2 ft. 3 in., and an increased tonnage of 360 tons) will secure for them a higher speed, and their thick plating has been continued entirely round the main deck, so as to protect the gunners throughout the length of the ship; and these, therefore, though defective, are certainly better vessels than the others.

It is important to observe that, notwithstanding the long delay of the admiralty, and despite all we have heard respecting experimental targets, the irresistible determination of parliament to have a large iron-cased fleet has overtaken the admiralty before they have obtained answers to any one even of the questions which we have before mentioned, and upon which they have been so long deliberating. The cause of this is undoubtedly to be found in the indisposition of the admiralty to perform experiments upon a sufficiently large scale. Small targets, a few feet square, have been constructed and tested in abundance; but the results thus obtained correspond to nothing that would take place in practice against a full-size ship afloat. Not a single target of sufficient size, and of good manufacture, has yet been tested. The admiralty are at length, however, having suitable structures prepared; and before long some of our principal doubts upon this subject will be resolved. Perhaps the slackness of the board in undertaking these colossal experiments will be understood when I say that a committee of eminent private shipbuilders, including Mr. Scott Russell, Mr. Laird, Mr. Samuda, and Mr. R. Napier, have estimated that a target large enough to try half-a-dozen modes of construction would cost no less a sum than £45,000, and that another £45,000 would have to be expended upon an iron hull capable of floating this target, if the use of such a hull were considered indispensable.

But, however unprepared the admiralty may still be, they have been compelled by the public sentiment, and by the power of parliament, to make large additions to our iron-cased fleet during the last few months. When the House of Commons devotes immense sums of money to a national object with acclamations, and the single opponent of the measure acknowledges himself in error, the time for questioning and parleying upon points of detail is passed. And this is what has happened in this iron-cased ship business. The government has declared a number of new ships necessary; parliament has voted the requisite funds with unanimity and cheers; Mr. Lindsay has confessed himself in error; and the board of admiralty have been instructed to build the ships with all possible despatch. Let us now see what kind of ships they are to be.

The first of them, the Achilles, which has recently been begun in Chatham Dockyard, so nearly resembles the Warrior and Black Prince, that a very few words will suffice for her. The chief difference between her and those vessels lies, I believe, in the fact that her beam is slightly broader, and her floor somewhat flatter, than her predecessors, whereby her tonnage is increased from 6039 to 6089 tons, and her displacement from 8625 to 9030 tons. All her other dimensions, and all her essential features of construction, are exactly like those of the Warrior,—from which it may be inferred that the method of plating the central part only of the ship, which was introduced by your distinguished vice-president, Mr. Scott Russell, is still viewed with favour by the admiralty designers. Mr. Scott Russell did not patent this invention, I believe; perhaps he will kindly tell us whether he has found his rejection of the Patent Law to pay him well in this instance.

In the class of ships which come next, however, the admiralty have consented to forego the plan of plating amidships only, and purpose plating the ship from end to end with thick iron. But in order to do this it has been necessary to resort to larger dimensions than the Warrior's; and hence these six new ships, three of which have just been contracted for, are to be 20 feet longer than her, 15 inches broader, of 582 tons additional burden, and 1245 tons additional displacement. As the displacement is the true measure of the ship's actual size below the water, or of her weight, it is evident that the new ships are to be considerably more than 1000 tons larger than the Warrior class. As their engines are to be only of the same power, their speed will probably be less.* This diminished speed is one of the penalties which have to be paid for protecting the extremities of the ship with thick plates. Another will probably be a great tendency to plunge and chop in a sea-way. The construction of such vessels is a series of compromises, and no one can fairly blame the admiralty for building vessels on various plans, so that their relative merits may be practically tested.

The cost of this new class of ships will exceed that of the Warrior class by many thousands of pounds, owing to the increased size. But it will certainly be a noble specimen of a war-ship. A vessel built throughout of iron, 400 feet long and nearly 60 broad, invulnerable from end to end to all shell and to nearly all shot, armed with an abundance of the most powerful ordnance, with ports 9 ft. 6 in. above the water, and steaming at a speed of, say 13 knots per hour, will indeed be a formidable engine of war. And, if the present intentions of the admiralty are carried out, we shall add six such vessels to our navy during the next year or two. We must be prepared, however, to dispense with all beautifying devices in these ships. Their stems are to be upright, or very nearly so, and without the forward-reaching "knee of the head" which adds so much to the beauty of our present vessels. Their sterns will also be upright, and left as devoid of adornment as the bows. It should also be stated, as a characteristic feature of these six new ships, that their thick plating will not extend quite to the bow at the upper part, but will stop at its junction with a transverse plated bulkhead some little distance from the stem, and this bulkhead will rise to a sufficient height to protect the spar deck from being raked by shot.

It has not yet been decided whether these new iron ships are to have their plating backed up with teak timber, as in the previous ships; or whether plating 6½ inches in thickness, without a wood backing, is to be applied to them. The determination of this point is to be dependent, I believe, upon the results of the forthcoming experiments with the large targets to which I have previously adverted, and partly upon the recommendations of the iron plate committee, to which our president belongs, and which is presided over by that distinguished officer, Captain Sir John Dalrymple Hay, R.N. All that has been decided is, that whether the armour be of iron alone, or of iron and wood combined, its weight is to be equivalent to that of iron 6½ inches thick. The designs of the ship have been prepared subject to this arrangement, and provision has been made in the contracts for the adoption of whichever form of armour may be deemed best when the time comes for applying it.

All the iron-cased ships which I have thus far described are built, or to be built, of iron throughout, except in so far as the timber backing of the plates, the planking of the decks, and certain internal fittings may be concerned. I now come to notice a very different class of vessel, in which the hull is to be formed mainly of timber, the armour plating being brought upon the ordinary outside planking. The Royal Alfred, Royal Oak, Caledonia, Ocean, and Triumph are to be of this class. Their dimensions are to be—length 273 feet, breadth 58 ft. 5 in., depth in hold 19 ft. 10 in., mean draught of water 25 ft. 9 in., and height of port 7 feet. They are to be of 4045 tons burden, and to have a displacement of 6839 tons. They are to be fitted with engines of 1000 horse-power. They are being framed with timbers originally designed for wooden line-of-battle ships, but are to be 18 feet longer than those ships were to be. They will form a class of vessels intermediate between the Hector and the Warrior classes, but, unlike both of them, will be plated with armour from end to end. They will be without knees of the head, and with upright sterns; and will therefore look very nearly as ugly as La Gloire, although in other respects much superior vessels, being 21 ft. 6 in. longer, 3 ft. 5 in. broader, and of less draught of water. They will also be quite equal to her in speed.

It will occur to some now present, that in adopting this class of ship we have, after three years' delay, approximated somewhat to the Gloire model at last. And undoubtedly we have done so, in the present emergency, in order to compete with the movements which France is now making. At the same time, we have not gone to work quite so clumsily as our neighbours. Instead of retaining the old line-of-battle ship proportions, we have gone somewhat beyond them; and have lifted all the decks, in order to raise our guns higher above the water. We have consequently secured a height of port or battery nearly 18 inches greater than La Gloire's —an advantage which will prove valuable under all ordinary circumstances, and incalculably beneficial in rough weather.

The whole of the new iron-cased ships, including the five plated timber ships and the six 400-feet iron ships, will, there is every reason to believe, match La Gloire in speed, supposing the engines put in them to be of the respective powers already mentioned—a condition which it is necessary to state, since there is, I regret to say, a probability of smaller engines being placed in some of them. But not one of all these new ships, the Achilles only excepted, will have a speed equal to the Warrior's. Perhaps we ought not to complain if our fleets are as fast as the French; but I, for one, certainly do regret that there should be any falling off in this prime quality of our iron-cased vessels. Iron and coal will give us fast vessels, and we have these in abundance. The truly admirable engines which Messrs. Penn have placed in the Warrior show that we can command any amount of engine-power that we require, without incurring risk of any kind; and it would indeed be a blind policy to deprive ourselves of that speed which is pronounced invaluable by every naval officer and man of science who writes or speaks upon this subject.

I have thus far said nothing concerning the armaments of the new classes of vessels which I have been describing, because nothing has yet been finally decided respecting them. Nor would it be wise to decide this matter in the present state of our artillery, until to do so becomes absolutely necessary. We are, it is said, producing 100-pounder, and even larger, Armstrong guns with great success now, and may therefore hope for supplies of ordnance of at least that class for these vessels; but the modifications and improvements which even Sir William Armstrong himself has introduced since he became our engineer-in-chief for rifled ordnance have been so great that we have lost all confidence in the continuance of existing systems, and hold ourselves prepared daily for further changes. Before these new ships are fit to receive their armaments, or even before they have so far progressed as to make it necessary to fix the positions and dimensions of their ports, we may be put in possession of a far more effective naval gun than we can yet manufacture; and the best gun, wherever it may come from, must unquestionably be adopted for them. Whoever may produce it, we shall have, let us hope, the great benefit of Sir William Armstrong's splendid mechanical genius, and large experience, in manufacturing it in quantity at Woolwich. This is an advantage which should not be thought lightly of; for, whatever other views some may entertain, either through jealousy, or rivalry, or conscientious conviction, we must all agree in believing it a great piece of good fortune to have one of our very ablest mechanicians placed at the head of this great mechanical department.

I am able, however, to afford some information respecting the number of guns which the various classes of our new ships will be able to carry, and probably will carry. Of the Defence, Resistance, Hector, and Valiant I shall say nothing, because they cannot be considered fit for the line-of-battle, or suitable for any other service than coast defence. Nor need I say more of the Achilles than that she will in all probability be armed with such ordnance as may be found to answer best in the Warrior and Black Prince. We come, then, to the plated timber ships; and these I may usefully compare with the model French vessel. We know that La Gloire, which is 252 ft. 6 in. long, has an armament of 34 guns upon her main deck, and two heavy shell-guns besides —36 guns in all. Now our ships are to be more than 20 feet longer than her, and will therefore take two additional guns on either side; so that they will carry not less than 40 guns, if the ports are placed as close together as in La Gloire. I need claim no greater advantage for them in respect of their armaments; but they are manifestly entitled to this. As a matter of fact, however, they will probably have a much more powerful armament. It is proposed, I believe, to arm them with about as many guns

* Since this paper was read at Manchester, I have learnt that the controller of the navy always intended these vessels to have a speed of 14 knots, and will give them sufficiently powerful engines to secure that, if possible.—E. J. R.

as La Gloire on the main deck, all 100-pounder Armstrongs, and 16 or 18 other guns, principally Armstrongs, on the upper deck, making about 50 guns in all. If this intention be carried out, they will manifestly be much more powerful vessels than the original French ship. The newest and largest vessels, those of 400 feet in length, will each carry at least 40 Armstrong 100-pounders on the main deck, which will be cased with armour, as I before stated, from end to end. In addition to these they will doubtless have powerful ordnance on their upper decks, for use under favourable circumstances. But all these arrangements are, I repeat, liable to change.*

Unfortunately, I am unable to compare the power of these vessels with that of the largest of the French iron-cased ships, owing to the absence of all detailed information concerning them. I trust, however, that the admiralty are in possession of the necessary particulars, so that the delay which has taken place may be turned to the best possible account by securing superiority for our fleet. If this be so, then we shall, after all, profit by the apparent sluggishness of our naval authorities. In fact, if England had France only to consider, and if the government of England were embodied in a single sagacious ruler as absolutely as is that of France, so that we could insure prompt action in an emergency, the very best course for us to pursue in this great naval competition would be to leave the lead in the hands of the French Emperor, taking care to add a ship to our navy for every one added to his, and to make ours much more powerful than his. In the event of a war, our manufacturing resources would be abundantly sufficient to secure for us a further and almost instant preponderance. The game which we should thus play would be both political and economical. But with other naval nations to compete with, and with the inertia which inevitably, and often happily, attends a constitutional and parliamentary system of government, we cannot afford to play games of skill with omnipotent emperors, but are bound to be ever ready to assert our pre-eminence.

I have a little information concerning the Solferino and her sister French ships, which it may be useful to give you. Her length is 282 feet, breadth 54 feet, mean draught of water 26 feet, displacement 6820 tons, thickness of armour plating 4¾ inches, nominal horse-power of engines 1000. Her plating extends from stem to stern over the lower gun-deck, and rises up amidships sufficiently high to cover two decks. She is furnished with an angular projection or prow below the water, for forcing in the side of an enemy, when employed as a ram. I regret my inability to add materially to these details of the largest French ships.

Let me now consider briefly the pecuniary phase of this iron-cased ship question. We may fairly assume that the average cost of such vessels will not be less than £50 per ton, and that their engines will cost at least £60 per horse-power. Supposing these figures to be correct, then the hulls of the eighteen ships which we have been considering will cost £4,681,600, and their engines £1,143,000—together nearly *six millions* pounds sterling. When masted, rigged, armed, and fully equipped for sea, they will, of course, represent a much larger sum—probably nearly *eight millions*. These estimates will afford some faint conception of the nature of that "reconstruction" of the navy upon which we may now be said to have fairly entered, in so far as the ships themselves are considered.

But I must not conceal the fact that the introduction of these enormous iron-cased ships has entailed upon us the construction of other colossal and most costly works. We have now to provide immense docks for their reception; for we at present possess none suitable to receive them. Nor must these docks be of large proportions only; for in order to sustain ships burdened with thousands of tons of armour, they must be furnished with more substantial foundations and walls than any hitherto constructed, and be built of the best materials and with the soundest and firmest workmanship.

Many considerations combine to exalt the importance of this part of my subject. In the first place, the tendency which iron ships have to get foul below water will render it necessary to dock our new ships frequently under ordinary circumstances, and whether we go to war or not. In the second place, for aught we yet know, these ships may be found to give signs of local weakness as soon as they are taken on an ocean cruise, and to require such repairs and strengthenings as can only be performed in dock. Again, being steamships, they will be continually liable to accidents in connection with the engines or the propelling apparatus; and with many such accidents docking will become indispensable. And so I might proceed to multiply examples of this kind. But there is one consideration which is paramount, and which may therefore be stated at once: we dare not send these ships against a French fleet unless we have docks for them to run to in the event of a disaster. We know not what may happen to these altogether novel structures, until they have been exposed to successive broadsides from a heavy naval battery; and it would be madness to send them out to encounter a powerful fleet of vessels as strong as themselves unless we are prepared to open docks to receive them in case of necessity.

I have said that we are at present without dock accommodation for these ships; and it may be desirable to illustrate the correctness of this statement in detail. What we require for them in each case is, first, deep water up to the entrance of the dock; secondly, a depth of not less than 27 or 28 feet of water over the sill of the dock; and thirdly, a length on the floor of the dock of 400 feet. Now, these three conditions are not combined, I believe, in any dock in Great Britain—certainly not in any of Her Majesty's dockyards. At Portsmouth we have just completed a pair of docks which can be thrown into one, 612 feet long. But over the bar of Portsmouth harbour there is a depth of 17 feet only at low water, 27 feet at high-water *neaps*, and 30 at high-water *springs*. Consequently, these large iron-cased ships, if they went to Portsmouth in a dangerous state, or in hot haste to get to sea again, would nevertheless have to wait for the very top of the tide before they could get either in or out. But even if there were no bar, the Portsmouth dock would still be unavailable in such an emergency; for the depth of water over the sill of one portion of it is but 25 feet at high-water springs. It is into this dock that the Warrior is shortly to be taken for the purpose of having her launching cleats removed, and her bottom cleaned. As she can at present afford to wait upon the tide without inconvenience, there will be no difficulty in this case. But in war time it would never do to keep such an important member of your squadron fretting for the tide at Spithead, or to have to lighten her before she could cross the dock's sill. At Devonport, again, the longest dock is only 299 feet long over all; but I am happy to state that one is in progress of construction 437 feet long, 73 broad, and 32 deep at the sill. At Keyham, the longest dock (the South), which is 356 feet in length, has but 23 feet depth at the sill, while the North, which has 27 feet, is but 308 feet long. At Pembroke there is a dock 404 feet, but it has a sill of 24 feet 6 inches only. The longest dock at Sheerness is 280 feet; at Woolwich, 290; and at Chatham, 387, but the last has but 23 feet 6 inches at the sill. At Deptford there are but two docks, opening into one, and they are very shallow. There are a few large private docks in the country which come very near to our requirements. There is the Canada Dock at Liverpool, for example, 501 feet long, 100 broad, and with 25 feet 9 inches over the sill. There are also No 1 Dock at Southampton, and the Millbay Dock near Plymouth, of which the former is 400 feet long with 25 feet over the sill, and the latter 367, with 27 feet 6 inches over sill. But none of these answer all our requirements, nor could we avail ourselves of more than one or two of them in time of war if they did.

If we turn to the French coast, we shall find that in this matter also we are far behind our neighbours. At Cherburg there are two docks 490 feet long and 80 broad; two 380 by 70; two 350 by 65; and two smaller ones besides. At Brest, again, there is building a double dock 720 feet by 90; and there are also two 492 feet by 60, and two smaller. At L'Orient there is one 350 feet long, and another (building) 507 feet. At Toulon there are two in progress, one 409 feet long, and the other 588, beside several smaller docks which have existed for some time. I cannot give the depth of the sills of any of these French docks, for I have been unable to obtain that element in any single case even, and I am assured no account of it is anywhere recorded in this country. But there is no good reason to doubt that a proper depth has been given in most instances.

You will now be able to comprehend the advantage which France has secured in this matter of dock accommodation for her iron-cased fleets, and will readily discern that danger to which we should be exposed in the event of an early war with that country. A single action might so seriously cripple both fleets as to render large repairs necessary; but France alone would be capable of renewing her strength,—it would be our lot to lie crippled in our harbours, while she captured our commercial vessels and menaced our coasts.

I am perfectly well aware that a large increase of dock accom-

* Since this paper was read, the issue of 100-pounder Armstrongs has been suspended.—E. J. R.

modation is to be supplied at Chatham forthwith. But our Channel and Mediterranean fleets must not depend upon docks at Chatham, which cannot be reached from the south until a long passage has been made, the Nore sands threaded, and an intricate and shallow river navigated. We must give to our ships the advantage which Cherburg secures for the French, and which they propose to augment by establishing at Lezardrieux* an immense steam arsenal, protected by an impregnable series of defences.

It will now be seen that, in order to place ourselves upon an equality with the French navy, no less than to meet the certain emergencies which must arise with our reconstructed fleet, we ought without delay to found a colossal dock establishment on some favourable point of our southern shores, furnished with the means of carrying on extensive repairs in time of war. The most suitable of all positions is probably that of Southampton Water, the shore of which, at the entrance to the river Hamble, presents conditions and circumstances which finely qualify it for the purpose. If we are wise enough to build a set of suitable docks there before the time of war arrives, we shall have the satisfaction of knowing that the largest iron-cased ships now in contemplation will be able to run in and be docked with all their stores on board, and everything standing. And nothing less than this should satisfy us.

INSTITUTION OF ENGINEERS IN SCOTLAND.

The first meeting of the session 1861-2 of the above society was held November 13, 1861; the president, Wm. Johnstone, Esq., delivering the introductory address on the occasion, as follows:—

In appearing before you, I think it right to tender you my best thanks for the honourable position you have placed me in, by electing me president of this rising and, what I trust it will yet be, great and useful institution; and while I do so, I cannot but feel that the important duties attaching to the office would have been more efficiently discharged by some other of its members, although by none who has more at heart the interest of the institution. I crave, therefore, your indulgence for any deficiencies and shortcomings.

I have not the same cause as my worthy friend who preceded me to regret, as he did at the opening of his last address, that few papers had been read and discussed before the institution; as during last session there was not only a good number of them, but they were all of a highly interesting character, and at once calculated to advance science and throw much light on the various subjects treated.

It must indeed be generally admitted that the volume of our transactions for last session, just issued to the members, exhibits a decided advance upon the previous reports of our earlier proceedings; and this whether we consider the amount of matter, the importance of the subjects discussed, the value of the information elicited, or the increased willingness of our members to take part in the discussions. As showing the great interest taken in the subjects brought before us last session, I may remind you that the discussion of some of them was renewed on several different evenings.

The important subject of air engines was introduced at the first meeting by our late president; who exhibited in actual operation a small engine of this kind made by Ericsson, and brought over from New York. The chief merit of this little engine appeared to be its convenience in application where a very small power was required; but it did not seem to be economical in the use of fuel. The subject was resumed at the third meeting by Mr. P. Stirling, who gave us a description of, and the practical results obtained by, the earliest air engine ever in operation for any length of time, and which was erected by Mr. James Stirling at Dundee in 1842—the economy in fuel of which has hardly been surpassed during the interval since that date. It is true the particulars given in the paper had been furnished to the Institution of Civil Engineers some years ago; but the council, in requesting Mr. Stirling ro read it, believed that the time had arrived when it was desirable to re-open the discussion of the subject, which could not be done better than by the paper in question. The extremely interesting discussion which followed fully justified this step. Stirling and Ericsson's engines were compared, and the important differences in their modes of action considered, and the advantages of the former pointed out. It appeared that Stirling's could be made to work satisfactorily up to fifteen or twenty horses power; but that for larger powers great difficulty was experienced in getting heaters to stand. The subject was again brought up at the last meeting of the session by Mr. Lawrie's elaborate theoretical paper on the operation of air engines; and in the discussion which followed a prominent part was taken by Prof. Rankine and Mr. Brownlee, who contributed valuable materials towards the elucidation of the subject. It is not, however by any means exhausted, and there is reason to expect that we shall have additional papers during the present session. In some respects, if theoretical promises are realised, the air engine should apparently possess advantages superior to those of the steam engine; and the prosecution of the subject should not be relinquished until practical difficulties are overcome, or the supposed advantages proved to be imaginary.

At our second meeting we had useful papers read by Prof. Rankine on engineering field-work, and by Mr. Froude on the junction and laying out of railway curves—another branch of the same subject. The former supplied rules for ranging and measuring the inaccessible parts of straight or curved lines; whilst the latter entered with extreme minuteness into the important questions of the cant that should be given to the outside leg of the curve, and the best modes of uniting two unequal or contrary curves, or a curve with a straight line. The discussion of the subject was again taken up at the fourth meeting, when additional matter was furnished by Mr. Froude, and the particulars of a case of sharp reversal of curvature on the South Devon Railway were given by Mr. Bell—showing that a careful and pains-taking correction of the line by those in charge, in accordance with the indications of defects produced by passing trains, had gradually brought it to closely approximate to Mr. Froude's curve. A small portion only of our members took an interest in the subject of this paper. In an institution, however, like our own, designed to comprise and bring together all classes of engineers, something of that kind must occasionally happen; but it should be remembered that the interest of our transactions is considerably enhanced by the variety in the topics of the papers they contain; and each of us should bear in mind when listening to a paper of little interest to himself, that other papers of more interest to him may have been of considerably less to other members. It is due, however, to Mr. Froude to award him special praise for the very interesting manner in which he treated the subject, and for the very great care and labour bestowed by him in order to render it as complete as possible. It is a paper which well deserves to be referred to as an example by future contributors to our proceedings. In it and the discussion which followed thereon will be found sufficient data to guide and educate the young engineer in this important branch of civil engineering; and there is no other branch that I consider more necessary for an engineer to make himself thoroughly master of than this. It will have the effect of economising time in the laying out of a railway, and capital in its construction; while it will insure mathematical accuracy in the laying down of the permanent way and works, as well as their maintenance on correct principles.

At our fourth meeting we had two papers from Mr. Simpson, one describing an improved pump, which was illustrated by a working model. The institution will, I am sure, be glad to receive from Mr. Simpson an acccount of the practical application of this pump to mines; its trial on a large scale having been recommended when the paper was read.

Mr. Simpson's second paper was on the ventilation of mines. It described a very ingenious apparatus for indicating the dangerous presence of explosive gas; and with respect to it the institution also hope to receive an account of practical experiments which were to be undertaken to test the range and accuracy of the indications. If these experiments are satisfactory, the instrument will be a most valuable protection for the miner.

We had during the session another paper relating to mines, by Mr. James Ferguson. It treated principally of underground mineral transit. It was highly interesting, and will prove to be a valuable paper for reference, on account of its numerous and carefully narrated statistics, and its elaborate comparisons of the different modes of underground conveyance hitherto and at present in use.

The subject which last session elicited the keenest discussion was that of the surface condenser, introduced at the fifth meeting

* See an admirable article in Capt. Beecher's 'Nautical Magazine' for July 1861.

by Mr. Davison's paper, and resumed at the sixth and eighth meetings. It has been remarked that in this discussion there was a little too much irrelevant contention between the advocates of rival plans; but it must not be forgotten that, without this element of rivalry, those taking part in the discussion would not have felt themselves impelled, as they were, to supply us with the large amount of information, the numerous facts and practical results, and the various considerations both in favour of and against each plan, which were actually elicited; and all of which should be known and considered by every one desirous of selecting the best condenser. It is in laboriously endeavouring to devise a condenser (or other useful machine) that shall surpass all others, and thus confer a benefit on the community, that an individual becomes the interested advocate of a particular kind. It is natural to suppose that such a person has studied the subject more than one not specially interested in it, and in consequence of such study he should be more able to supply correct information and advice upon it. It is always the best information and advice on any subject brought up which the institution is desirous of eliciting and placing on record; and if we except purely theoretical subjects, it is from interested advocates of particular views and plans that we should expect to get it. The reading of papers before institutions like this, even though it be by interested advocates of the plans such papers describe, cannot in any sense be likened to ordinary advertising. In the latter, everything that can be said in praise is fully written up, and much there are no grounds for; whilst all particulars on which the readers can exercise their own judgment are studiously omitted. In the former the author challenges the criticism of his hearers, exposes his plans to comparison with any others that may be brought forward, and submits his advocacy to searching examination. His paper is thoroughly discussed, and, as the result of discussion, his views may be confirmed and advanced, or, it may be, discouraged and negatived. He risks this from a *bonâ fide* belief in the merits of his plans; but whatever the result, the institution will have elicited the best information on the subject that is obtainable from its members.

At the fifth meeting our attention was also directed to the subject of gas engineering by Mr. David Laidlaw. It was not Mr. Laidlaw's design to introduce to our notice any special novelties, nor to enter into any very abstruse questions; but he gave us, in an interesting and concise manner, a brief retrospect of past doings, and a general view of modern practice, in that important department of engineering. Mr. Bartholomew contributed considerably to the interest taken in the subject, by presenting us with drawings and description of the large gasholder and tank recently erected from his designs by the Glasgow City and Suburban Gas Company.

At our ninth meeting we had Mr. Milne's most valuable paper describing the removal of the junction lock at Grangemouth, and its replacement by an enlarged lock, forming an imporant addition to his contribution of the previous session, which also related to improvements in the canal works at Grangemouth. These papers are of a class that, I think, the institution ought to be desirous of encouraging, on account of the value they impart to the transactions, from their importance as articles of reference. The simple and concise phraseology, and the quantity and minuteness of details, both in the description and drawings—upon which the practical value of such papers mainly depends—entitles them to be taken as standard examples for future authors of similar ones; but they have also the advantage of describing engineering expedients, remarkable not only from the nature of the difficulties to be overcome and from their novelty, but also from the ingenuity displayed in devising them, the skill shown in carrying them out, and, above all, from their small cost compared with the practical advantages derived from them.

We had, finally, Mr. Simpson's paper on canal locks, which was illustrated by a working model. Mr. Simpson remarked on the great waste of water involved in the ordinary lock system, and proposed as a substitute a very ingenious plan, exceedingly simple in its action, and which promised to be considerably less costly in construction, working, and maintenance, than mechanical lifts, such as that at Blackhill on the Monkland canal; whilst the expenditure of water would be reduced to a minimum, and in some cases altogether obviated. It appears to me this plan merits careful consideration.

Having gone over the various papers brought before the institution during the last session, I shall only shortly refer to some of those subjects which I think ought to continue to engage the attention of the members of the Institution, and to obtain from them valuable papers thereon.

The subject of mining is one of great importance, and there is none more deserving the attention of the engineer, with the view towards an improvement in the mode of conducting underground operations—tending not only to improve the condition of the miner in every respect, but economising to the proprietor the cost of production. The produce of our mines, whether considered as the great element of industry, or as the mighty agent used for the production of mechanical power alone, is well deserving of the consideration of the members of this institution. Before the days of Watt and the steam engine, the mining of this country was meagre and insignificant compared to the important position it has since acquired. The steam engine, which gave the miner facility for draining the seams of coal and ironstone, also enabled him to make deeper shafts, obtain larger outputs, and carry them to markets never dreamt of until the days of the steam engine and rail.

The field of labour under this head is wide, and always attractive to the mechanical engineer. It is doubtful if the genius of Watt, when he first took up the steam engine, could have found more congenial employment than in scheming and arranging its details to win and unwater the vast fields of coal which lay deep and inaccessible throughout the country. It is well known that the extensive fields of the north of England gave rise to the first practical development of the idea of locomotives and rails.

From reliable sources we learn that the annual produce of coal throughout Great Britain has now reached the enormous output of 80,000,000 tons. It would be difficult to arrive, even approximately, at the power of the machinery employed to lift this ponderous weight to the surface, scattered as it is throughout all parts of the country. It is calculated, however, to be not more than a fourth of the total power required to raise it and the drainage; or, in other words, for every ton of coal lifted there are three tons of water. It has been estimated that nearly one-sixth of the total annual produce of our coal mines is used for the production of mechanical power alone, from which a power equal to 66,000,000 able-bodied men is obtained; and, upon the same calculation, the total annual production of the United Kingdom is equal to the strength of 400,000,000 men, or more than double the number of adult males now upon the globe. The mechanical appliances employed underground are daily increasing; and the engineer who could contrive and arrange a locomotive to suit the peculiarities of underground haulage, would receive and well deserve the lasting gratitude of the coal owners of this country. Though various schemes have been tried to introduce machinery to work coal, I am not aware that any of them have been found effective or practically useful. However, the many ingenious contrivances to be found in our workshops and engineering establishments for reducing manual labour, would induce the general observer to anticipate that even in coal-hewing the time may not be far distant when some mechanical arrangement will be introduced to aid and economise the labour. Though no very alarming question has yet been put regarding the duration of our coal-fields, it is well known that more attention has of late been paid to the economising of them. Modified and improved systems of mining are being gradually introduced; and these improvements, while they reward the enterprising, keep this country ahead of other countries, from the aid and impetus which a cheap supply of fuel gives to the manufacturer.

Situated as we are in the centre of a rich and extensive mineral field, enjoying the advantages of cheap coal and iron, we cannot forget that the hands who produce so much of this country's wealth are subject to many painful casualties; for we have the means of knowing that throughout the mines of the United Kingdom upwards of a thousand persons, from various causes, are sacrificed annually. In this immediate neighbourhood we have been lately startled by one or more of these disastrous occurrences; and while those best informed on these matters seem not to calculate upon more than an amelioration of such calamities, yet it is clearly the province of this institution to foster and encourage every aim having for its object the safety and improvement of this useful and invaluable class of men.

During these days of general progression, the locomotive engine has not been stagnant, but has been becoming gradually more matured, and its powers more fully developed. From the great advantages derived from machinery in its construction, and from the superior description of materials now used, engines are manufactured with a precision approaching perfection, thereby largely diminishing the cost of construction, and greatly increasing their powers of endurance. As an instance, I may mention the pretty general introduction of cast-steel tires, which from their superior quality and hardness will last twice as long as the best Yorkshire iron, and from their great toughness and strength will be much less liable to accident than those presently in use. I think before many years cast-steel will be universally adopted for the tires of both engine and carriage wheels. The chief objection to them at present is their cost—an obstacle which, I have no doubt, will be got over as the demand for them increases.

Perhaps the greatest improvements that have been made on locomotive engines of late, however, have been more immediately connected with the economy of their use. Since the introduction of coal as a substitute for coke, it is gratifying to know that the same work can now be done for one penny per mile which only very lately cost threepence; and, as an illustration of this, I may mention that some passenger trains, having a gross weight of from fifty to sixty tons, are now propelled at a speed of forty miles an hour, at a cost of a fraction over a farthing per mile for fuel. Not long ago, eightpence to tenpence per train mile was considered no extravagant sum to pay for locomotive power; the same work is now done for something less than sixpence. This result has, no doubt, been brought about by the attention that has been paid to the construction and working of the locomotive engine. No doubt much remains yet to be done by skilful and enterprising mechanics; but, I must say, it seems at present difficult to point out by what means much greater economy, in fuel at least, can be obtained.

Giffard's feed injector appears to me destined to play an important part in locomotive economy. From its perfect simplicity in construction, being entirely without parts in motion, there is a complete exemption from the wear and tear consequent on the use of pumps, with their various valves, plungers, and conducting pipes. Unlike the ordinary pump, it is entirely free from liability to damage by frost in severe weather; while the engineman can feed his boiler when the engine is at rest, in a siding or other situation where he could not pump water by the old arrangement —and so getting rid of donkey engines and pumps, and their attendant tear and wear. The ease with which it can be applied to any position that may be wanted, and the readiness with which the method of working it can be picked up by any ordinary fireman in a few minutes, insures its almost universal adoption at no distant date. I am aware of instances where locomotive engines employed in all descriptions of traffic for months past, having no other means of supplying their boilers with water; and in no instance has there been the slightest detention to the trains or want of action on the part of the injectors, and the engine-drivers have the fullest confidence in them. I believe the only conditions to be carefully attended to with them is the using of pure water, and the maintaining of the water to be injected under a temperature of 130°, as above that heat the water does not seem to be capable of condensing quickly enough the steam which is used to force the water into the boiler. It seems to be equally manageable at all pressures of steam; and one of its peculiarities is, that the higher the pressure of the steam, and consequent resistance of the water in the boiler, the greater is the quantity of water it will deliver in a given time.

Allan's pressure gauge is another recent and very successful improvement in the locomotive engine, the engine-driver being at all times able to assure himself that it is in accurate working order. This gauge indicates the pressure by the compression of a quantity of air, which can be measured and renewed at any time by the turning of a couple of cocks. I am glad to say that it is beginning now to be pretty generally adopted.

I have noticed what occurs to me to have been the most prominent improvements recently made on the locomotive engine; and, as regards the carrying stock of railways, it appears to me that the most important improvement is their increased capacity, whereby each carriage and waggon is made capable of carrying double the load of the old ones, and that without greatly increasing the weight of the vehicles, while only the same number of wheels and axles is employed; so that the tear and wear has not increased in the same ratio that it would have done had the same original description of plant been perpetuated. And while these improvements have been made in the carrying stock, it is evident that the same amount of tonnage can be shifted with a much less expenditure of locomotive power than formerly.

I may further call attention to the use of malleable-iron girders in the construction of railways and other works, and the adoption of cast-iron cylinders for the under structure of bridges and viaducts, where such required to be carried over rivers and streams of considerable depth. One of these has been constructed by Messrs. Blyth, of Edinburgh, for carrying the Portpatrick railway over Loch Ken in Kircudbrightshire. It consists of three water arches, with land arches on each side. The two water piers are founded in very deep water, considerably above twenty feet. The cylinders are somewhere about eight feet in diameter. After the cylinders were loaded and sunk to their proper depth, and the stuff excavated from the interior, they were securely built inside with solid ashlar freestone wrought to the circle of the cylinder. The top of the cylinders correspond nearly with the ordinary level of the loch, upon which ashler piers are raised to the level of the lattice girders for carrying the permanent way. It is altogether a very neat and substantial structure, and reflects great credit upon the designers. I have procured photographic views of it, which are now laid on the table for the members' use. The great advantage such a work has over the old plan of building viaducts in such a situation, is the facility afforded in obtaining a foundation for the piers, without resorting to the expensive, tedious, and uncertain process of coffer-dams. This plan is also being adopted for carrying the Charing Cross railway from the Hungerford market across the Thames to the Surrey side, on the site of the present suspension bridge.

INSTITUTION OF CIVIL ENGINEERS.

G. P. Bidder, Esq., President, in the chair.

Nov. 19, 1861.—The whole of the evening was occupied by the Discussion upon Mr. Longridge's paper on "*The Hooghly and the Mutla.*"

It was remarked that owing to the increased trade of Calcutta, and the insufficient accommodation for shipping in the river Hooghly, as well as of warehouse room on the bank, an inquiry had been instituted as to whether any of the channels in the Sunderbunds could be rendered available for the relief of that port. The Mutla had been found to answer the requirements, as it possessed a safe and convenient navigation, with a tract of land suitable for warehouses and offices on its banks, within a moderate distance of Calcutta. The chief objection to the new settlement had hitherto been the unhealthiness of the site; but its salubrity would improve year by year, as embankments were being made to keep out the flood of high tides, the land was being drained, roads formed, and tanks or reservoirs excavated to hold and ensure a good supply of pure fresh water. There were numerous applicants for the land, which was sold in allotments on building lease, and there was every prospect of the new port affording a useful and necessary adjunct to Calcutta.

With a view of ascertaining what peculiar causes were in operation to make the channel of the Mutla so much deeper and more regular than that of the Hooghly, a chart of the upper part of the Bay of Bengal had been contoured. It was thus found, that there was a deep water channel in the centre of the gulf, some portions of which had not been sounded at 300 fathoms; that the water shoaled from 100 fathoms at 20 miles from the coast to 5 fathoms at 5 miles; and that the channels passing up the creeks were nearly at right angles to the line of from 30 to 50 fathoms of water. Also, that the entrance to the Mutla was the nearest to the deep water; hence, there was a greater freedom of current, and the flood was carried more quickly up to the head than in the others, causing its channel to be superior to that of the Hooghly.

The most violent winds in the Bay of Bengal were from the south-west, and if accompanied with a spring tide, the littoral of Hindostan must be swept from its southern part to the mouth of the Hooghly, which lay open to receive it, and meeting with extensive shoals the force of the flood was checked, until it had attained some height, when it was hurried forward up the estuary of that river, and formed a dangerous "bore." Such could not be the case in the Mutla, from its deep water channel being at right angles to the course of the flood, and immediately connected with the deep water in the centre of the bay. On the other hand, with north-east winds, the deep water of the centre of the bay and the whole length of the gulf was forced seawards, and must be the cause of littoral counter currents running northwards, carrying with them the detritus to the head of the bay on both sides. Hence there was a preponderating power in the tidal currents, as well as the detritus brought down the rivers to find a resting-place there.

In regard to the amount of solid matter contained in the waters of the Hooghly, it was stated, that although Major Rennell had in his 'Memoir of Hindostan' estimated the water of the Ganges to consist of one-fourth part mud, yet in other writings he had given it as only the $\frac{1}{200}$th part. This agreed more nearly with Mr. Piddington's experiments, which showed the quantity to be the $\frac{1}{515}$th part, and with the Rev. Mr. Everest's, who made it the $\frac{1}{858}$th part, both during the rainy season. The Nile contained $\frac{1}{120}$ of its bulk in mud, and the Humber $\frac{1}{180}$, of which latter, sand formed about 75 per cent. But even allowing that 78,000,000 cubic yards of solid earth were deposited yearly in the Hooghly and its estuary, this would only give $1\frac{1}{2}$ inch in depth over an area of 600 square miles, included within the 3-fathom contour; and if the area was extended to the 5-fathom contour, and embraced also the inlet of the Hooghly, then the area would contain 1200 square miles, and the deposit would only amount to $\frac{3}{4}$-inch in depth.

A belief existed that a great deal had been done by the former government of India to facilitate a boat passage from Calcutta through the Sunderbunds, But by a return to parliament, this amount appeared not to exceed £37,000; and the chief improvements in the canals in the immediate vicinity of Calcutta had been in throwing bridges across the streams, and in making roads on the banks. Scarcely any outlay had been incurred in straightening the water courses, or in deepening them, either by manual labour or by dredging. It was thought that one of the three Nuddea rivers, which were now only navigable during the months of July, August and September, should have been rendered fit for navigation throughout the year, not only for the native boats, but for the light-draught steamers trading on the Ganges. According to a parliamentary return, the average cost per annum, extending over ten years, of maintaining these rivers, including salaries and the whole establishment, was £3248; whilst the average tolls, after deducting the expense of collection, amounted to £14,486 per annum. There must therefore be a consierable balance in hand, which might well be laid out in straightening the best of these channels, deepeniug its bed and raising its banks, with other engineering works, so as to maintain a sufficient depth of water for the purposes of navigation.

Turning now to the Sunderbund district itself, it would be found that it comprised an area of 4500 square miles of low lands inundated during the rainy season by the overflowing of the numerous rivers and water courses, producing a rank vegetation, and over most of it a dense jungle, the hot-bed of fever, fatal to human life, and the miasma from which must, with certain winds, be carried to the cultivated districts, and even to Calcutta itself. If a proper system were adopted, of dividing this vast and at present useless territory, by a series of cuts, surrounding the districts by embankments, and allowing the water when charged with sediments to remain for a time within them, and run off at low tide, these lands would rapidly be warped up, probably two or three feet in a season, and make an ample return of most valuable produce, as had been for many years past so successfully adopted in the Trent, the Ouse, and other rivers in connection with the Humber.

It was believed that the flood and ebb tides both took the same course in the Mutla, whereas they entered and left by different channels in the Hooghly, and that this was sufficient to explain the difference in the depths of the channels. As to the utility of back water, it was argued that the Mutla navigation must have been maintained by back water through the same channel, and not by tidal scour alone; that it was made by the waters of the Ganges, and afterwards abandoned; and that so long as there was an absence of any great quantity of mud, the channels must remain open.

There were several other examples in India of harbours which were exceedingly good, where there was little or no fresh water, though originally made by the great waters from the land. The easterly and westerly branches of the Indus were at the present moment both tidal estuaries, and other places might be named.

It was mentioned that Barrow Harbour, on the north side of Morecambe Bay, afforded another illustration of an unchanging channel kept open by tidal scour alone; but, on the other hand, it was thought that the freedom from deposit in this harbour was due to the stream which ran through it. The harbour at Portsmouth, and, in a less degree, that at Ramsgate, were instances of harbours silting up for the want of fresh water scour, which it was contended, should always be sought for to keep a harbour clear. To this it was replied, that there were numerous instances in which channels were kept open purely by tidal water—in fact such channels would always be maintained, if the water flowed through them with sufficient force to prevent deposit, whether the stream were continuously in one direction, or whether it oscillated backwards and forwards. In nature, every possible condition was of course to be found; in some cases the fresh water, and in others the tidal water greatly preponderating, and their relative quantities ever varying. For instance, the rivers flowing into the Baltic and into the Gulf of Mexico, possessed an enormous proportion of fresh and very little tidal water, yet the channels continued open. It was quite as erroneous to say, on the one hand, that fresh water was of no use, as, on the other hand, that a channel could not be kept open without fresh water.

When Great Britain was looking to India as the future cotton field of Europe, and when endeavours were being made to open that country to commercial enterprise, the importance of a well-organised system of transit co-operation by railways, by water and by ferry-bridges, could hardly be over-estimated. As fifty millions sterling had been expended in trunk railways and canals, it would be necessary to improve and utilise to the utmost the river navigations, to act as feeders to those main lines, and to provide an additional number of river boats. Since any alteration in the channels of the rivers, and especially of the great Delta, would be costly, and the result very uncertain, it was contended that it would be preferable to construct vessels of suitable size and form for the navigation of shallow and tortuous rivers, and that economy of transit, as well as management of the vessels, was, in such cases, mainly dependent on the efficiency of the steering and towing apparatus.

It was observed, that no great faith could be placed in any scheme for the improvement of Indian rivers, inasmuch as for eight or nine months in the year the weather was perfectly dry, and for four months there was a tremendous rainfall, producing an immense flow of water, when the rivers assumed a character quite unprecedented in this country.

With respect to the change of the seat of trade from Calcutta to the Mutla, there were as many difficulties in the way as if the attempt were made to transfer the trade of the Thames at London to the Medway. It was more a question of economy than anything else, for if millions of money had been sunk in the erection of warehouses and buildings for the purposes of trade, that was an element quite as important as the question of the river itself. Looking to these facts, and to the delays and costs of unloading a cargo twenty or thirty miles from the place to which it was consigned, and conveying it that distance by railway, it was thought that there was no prospect of the navigation of the Hooghly being changed for that of the Mutla. To this it was replied that the difference of expense between Mutla and Calcutta would be considerably in favour of the former port. It was thought that preference should be given to a river where there was always 26 feet of water, to one which was beset with shoals; and to a river, the mouth of which was only 50 miles fron the head of the navigation, available in one day's steam, to one which required three day's steam, in a country where steam-power was costly. It was not a question of superseding Calcutta as a port of commerce, but it was contended that Mutla would form a valuable auxiliary—like Birkenhead to Liverpool—and that by the route advocated the physical difficulties of the approach would be lessened, and the same point arrived at, only with diminished risk and greater economy.

In closing the discussion, it was remarked that there was not sufficient information relative to the physical features and the conformation of these rivers, to enable a proper discussion to be raised on matters specially appertaining to this Institution. With regard to the commercial part of the subject it should be said, that there was always great difficulty in changing the locality of an important commercial business. No doubt there were large establishments at Calcutta, with all the accessories for the trans-shipment of goods. Granting that the Mutla had all the advantages ascribed to it, a long and severe struggle would be made on behalf of existing interests, though it should not be treated as a hopeless affair, especially as it had been stated, and not denied, that the Mutla presented an unchanging channel, accessible at all times. As Southampton had been cited, it might be said that, although the heavy merchandise trade had not been drawn there, yet that port was resorted to by the trade requiring quick transit—mails and pasengers. In like manner, probably, the first trade to frequent the Mutla would be the mail steamers, for which speed was the main object, and in the course of time it might receive a share of the heavy trade.

Long Tube Barometer.—After the meeting, Mr. R. HOWSON exhibited in the library a Barometer, consisting of a long tube freely suspended open end downwards, a cistern which was of a tubular shape, and a "stalk." The stalk was a glass tube, sealed at both ends, attached firmly at its lower end to the bottom of the cistern, and rising axially up the tube until it nearly reached the surface of the mercurial column. The consequence of this arrangement was, that the top of the stalk came into a region of very low pressure, and there was an excess of pressure tending to force the cistern upwards. This excess was represented by the weight of the cistern (and stalk), and the contained mercury, so that under a given atmospheric pressure, the cistern would always hang suspended at a given level. When the preassure of the atmosphere rose, a portion of mercury left the cistern and passed into the tube, and the cistern also rose, until the level was replaced by the immersion of the glass which formed the tube. When the pressure fell, the converse took place. An elongated scale was thus produced, the extent of range being dependent upon the relative areas of the tube, and of the glass which composed it. The action might also be simply viewed as that of a long piston, or plunger, with a liquid packing, having a vacuum on its upper side, and a self-graduating weight attached to its lower side.

J. R. MCCLEAN, Esq., Vice-President, in the Chair.

Nov. 26, 1861.—The paper read was "*On Measuring Distances by the Telescope.*" By W. B. BRAY, M. Inst. C.E.

The author's attention was attracted to this subject by a paper by Mr. Bowman, read before the British Association in 1841; but it required further investigation and modification to bring it into a form of practical utility. He found that it was convenient to have two distance hairs on the diaphragm of the level, one about $\frac{5}{10}$ of an inch above the level hair, and the other as much below, so as to read 1 foot on the staff at 1 chain, and 10 feet at 10 chains. Since, however, in focussing the instrument to any object, it was necessary to bring the cross hairs into such new focus, which was proportionally further from the object glass as the object was nearer, the angle which the hairs subtended from the centre of the object glass must be variable, diminishing as the distance was diminished. Hence a correction was necessary, and this the theory of refraction by lenses furnished. It showed that the error was constant at all distances, amounting in every case to the focal length of the object glass for parallel rays. This constant was to be added in reading the staff, by bringing the lower cross hair near any even division of feet, but exactly ·02 of a foot above it, corresponding with the two links from the centre of the instrument to the anterior focus, in the cases of a 5-inch theodolite and 10-inch level. Then, by reading the upper distance hair, and deducting the even number of feet at the lower hair, the difference was the distance in chains and links. If the compass was sufficiently delicate, any operation of contouring, or running trial levels, could be performed with rapidity and accuracy. When provided with the two distance hairs, the level of the ground could be taken above and below the ordinary range of the instrument. The use of these distance hairs for eighteen years had proved their practical value. In taking the widths of rivers or deep ravines, distances of 20 chains had been read in favourable weather; and when the hairs were accurately fixed on the diaphragm, they might be used even for fractions of a link, in taking widths incapable of direct measurement.

When applied to a theodolite, they could be used for measuring distances on sloping ground. But in that case, since the line of sight was no longer perpendicular to the staff, a correction was necessary, for which a table was given, showing the angles of elevation of the various heights which were simple fractional parts of the horizontal distance. When the horizontal distance to the staff had been ascertained, the theodolite was to be elevated to the tabular angle corresponding to the fractional rise nearest to the slope of the ground; then that fraction of the horizontal distance, less the reading on the staff, would be the correct rise. With the theodolite it was convenient to have another set of hairs for reading the distance in feet as well as in links. In clear weather, with a distinct reading staff, a distance of 40 chains had been read between the foot and link hairs.

In the course of the discussion it was remarked that the arrangement described by the author was of a much earlier date than had been mentioned. Possibly its application might hitherto have been limited, from the want of a correction for the errors introduced in focussing the instrument, which had now been supplied. Reference was made to the micrometer arrangement of the diaphragm of Mr. Gravatt's original dumpy level. This system of measuring distances had lately been applied to rifle practice, and for military purposes generally it was thought that a micrometer telescope could be relied on for distances up to 12 or 15 miles. It had also been employed for determining the speed of vessels at sea, when the exact length of the vessel was known, as well as for other purposes.

It was observed that the great improver of instruments of this kind was M. Porro, an officer of engineers in the service of Piedmont, a detailed account of whose "Instruments pour les lèves de plans" was given by M. H. de Senarmont in the *Annales des Mines*, 4th series, vol. xvi. (1849). None of the modifications in M. Porro's instruments had been introduced into this country, and yet with his micrometer scale of wires the staff could be read off in metres at once—and, it was stated, at a distance of 800 metres the error did not exceed 2 centimetres.

Dec. 3, 1861.—The paper read was "*On the Discharge from Underdrainage, and its effect on the Arterial Channels and Outfalls of the Country.* By J. Bailey Denton, M. Inst. C.E.

This paper contained deductions from a series of experiments made at Hinxworth, to ascertain the relative fall of rain on the surface, and the discharge of water from the under-drains. The experiments extended from 1st October 1856, to 31st May 1857. They were made on fields containing about 100 acres, in equal proportions of the two descriptions of soil into which the agricultural land of Great Britain requiring draining might be divided, viz.: The surcharged free or porous soils, and the absorbent retentive soils, though incorrectly called "impervious clays." A description was then usually given of the lands experimented upon, as well as analyses of the soils. Also tables, which had been published in the 'Journal of the Royal Agricultural Society,' vol. xx. (1860), showing the daily rainfall, the discharge of water from the drains, the height of the barometer and thermometer, and the temperature of the soil at 18 and 42 inches respectively below the surface.

The whole estate was drained by one connected system of works; but the mode of draining necessarily differed. Thus, the "free soils" were drained by occasional and wide drains from 4 to 8 feet deep, at a cost varying from £1 10*s*. to £3 10*s*. per acre; while the "gault clay" was drained uniformly by a parallel arrangement of drains 25 to 27 feet apart, 4 feet deep, at a cost varying from £5 10*s*. to £6 10*s*. per acre. In the latter case, the number of drains was increased to a maximum, the object being not only to remove excess of wetness, but to promote the aëration and disintegration of the soil.

It was remarked that the average annual rainfall in the district was 24 inches, which had not been exceeded in the three years preceding the experiments. The greatest fall in twenty-four hours, during the eight months from October to May, was 0·542 of an inch, and the total fall was 10·045 inches, while the average fall over the same period amounted to 13 inches.

After some general remarks as to the time when under-drains commenced discharging, and upon the condition of the free soils and of the clays at Hinxworth prior to under-draining, the author proceeded to consider the effect of that operation. On the "free soils," and in fact on most of the mixed soils, it was observed that no water could run from the under drains until the water had been raised by descending rains to the level of the drains—which was not exactly the case with "clay soils"—and that as the surface springs rose higher and higher before draining, so the lowest drains would begin to run first, and as soon as the water bed of the whole area drained, forming an inclined plane, had risen by degrees to the height of every drain, the whole system would be at work, and not till then. The quantity discharged by the drains did not represent the whole of the infiltrated water, which included the water discharged by the drains; the water which gravitated to the outcrop springs; and the moisture which rose from the subsoil beneath the drains by attraction into the soil above them, to be dispersed by evaporation at the surface. The quantity of water discharged by the surcharged "free soils" was rather more than two-thirds of the rain which fell on the surface, the actual quantities being 163,550 and 227,220 gallons per acre, or 7 and 10 inches respectively. This proportion had reference to the rainfall of eight months only. If the discharge of the whole year were compared with the rainfall, it would be found to be less than one-third, arising from the fact that while the discharge of the remaining four months was very trifling, the rainfall was 11 inches, or 250,000 gallons per acre. If the mean discharge for twelvemonths of the free and mixed soils were taken together, it would be found to amount to one-fourth of the corresponding rainfall, a proportion which would give 6 inches in depth, or 135,732 gallons per acre as the mean quantity of water discharged from such soils to the outfalls from under-draining, a result not inconsistent with the experiments of Dickinson, Dalton, and Charnock. This quantity was, for the most part, new water rescued from evaporation, and would, *pro tanto*, swell the ordinary flow of rivers.

It was stated that, under ordinary meteorological and physical conditions, the under-drains of the free soils would begin to discharge in the month of October, or the beginning of November, and those of the clay soils in the end of November, or the beginning of December. Thus, at Hinxworth, the drains from the clay soils did not commence to discharge at all till the end of November, by which time 3¼ inches of rain had fallen, or just sufficient to fill the inner pores of the soil, though the water had not risen to the height of the drains. After ceasing for a time, they commenced a continuous discharge early in January, when the water in the soil had risen to the height of the drains. The tables showed that as the character of the subsoil became more open and mixed, sudden discharge was lessened. It was when, by repeated rains, the clays had had their peculiar property of retention fully satisfied, and held within them as much in their drained condition as they were capable of holding, that they were in that state which fitted them to discharge the largest proportion of any subsequent rainfall in the shortest time. The total quantity of water discharged by clays annually was small compared with that discharged by free soils. The Hinxworth experiments showed it to be only 59,931 gallons, or about 2¼ inches, per acre. If this quantity were regular over the the discharging period, it would not materially affect the arterial system of the country. But as a large portion of the heavier rainfalls was immediately discharged when the soil was saturated to the extent of its capability, and when the free soils would be discharging at least 1000 gallons per acre per diem, and the rivers might be pre-occupied by their present natural supply, and by the waters that passed off the surface without entering it, another feature of importance presented itself.

The general results of under-drainage on the arterial water supply and outfalls seemed to the author to be—first, to render the surface more capable of absorbing the rain that fell upon it;—secondly, to lower the discharge of the upper surface springs in a slight degree;—and thirdly, to withdraw from the power of evaporation all the water which the under-drains discharged.

Upon the first result there could be no difference of opinion. If drained land were deeply cultivated, there would scarcely be any overflow from the land surface. But there were circumstances which must interfere with the complete absorption of which a drained soil was susceptible, and would prevent any very sensible reduction of the floods. Freshets, from such circumstances, would still prevail; though, as steam cultivation and deeper ploughing gained ground, a greater proportion of the rain would be admitted, and to a certain extent floods would be diminished.

With regard to the second result the deduction appeared equally clear. It had been shown by Mr. Charnock, in his Holmfirth experiments, which extended from 1842 to 1846 inclusive, that evaporation from an undrained soil, maintained in a state of saturation, was 8 inches more than the rainfall, while that from the same soil, when drained, was 5 inches less. The effect of under-draining upon the main perennial springs which supplied the rivers, was, therefore, to increase and not to diminish their flow, as had been stated; a circumstance considered of great advantage when viewed in relation to the increasing pollution of the rivers by the discharge of town sewage. Again, the beneficial effect upon vegetation of lowering the standing water-bed during the spring and early summer, when all vegetable life was in its most sensitive stage, could not be overrated. The Hinxworth experiments showed that in March, April, and May, the temperature of the drained soil was higher by 2° Fahrenheit than the undrained soil. As a further illustration of the evil of a shallow water-bed, it was mentioned that, during the survey for the drainage of the Test Valley in 1852, a violent storm occurred, which blew down many trees. It was then found that the relative height of the several tree bottoms formed one line, or inclined plane, precisely agreeing with the water level throughout the length of the valley; and showing that the soil of that valley, and those of which it was a type, was maintained in a state of wetness very closely approaching complete saturation.

As regarded the third result, that under-drainage diminished evaporation and so lessened the rainfall, it was observed, that as Great Britain was surrounded by the ocean, a sufficient supply of water would be obtained from that source. Dr. Dalton had stated that in England the average quantity evaporated from a water surface was 44·43 inches, while Mr. Charnock showed it to be 35 inches at Holmfirth;—both in excess of the rainfall, with the quantity of moisture precipitated as "dew" added.

In conclusion, the hope was expressed that sufficient had been advanced to show that the tendency of under-drainage, as at present progressing, was to augment the ordinary flow of rivers at that period of the year when the soil was saturated to the extent of its capability, and that the time was not far distant when the subject of this paper would force itself upon the attention of the country.

With regard to the act of last session, which enabled the proprietors of the lower lands to remove mills, dams, weirs, and other impediments, under certain conditions, it was explained that these legal facilities, though they would aid in the removal of certain irremediable obstructions, did not involve any actual reduction of mill power in the aggregate. On the contrary, it was believed that, in a majority of cases, the point aimed at would be not the destruction of the mill, but the means of discharge into the mill-tail, and that many valleys would be divided into a series of smaller areas, feeding each other with increased water supply, by the actual process of draining.

Annual General Meeting.

Before commencing the proceedings the president said, that under ordinary circumstances he should have suggested to the members the propriety of adjourning the meeting, in order to testify their regret for the lamented decease of their honorary member H.R.H. the Prince Consort, and their deep sympathy with their beloved Sovereign and the Royal Family on their bereavement. As, however, the charter imperatively demanded the election of the council and officers on that evening, the council did not feel authorised in postponing the meeting, which would be restricted to the mere routine of the election.

In presenting an account of the proceedings of the institution during the last twelve months, to which the report was exclusively devoted, it was stated that they would contrast favourably with those of any previous year. The more than ordinary attendances at the meetings showed, that the subjects brought forward for discussion had equalled, even if they had not exceeded, in interest those of former sessions. The elections of members and associates had been as numerous, and as a consequence the abstract of accounts exhibited a very satisfactory result. Considerable additions had been made to the library, to which the attention of a special committee of the council had been closely directed.

The principal papers read during the session were then noticed; and it was remarked that many important works, some involving considerable novelty, had been executed by members of the institution both at home and abroad, which had never been described. It was therefore desirable that every acting and resident engineer, on the completion of any undertaking upon which he might have been engaged, should prepare a descriptive narrative of the progress of the works, of any peculiarities in their design, and particularly of any incidents that might have occurred during their construction.

With a view to encourage the production of really valuable original communications, in preparing the list of subjects for premiums for the session 1861-62, it was determined to offer pecuniary awards, not exceeding in amount twenty-five guineas each, in addition to the honorary premiums, for a limited number of papers of distinguished merit. Although five subjects had been specially selected, it was stated that other essays would be considered if of adequate merit. It was hoped that this would have the effect of inducing the presentation of many useful papers, not so much from the intrinsic value of the reward, as from the distinction it would confer on a successful competitor.

With regard to the library, it was stated that the application to the lords of the treasury for copies of the ordnance and geological maps of the United Kingdom had not been successful; the reason assigned being that their gratuitous supply had been discontinued in 1850, on the recommendation of the late Board of Ordnance, and that the Institution of Civil Engineers could not be made an exception to the rule. No steps had been taken for their purchase, as for the same sum, many books, atlases, and general maps could be obtained, which were likely to be more generally useful. The purchases already made included library maps of Europe (topographical and geological), of England, Scotland, Ireland, India, the United States, and Canada; and spaces had been left for maps of the World and of Asia to be added, as soon as the new editions now in hand were completed. Two comprehensive atlases and a few standard French and English works, especially to complete series hitherto imperfect, had been purchased. Much useful information had been procured, particularly from the continent, which would facilitate future purchases. Thus, there had been obtained, from the Ecole des Ponts et Chaussees a carefully prepared catalogue of works recommended by that school; from the Royal Institution of Engineers of Holland a marked list of the best books on water construction; and it was hoped that similar particulars would be shortly received from Germany and Italy. It was on all accounts desirable that the library should be unrivalled in its peculiar specialty; that it should contain copies of all treatises on engineering and the allied sciences, wherever published; and the co-operation of the members generally was earnestly solicited, to enable this to be accomplished.

The abstract of the acccounts showed that the amount received from subscriptions and fees was greater than in any previous year, and that the current subscriptions were now 50 per cent. in excess of what they where in 1851. During the year the Stephenson and the Miller Bequests had been invested in railway debenture stocks, and an addition of £900 had been made to the institution fund, so that the total investments now amounted to £12,194. 12*s*. 11*d*. The sums on deposit at the Union Bank, and the current balance at the bankers' raised this amount to nearly £15,000.

The amount of arrears of subscription due for 1861 was £241. 10*s*., and for 1859 and 1860, £89. 5*s*.; together, £330. 15*s*. Great exertions had been made to reduce the sums owing for previous years, and in some cases the arrears had been paid in full, while in others a composition had been made. But still the council had been under the painful necessity, "after suitable remonstrance," of erasing the names of one member, nineteen associates, and two graduates, from the register.

The deceases during the year were announced to have been:—Mr. Eaton Hodgkinson and General Sir Charles William Pasley, honorary members; Sir William Cubitt, Messrs. William Allcard, Samuel Clegg, Nicholas Harvey, Joseph Maudslay, John McVeagh, John Plews, James Ralph Walker, and John Ward, members; Colonel Robert Kearsley Dawson, R.E., C.B., Messrs. George Aitchison, James Braidwood, Charles Frederick Cheffins, Octavius Cockayne, Charles Cowper, Henry Alcock Fletcher, Lionel Gisborne, William Newton, John Pigott Smith, Edmund Treherne, and John Neville Warren, associates.

The number of elections had been 69, of deceases 23, of resignations 9, and of erasures 22; so that the effective increase of the year was 15, making the total number of members of all classes 945. It was mentioned that within the last quarter of a century the number of members of all classes had increased nearly four-fold.

In closing the report, the council urged that the success of the Institution depended a great deal more upon the individual exertions of the members, in support of its scientific character, than upon its pecuniary prosperity; and that it could not continue to hold the high position it had already attained without efforts and sacrifices being made by the present members, similar to those which were so unremittingly and so freely incurred by their predecessors.

After the reading of the Report, Telford Medals were presented to Messrs. W. H. Preece. G. P. Bidder, junior, and F. Fox; Council Premiums of books to Messrs. W. H. Preece, F. Braithwaite, G. Hurwood, and W. Hall; and the Manby Premium, in books, to Mr. G. Bidder, junior.

The following gentlemen were elected to fill the several offices on the council for the ensuing year:—John Hawkshaw, President; J. E. Errington, J. Fowler, C. H. Gregory, and J. R. McClean, Vice-Presidents; Sir William Armstrong, J. Cubitt, T. E. Harrison, T. Hawksley. G. W. Hemans, J. Murray, J. S. Russell, G. R. Stephenson, C. Vignoles, and J. Whitworth, Members; and Mr. John Cochrane, and Col. Simmons, R.E., Associates.

DE BATHE AND LYNALL THOMAS' ARMOUR-PLATES.

By Lynall Thomas.*

Having attended the discussion at the Institution of Naval Architects without having had an opportunity of taking part in it, I avail myself of this opportunity of exhibiting and explaining a method of affording resistance to the penetration of shot and shell into the sides of a ship, which may perhaps be worthy of your consideration, as I believe from long and earnest consideration, added to considerable experience, of the effect produced by shot generally, that the solid iron plate on a coating of timber, as adopted in the general service, is one of the worst which could be conceived. My chief reason for this opinion is, that the whole force of the blow coming at once upon the plate,

* Paper read at the United Service Institution.

its effect is felt instantaneously through the whole thickness of the plate in the direction in which the shot is moving. An immense thickness of metal is therefore required, and consequently an enormous weight upon the sides of, and strain upon the vessel generally; the joint efforts of which make the remedy almost as bad as the disease. With respect to the strength afforded by the wooden back, I have to observe, that in all my experiments I have found the wooden foundation to favour rather than prevent the penetration of the shot through the iron plate. There are several methods for preventing the penetration of shot or shell into the sides of a ship. 1st. By constructing these sides entirely of iron, thus opposing plates of solid metal to the impact of the projectile. 2nd. By sloping the sides in such a manner as to deflect the projectile. 3rd. By covering the sides with some substance which shall receive the first impact of the projectile, dispersing the force before complete penetration can take place.

The objection to the first of these methods is, that with the continual improvement in the means of attack, so great a thickness of metal would be required, that no ship could carry it without great detriment to her sea-going qualities.

With regard to the second method, namely, the sloping sides, the same objection holds good; for, although a less thickness of metal might be found sufficient to divert the blow of a shot when fired at ships thus constructed, unless under certain circumstances, yet such vessels must of necessity lie so low in the water, that in engaging land batteries or vessels much higher out of the water than themselves, the sides would be liable to penetration, unless the metal plates were of a thickness identical with those required for a vessel of an ordinary form, so that a still greater weight of metal would be necessary, inasmuch as more would be required to cover a sloping than an upright side, the surface being greater.

Up to the present time, I believe that the efficiency of the sloping side has only been tested with "round" shot, which are more easily deflected by the slope than flat-headed shot of an elongated form, for the following reason. The ordinary spherical shot only preserves sufficient force to penetrate an "ordinary" iron plate (*i.e.*, 4 inches) for a short portion of its flight. Consequently, unless at point-blank distances, it is useless to attempt to penetrate an iron plate with round shot. With a heavy elongated shot, however, this penetration could be accomplished from a greater distance. Now, supposing the gun to be fired with some elevation, the sloping sides would be rather favourable to penetration than otherwise, in proportion as the angle of the shot's descent approached that of the sloping side.

It has hitherto been a received opinion that the axis of an elongated shot remains always parallel to itself during the shot's flight, in which case its penetrative powers would be considerably decreased as the distance of the object struck increased. This however is not necessarily so. An elongated shot may be so constructed that its axis shall remain a tangent to the curve throughout the whole flight, so that such projectile will always fall point foremost on the object struck. This has been proved by experiment, in a manner which placed the truth of it beyond a doubt. In fact, I myself made the experiment with a 7-inch rifle gun at Shoeburyness.

What I have just stated shows that the thickness of metal for vessels constructed with sloping sides cannot safely be diminished. Should the vessel roll (and who can assert they will not, and that heavily) where will be the use of sloping sides? When the guns have to be worked on the top of the sloping sides, the effect of the ricochet of the broken shot, &c., from what may well be called an iron glacis, will probably be most destructive.

The third method, namely, that of dispersing the force of the shot before the latter has time to penetrate the sides of the vessel, appears to me to be the one likely to be attended with the greatest efficiency, convenience, and economy. The Warrior, and other iron-cased frigates, are examples of this principle in its most primitive form. These vessels have wooden sides, and to prevent the penetration of shot they are simply coated with plates of iron. The proposition to construct the sides of the vessel with iron, placing wood outside as a protection, is the same in principle, and would doubtless be more efficient in preventing the complete penetration of solid shot; but the facility with which a coating of wood, or indeed of any soft substance, would be destroyed by shells, puts this method out of the question. I entertained the above idea some time ago myself, but discarded it for the reason I have mentioned. With respect to the wooden vessel coated with solid iron plates, there appear to be several almost insurmountable objections to their permanent adoption. In the first place, it would appear to be necessary, after a ship of this description has been laying up for some time, that she should be stripped of her armour from stem to stern before she can be honestly pronounced fit for service again. Furthermore, in order to ensure the requisite protection, the iron would have to be nearly, if not quite, as thick as if she had no wooden sides at all.

The method which I have now to submit to the consideration of this meeting is one which I believe will be found better calculated to attain the desired ends than any of those I have mentioned. It is, I believe, quite a new idea, and consists of protecting an iron vessel with iron armour. This armour, to which we have given the name "louvre-plate," on account of its similarity to a louvre-board, or, what will be more easily understood by most, a "jalousie blind," is the joint invention of Colonel de Bathe and myself, and is the result of much careful consideration, coupled with some knowledge of, and experience in, the effect of heavy rifle projectiles.

The diagrams will show more fully the arrangement and disposition of the metal, and may be thus briefly described. Upon the sides, say $2\frac{1}{2}$ or 3 inches in thickness, of an iron vessel, are placed the plates one above the other in the manner shown, leaving an interstice between each which might advantageously be filled with

Fig. 1.

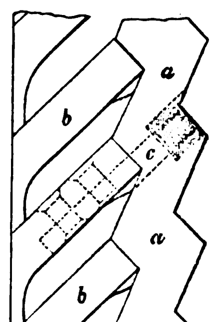


Fig. 2.

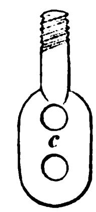
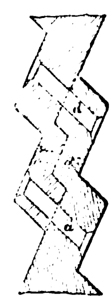


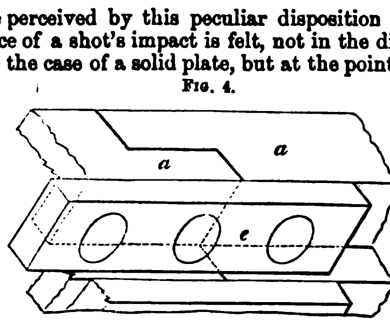
Fig. 3.



an elastic substance, such as New Zealand flax, junk, &c. In this instance the plates are supposed to be $2\frac{1}{2}$ to 3 inches thick, and the interstices $1\frac{1}{4}$ inch; but this, as well as the thickness of the plates, is arbitrary, and will depend entirely upon the size of the vessel and upon the relative protection which it may be considered desirable to afford her. By this means we get rid of a very large portion of weight; in fact, reckoning that of both the iron and wood in such ships as the Warrior, the weight would be over one-fourth less.

It will be perceived by this peculiar disposition of the metal, that the force of a shot's impact is felt, not in the direction of its flight, as in the case of a solid plate, but at the point above it, and

Fig. 4.



therefore the effect upon the hinder plate is enormously reduced. Very little solid resistance is offered to the first impact of the shot; but the quality of elasticity so largely possessed by iron is made subservient to resisting the effect of impact in a very great measure.

I would further draw your attention to several other advantages which this arrangement possesses in a high degree, one of which is the ease with which any damage may be repaired by means of spare plates; so much so, that a vessel may carry them and repair her damages at sea. Again, the effect caused by a shot striking the side is confined to a smaller space than is the case when a large solid plate is struck (more especially when the plates are not penetrated), since the whole plate, which may have a surface of 70 or 80 square feet, is affected by the blow. An elongated shot, from the unequal resistance which it would encounter upon its fore-end, would have its penetrating power very much more lessened in striking plates of this kind than in striking those presenting a surface offering a uniform resistance, from the greater ease with which the equilibrium of their axes would be destroyed. It will however, I believe, be found impossible to entirely prevent the sides of a vessel being penetrated by solid shot. There is a limit to the thickness and weight of iron which a ship can carry; but the limit to the weight of the projectile, and the force with which it can be driven, has not yet been reached. All we can at present hope to do is to prevent the penetration of the very destructive elongated shells which are now coming into use. The best course to be pursued, as it appears to me, would be first to ascertain what extra weight ships of each class could carry on their sides without much impairing their sea-going qualities, and then to distribute that weight of metal in the most efficient manner for her protection.

The experiments made upon the Trusty, as described by Capt. Halsted, although extremely valuable, I look upon as being far from a conclusive proof that that description of plate would afford so great a protection to ships as alleged. In this instance, single guns only were fired each time at her. Now, in order to form a correct estimate of the efficiency of these plates, or indeed of any method of protecting ships of war, the vessel experimented upon should be moored, or placed in a position where a large frigate could steam past her, delivering her broadside as in action. It is highly probable that the effect produced by two or three shots striking the same plate simultaneously would prove more destructive to it than if it were struck by them at separate intervals. Two or three broadsides of heavy guns well delivered, at a distance of 50 or 100 yards, might possibly from the sheer force of the concussion so damage or loosen her plates, that a few well-directed shots might suffice to place her at the mercy of her antagonist.

It has been stated that a solid 4-inch plate offers a greater resistance than four 1-inch plates placed apart—that the resistance, in fact, is as the square of the thickness; that is, in the case of the 4-inch plate, this resistance is as of 16, whilst with the four 1-inch plates it is only as of 4. This is perfectly true as regards the punching machine, or any similar continuously-exerted force, but quite erroneous with respect to a shot's impact. A punching machine of sufficient power to punch a hole in an inch plate will not only punch holes with equal facility through four, but through four hundred, if necessary; but a shot may penetrate an inch plate, and not be able to penetrate two placed one behind the other. One is a question of continued pressure on the inch, the other of impact and velocity. Solidity only would resist a large continuous pressure; but the effect of a shot's impact will be impaired by any diminution in its velocity; and the velocity may be diminished in various ways—in fact, it begins to be diminished the moment the shot leaves the muzzle of the gun.

I grant that, if these louvre-plates were placed under a punching machine of sufficient power, they would be penetrated much more easily than a solid plate of the same thickness, because, in the punching machine, time is of no account; but the time which would be required to bend these plates down is of immense importance in destroying the effect of a shot's impact, since it would cause the force of the shot to be rapidly dispersed in each direction.

Although, in the experiments which have been made against iron plates, the form of the projectile and the metal of which it should be composed are questions of great importance, I hold that they have engrossed an undue share of attention, and that scarcely sufficient regard has been paid to the force of propulsion. At short distances the form of the projectile is of small importance compared with the degree of force which is employed in its projection; thus, with a gun of a given weight, I believe it will be found to be of more importance in close action to employ a heavy charge of powder and a lighter projectile, than a heavier projectile and light charge of powder; for it must be remembered that it is the propelling force, *i.e.*, the charge of powder, which drives the shot through. Now, although the charge for rifled cannon is a comparatively limited one, because when exceeding a certain proportion the shooting becomes wild, yet at short distances, where great accuracy is not of so much consequence, a very heavy charge may be used with great effect. It has been proposed to increase the weight of projectiles employed against iron plates, diminishing the charge of powder. Now, were it an easy matter to penetrate both sides of an iron ship, this proposition would be reasonable; but in the present state of affairs it is altogether an erroneous idea. In support of what I have stated with regard to the effect of a shot's impact, I will quote a passage from Sir Howard Douglas's valuable work, "Naval Gunnery," page 77 :—

"If an oblong shot, twice the weight of a round shot of equal diameter, be fired with the same charge, the velocity of the former will be less than that of the latter, in proportion as the square root of the weight is greater; that is, the weight being as 2 to 1, the velocities will be as 1 to $\sqrt{2}$. But the effect of impact, measured by the volume of penetration, being as the weight of the shot and the square of its velocity, it follows that with equal charges the effect of the oblong shot will be just equal to that of a round shot of equal diameter."

From the above, therefore, it is evident that the charge of powder being constant, no additional weight in the projectile will increase the effect of its impact. The reason why the 68-pounder 95-cwt. gun has not yet been superseded in our naval service, lies in the simple fact, that a charge of 16 lb. of powder can be fired from it, and neither Sir William Armstrong nor Mr. Whitworth have been able hitherto to produce a gun capable of surpassing it on this point. With a view of beating the heaviest smooth-bores in the service upon every point, I have had a rifle gun constructed upon a principle of my own, from which a charge of 21 lb. of powder can be fired with perfect ease and safety, and with projectiles of any weight, from 120 lb. to 180 lb. or more, as may be deemed most advisable. It may, perhaps, have come to your knowledge that this gun has already been tried with very remarkable results, and a further trial is about to take place.

On the first occasion the charge was increased from 21 lb. to 28 lb. of powder, the projectiles being 175 lb. in weight. Nine rounds were fired, chiefly with a view to test the strength of the gun, and upon this, as indeed upon every other point, the result was most satisfactory. In order to try the gun (which I may here observe loads at the muzzle) to the utmost, three rounds out of the nine were fired at an elevation of $37\frac{1}{2}°$; two with 25 lb. and one with 28 lb. of powder. The range attained was very nearly six miles, and the penetration into the earth totally prevented the recovery of the shot, and could not be ascertained; the time of flight of these shot was from 37″ to 40″. No iron plate which has yet been placed on a ship's side could I think resist the impact of a shot from this gun at any distance within 2000 yards or more; and if Sir Howard Douglas's method of calculating the effect of the impact of shot be (as it doubtless is) correct, these shot would have the same force at any point within that distance, as that of a 68-pound shot when it first leaves the muzzle of the gun, since the mean velocity of flight in passing over a distance of 2150 yards was exactly 1200 feet a second, the time of flight being 5·31 seconds. I believe it is in contemplation to arm the Warrior and ships of her class with thirty-six 100-pounder Armstrong guns which are of about 4 tons each, whilst the gun I have mentioned is of about 6 tons. Now it appears to me that twenty-four guns of this description would prove a much more efficient armament than thirty-six of the Armstrongs, which have not shown much power against iron plates. There would be besides several advantages attending such a change. One of which would be, that two portholes only would be necessary where there are now three, and that in the future construction of this class of vessel the parallel sides would require to be of less length by 90 feet, since the same intervals only (15 feet) would be required for the purpose of working the guns. Those who heard Mr. Scott Russell's most interesting lecture at the Institution of Naval Architects will both understand and appreciate the suggestion.

But to return to the subject more immediately under discussion, I would remark that I believe no sea-going vessel can carry plates of any description which shall render her sides proof against the penetration of solid shot, and therefore that these vessels should only be protected as far as may be possible, without depriving them of other and vitally important qualities; and this, I believe, may be done in a manner to prevent the penetration of incendiary and explosive projectiles of a very heavy description, by some such distribution and arrangement of the metal as that which I have now the honour to introduce to your notice.

A powerful armament and great speed are matters of the very highest importance, and not to be lightly sacrificed; in fact, an iron-cased vessel wanting these qualities would present a mere inert target to a more active and better-armed opponent; and her certain capture and destruction would be simply a question of time. A ship of war is commissioned to "burn, sink, and destroy," and not simply to save herself fram being burnt, sunk, or destroyed. In conclusion, I would remark that having no experience in shipbuilding, but having had great experience in the effect of shot upon various materials, I have regarded the sides of a ship in this question in the light simply of a protection against destructive missiles, that is, in what manner the greatest protection can be afforded with the employment of the smallest possible weight.

The following is an explanation of the diagrams:—

Fig. 1 represents a transverse section of the side of an iron ship protected by the armour-plates, *a a* being the side or skin of the ship of a zig-zag form; *b b* the outer or "louvre" plates; *c* is the bolt which fastens the latter on to the former. The spaces between the louvre plates may be filled with some elastic substance.

Fig. 2 gives a front view of the bolt *c*.

Fig. 3 shows the manner in which the inside plates are connected one with another in a longitudinal direction, *ddd* being the rivets, which are placed at certain intervals apart.

Fig. 4 is a front view of the vertical joint, *aa* being the plates which form the side of the vessel, and *e* the plate which is placed at the back to strengthen them at the joint. This plate is also made fast with three rows of rivets.

In reply to various questions, Mr. Thomas stated that the gross weight involved in the proposed form would be one-fourth less than, and, according to the calculations of a well-known iron company, the expense about one-half (£25 instead of £50 a-ton) the expense of the Warrior,—that the saving would result chiefly from all the plates being rolled at the cost of about £8 per ton, whereas the Warrior's plates are very expensive, especially where there is tongueing and grooving,—that repairs could be made with great facility, without disturbing any but the injured parts. The width and thickness of the armour-plates would be adapted to the size and tonnage of the vessel; it will be impossible to give a small vessel a protection equal to that of a large vessel. The effect of the shot's impact is diverted, so that the blow upon the inner plate is not felt in the direction in which the shot is moving, but at a point above it, which considerably lessens the destructive effect. The spaces between the plates may be packed or not with some elastic substance, but the packing was objected to, as giving rise to the deposit of a great deal of moisture. The inside plates of iron, or skin of the ship, may be flat instead of a zigzag form, but the latter offers a better resistance to shot.

ON PHOTOGRAPHIC DISTORTION.*

By Robert H. Bow, C.E.

So many peculiarities of the photographic picture may be classed under this head that the term is very indefinite, unless it be understood to mean the total bad effect arising from the accumulated distortions of various kinds. Or it would be perhaps better to use the term in the plural number, and attach distinctive epithets to the several varieties of distortion. I here offer what is probably an incomplete list of the photographic distortions.

1.—We very frequently have an appearance of excessive enlargement of the nearer objects in a picture. This is more striking in the case of photographs of objects placed very near the camera, and taken with a lens of short focus. It consists of a perspective distortion arising from the distance from the eye at which the picture is held when inspected in the hand being far in excess of that distance with which the perspective is in accordance. Now, as portraits are most liable to this kind of distortion, and show it in a most offensive way, we may be allowed to distinguish it as the "portrait distortion."

2.—We have very commonly either a contraction or enlargement of scale at the margins as compared with the centres of photographs, producing the respective appearances called "barreling" and "pincushioning;" and as this is most observable in, and most detrimental to the value of, copies of plans and charts, we may particularise it as "chart distortion."

3.—We sometimes have a contraction of scale towards one margin of a picture, caused by the tilting of the camera. It is most frequently to be noticed in pictures including high buildings, the top of the picture having a contracted appearance, the result of an upward inclination given to the camera to enable it to embrace the higher objects. In copying a picture also this form of distortion may be produced, unless care be taken to have the axis of the camera so placed as to intersect perpendicularly the plane of the picture in the central point.

* Paper read before the Edinburgh Photographic Society.

4.—We have an undue width given to the high lights from their encroaching upon the neighbouring shadows. This is due to aberration of the lens and the use of too large a stop. The rays which are not brought to a perfect focus spread the effect of the strong light over a larger space. This distortion may be somewhat modified in magnitude by the length of exposure and the particular action of the chemicals employed.

5.—We have that variety of distortion pointed out by Sir David Brewster as affecting the images of small prominent parts of a body when taken with a lens of large unstopped aperture.

6.—We may note what, in some treatises on optics—as for instance Dr. Lardner's—is particularly called "distortion of the image," but this is perhaps better known by the better name of "curvature of the field."

It is to the two first varieties of these distortions that I mean to confine my remarks, viz., the portrait and chart distortions, and I shall chiefly dwell on the latter of these.

ON THE "PORTRAIT DISTORTIONS."

In the case of all pictorial representations into which perspective enters there is, for each picture, a certain point at which the eye should be placed in order that the apparent relative distances and magnitudes may be all correctly given. The truth of this, though known to all who have studied perspective, does not readily come home to us in a practical form, since the eye is so accommodating, or rather so little critical on this point, that a picture may be placed at a considerable range of distances from the observer without the ensuing incongruities of the perspective becoming offensive in amount. I speak thus in reference to the productions of our best masters in painting.

Another order of things, however, was established by the introduction of the quick-acting portrait camera, with its short focus, and the accompanying necessary proximity of the person to be operated upon to the instrument. Yet the distorted appearances which we find in the productions of such a camera, and which have in the public mind been attached as distinctive characteristics of photographic portraiture, are only exaggerations of a defect which is attached to every picture.

When a picture is looked at from the proper point of view the image in it of any object subtends the same angle at the eye as the object itself would do were it seen direct. But the error committed in taking photographs of near objects is, that the proper point of view for the photograph is at far too short a distance from it.

When a photograph is produced by a camera with a small unstopped lens, the proper distance at which it should be viewed to see it in correct perspective is identical with the focal length of the lens. Now this distance is frequently not above a third of that at which the photograph would generally be held when inspected in the hand. But, not to exaggerate, I will, in the following examples, speak of this focal length or proper perspective distance of observation as six inches, and the distance at which the photograph would generally be held when inspected in the hand, at double this, or one foot.

Let the objects of which we are supposed to take experimental photographs be two sticks or posts of equal and suitable lengths, placed 5 feet apart, measured in the direction of observation. Now let us first plant our camera at a distance of 100 feet from the further-off post, which we will consider the standard or undistorted one. Let the angle subtended at the distance of 100 feet by this post be represented by *a*, then the angle subtended by the nearer post will be $= \frac{100}{95} - a$.

Taking a photograph of these with an unstopped lens of small aperture, it is evident that, when this is held at the focal length of six inches from the eye, the angles subtended by the imaged posts will be the same as if actually looking at the posts direct. But the photograph would not be so held: it would we assume be naturally placed at a distance of one foot from the eye, so that the angles subtended by the imaged posts will be reduced to half their former values,* or become $= \frac{a}{2}$ and $\frac{a}{2} \cdot \frac{100}{95}$. We have now to inquire into what change these altered angles represent, and we shall arrive at the apparent distortion or change, by arranging

* It is not strictly correct, but sufficiently so for the present purpose, to say that the angles become of half their former values. They really become such as to have tangents equal to half the tangents of the original angles.

the actual posts so as to subtend these new angles at the eye; and this may be done in three different ways:— 1st. We may double the distance of each post from the camera, putting one 200 feet off and the other 190 feet: the accompanying effect of this would be to lengthen out the distance at which they are apart from 5 to 10 feet. 2nd. Retaining the distance apart of 5 feet we must place the standard one at 200 feet off, and lengthen out the nearer post to a certain degree, ascertained thus:—the angles we would have if we did not lengthen the nearer post would be $=\frac{a}{2}$ and $\frac{a}{2}\cdot\frac{200}{195}$, and the angles we want are $=\frac{a}{2}$ and $\frac{a}{2}\cdot\frac{100}{95}$; so that the length to be added to the nearer post $=\frac{a}{2}\left(\frac{100}{95}-\frac{200}{195}\right)=\frac{1}{74\cdot2}=$ 0·01344, its length being taken as unity: the increase of length would therefore amount to only about $1\frac{1}{3}$ per cent. The third method of bringing about the change in the angles is by a partial adoption of each of the above expedients, and this, as we shall more particularly point out, is the actual change which the picture represents.

From the above example we see that for such objects placed at so great a distance from the instrument the amount of apparent perspective distortion is very trifling, and far less than what would be required to strike the eye. But let us now take a more trying example. Let us produce the photograph of the posts with the camera only 10 feet from the further-off one; and let the angles under which they are seen direct, and their images seen at 6 inches off, be $= b$ and $b\ \frac{10}{5}$ or $2b$; these become in the photograph placed 1 foot off $=\frac{1}{2}b$ and b. To make the actual state of matters correspond, we must—1st, either place the posts at the respective distances of 20 and 10 feet; or, 2nd, placing the standard one at 20 and the nearer at 15 feet distant, we must lengthen the latter by an amount $=b-\left(\frac{1}{2}b\frac{20}{15}\right)=\frac{1}{3}b$, or $33\frac{1}{3}$ per cent.; or, 3rd, we must so far make both changes that their combined effect will give the requisite change in the angle subtended at the eye by the nearer post.

The effect produced upon the eye by the two first alterations of the positions or lengths of the posts are identical, so that the eye alone is not capable (in so far as perspective is concerned) of judging between them, or saying in what degree either form of distortion exists to the displacement of the other; and the judgment really formed will be very much directed by the character of the picture, and the ideas respecting it pre-occupying the mind. We may venture, however, to say that, in the case of an ordinary picture, the idea of enlargement of the nearer objects will predominate over that of their exaggerated separation from the background, since this makes a less demand upon the power of calling up the idea of relief. In some stereoscopic pictures, on the other hand, where the idea of relief may be exaggerated, the nearer objects will actually appear diminished as compared with the background or more distant objects.

All that need be said in regard to obviating this form of distortion is merely to repeat directions which have already been given by others—to avoid taking a photograph of an object with the camera placed too near it; or, when that is unavoidable, to use a lens of much longer focus than usual.

This form of distortion is peculiarly prominent in the case of portraits, but these are also liable to all the other varieties.

(To be continued.)

REVIEWS.

A Complete Treatise on Cast and Wrought Iron Bridge Construction. By William Humber, A.I.C.E., &c. Folio, 2 vols. (text and plates.) London: Spon. 1861. (Second notice.)

We have reserved for this concluding notice the consideration of the practical, and perhaps most important and useful, portion of Mr. Humber's work.

Under this head we may with propriety include the tables of the dimensions, weight, strain, and cost of various iron bridges. We extract, by way of specimen, the data of a few bridges: but the entire tables (comprising particulars more or less complete of between seventy and eighty bridges) will be consulted with advantage in the volume itself (see next page).

Assuming the correctness of the preceding figures, we remark that, for its scale of span, the Saltash (Royal Albert) Bridge is as remarkable for its cheapness as for its original and elegant design, the cost per foot forward being about £100, while that of the Britannia Bridge is £400. The Pimlico Bridge, consisting of wrought-iron arches, and having spans of but 175 feet, appears as costing very nearly as much per foot forward as Saltash, with its spans of 445 feet. The marvellous economy of the latter is partly due to the depth of truss employed, but mainly to the skilful adaptation of the suspension principle.

After the first of the tables on the strength of iron, mentioned in our former notice, we find the following remarks as to the influence of foreign ingredients on the quality of cast iron.

"In comparing the tensile and compressive resistances, we notice that there is not a constant ratio between these quantities, but, on the contrary, this ratio varies widely, and we find that with some specimens the resistance to crushing force is three times the tensile resistance, and in others the crushing strength is even seven times as great as the tensile strength; and between these two values are the ratios of the strengths of the remaining specimens. We have not deemed it advisable to encumber our space with chemical qualities of the various irons, but will now mention some of the characteristic constituents of some of the specimens now exhibiting well marked differences of strength. As the tensile and compressive resistances do not bear any constant ratio to each other, we must consider the effects of chemical constitution upon each separately.

We will first consider tensile resistance. We here find, as a general rule, that the ingredients which deteriorate the strength in the greatest degree are silicon, phosphorus, and sulphur, but there are some samples in the table which are actually stronger than some others containing less of these constituents. Of the effect of manganese we cannot certainly assure ourselves, as some experiments appear to be in its favour, whilst others give adverse indications, although the former are perhaps more marked than the latter. Let us select a few specimens for special consideration. Hæmatite iron, No. 1. F. P. has a strength of 14,233 lb., and the important foreign constituents are, manganese 0·11 per cent., silicon 3·02, phosphorus 0·06; and again, the Netherton iron, Nos. 4 and 5, exhibits a strength of 30,344 lb., and contains, manganese 0·27, silicon 0·83, graphite 3·03, sulphur 0·04, phosphorus 0·31, we may expect here an increase of strength on account of the diminution of silicon and graphite, the former most particularly; but, on the other hand, this iron contains a larger proportion of phosphorus than the preceding sample, and it also contains sulphur. The manganese is in excess, and it is a question which way this operates; if favourably, then the great strength of this iron is more readily accounted for. If we examine Nos. 3 and 4 of the hæmatite iron, we find that their respective strengths are nearly equal, while their constituents are as follows: the manganese is the same in both samples, the silicon is least in the second, which is a little the weaker of the two; the total amounts of carbon are very nearly equal, but in the second sample a small portion of it is combined; there is ten times as much sulphur in the second as in the first, but there is less phosphorus—three-fifths of the quantity; from this it would appear, that sulphur does not exhibit its effects in so great a proportion as phosphorus, for the difference of silicon is but small, and the sulphur in the first specimen is 00·1. and in the second 0·10, and the phosphorus in the first 0·05, and in the second 0·03. We observe another case of two irons, one having a tensile strength of 30,115 lb., and the other 30,334 lb.; though the former contains twice as much phosphorus, one and a half times the silicon, and more sulphur than the latter, which disadvantages *appear* to be compensated by a great excess of manganese, and a slight diminution of graphite.

With regard to the compressive strength, it will be advisable to compare the constitution of specimens of equal tensile resistances, or nearly so. In the case of two of the specimens, we find that one has a tensile resistance of 10,886 lb., the other 12,593 lb., while the compressive strengths are respectively 77,690 lb. and 56,119 lb. The first specimen contains only a trace of manganese, the second a considerable quantity; the first has twice as much silicon, less graphite, more sulphur, and eleven times as much phosphorus as the latter. From this example, and also from three or four others where the tensile resistances are not widely different, but varying inversely to the compressive, we are led to conclude that deterioration due to silicon and phosphorus is not so great for compressive resistance as for tesile, though a general examination of the table shows that an effect similar in kind, though different in degree, is certainly exhibited; we also find that for compressive strength the presence of manganese is not advantageous."

The following passage on the proportions of foreign constituents in various iron ores is also interesting—

"The nature of the metal employed will, of course, depend in a great measure upon the purpose for which the casting is required; it would therefore be useless to enter into this subject, but we will give a brief account of the properties of the irons made in various parts of the country, previously stating, however, that our information is

Dimensions, Weight, Strain, and Cost, of various Iron Bridges.

Name.	Description.	Length.		No. of Spans.	No. of Ribs.	Greatest Span.		Depth of Rib.		Rise or Versine.		Distance between Ribs.		Width of Platform.		Weight of Iron.	Strain per Sq. In.	Reputed Cost.
		Feet	In.			Feet	In.	Feet	In.	Feet	In.	Feet	In.	Feet	In.	Tons.	Tons.	£
Westminster	Arched rib	1160	0	7	15	120	0	2 / 1	7 / 10	20	0	5 / 7	2¾ / 9	83	0	3100	3·00	235000
Southwark	Do. do.	800	0	3	8	240	0	...		...		4	0	42	6	4585	...	384000
Vauxhall...	Do. do.	830	0	9	...	80	0	6	0	24	0	...		36	2	...	...	300000
Britannia...	Tubular	1511	0	4	2	460	0	30	0	...		...		14	0	9360	5·62	601865
Conway	Do.	424	0	1	2	400	0	25	5	...		...		14	0	2892	4·50	145190
Victoria, Montreal...	Do.	9500	0	25	1	330	0	22	0	...		...		16	0	10400	...	1350000
Crumlin	Triangular Girder	1800	0	10	4	150	0	15	6	...		9 / 6	0 / 0	26	0	...	...	27200
Boyne	Lattice do.	550	0	3	2	264	0	22	6	...		...		24	8	792	5·00	140000
Charing Cross... ...	Trellis do.	1365	0	8	2	154	0	13	6	...		49	4	67	4	...	...	160000
Saltash	Bowstring do.	2240	0	19	...	445	0	...		...		...		17	0	4000	...	225000
Pimlico	Arch do.	920	0	6	4	175	0	3	6	17	6	13 / 2	2½ / 0	30	9	1521	...	90000
Hungerford	Suspension	1353	0	3	...	676	6	...		50	0	...		14	0	...	...	98760
Fribourg	Do.	...		1	...	820	0	...		63	6	...		21	0	...	...	24000
Chelsea	Do.	704	0	3	...	348	0	...		29	0	...		47	0	...	...	88000
Niagara	Do.	...		1	...	800	0	...		...		...		24	0	...	...	80000

obtained from the published report of the experiments on cast-iron conducted in the years 1856 to 1859 at the Woolwich Arsenal.

The iron prepared from the ores of Whitehaven, Weardale, and those of the Forest of Dean, are remarkably free from phosphorus. This is due to the very high quality of these ores, which are almost entirely free from phosphoric acid; the considerable percentage of silicon contained in a great number of the ores is not so easy of explanation, but may perhaps be due to the use of hot-blast in the reduction of the iron. The products of the ores of South Staffordshire and South Wales are for the most part of excellent chemical quality. Out of twenty-six samples examined, only three occur in which the silicon amounts to 2 per cent. Out of thirteen examples from the Netherton and Old Hill Works, only seven cases occurred in which the silicon exceeded 1·15 per cent.

The proportion of phosphorus and sulphur in iron from the ores of these districts was also inconsiderable in the samples of iron which were examined: in only three out of the twenty-six samples did the sulphur amount to 1-10th per cent., and the phosphorus amounted to less than 0·5 per cent. in twenty samples; of the remaining six samples three contained less than 0·6 per cent; one from the Old Hill Works contained 0·63 per cent., and two samples from the Brierly Hill Works contained 0·64 and 0·72 per cent. The ores employed at the latter works contained somewhat higher percentages of phosphoric acid, the effects of which on the composition of the iron produced are therefore clearly traced. The percentages of the phosphoric acid in the ores used at the Old Hill Works are also higher than in those used at the remaining South Staffordshire Works, and its influence on the quality of the product is shown by reference to the composition of some of the iron from those works.

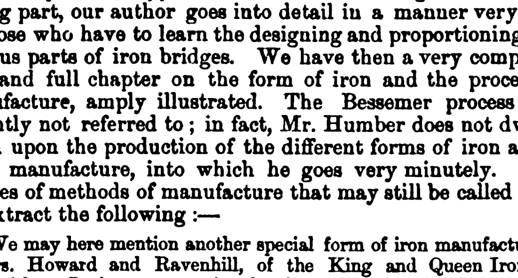
The oolitic ore and clay iron-stones used at the works in the North Midland and North Staffordshire districts, as also the ochrey-brown ironstones used at the Northamptonshire Works, contained proportions of phosphoric acid which are more considerable than those existing in the greater number of the other ores examined. Thus the ore employed at the South Bank Furnaces contains nearly 2 per cent. of phosphoric acid; that used at the Stockton Works contains upwards of 1·5 per cent., and very nearly the same amount exists in one of the ores in the Butterly Works, and in that employed at the Goldendale Works. The proportions of phosphorus in the various samples of iron from these sources exceed 1 per cent., except one sample from the Butterly Works, in which however it amounts to 0·72 per cent. The samples of iron produced from the Northamptonshire ores also contain more than 1 per cent. of phosphorus, the proportions of phosphoric acid in the ores are, however, not quite so high as those in the last alluded to, amounting to 0·84 and 1·03 per cent. The samples from the East End Works are stated to have been produced by the cold blast. The North Staffordshire ore used at the Goldendale Works contains nearly 1·5 per cent. of phosphoric acid, and the proportion of phosphorus in the iron produced from it just exceeds 1 per cent.

A general inspection of the results obtained from the examination of the ores and of the irons manufactured from them appears to justify the following conclusions:—The proportion of silicon in the iron is much less influenced by the constitution of the ores than by the conditions of smelting under some circumstances, among which may be included a deficiency of alumina in the ore of flux employed; an ore containing much silica is very liable to give rise to a highly silicious iron. The proportion of sulphur existing even in light grey pig-iron is never so considerable as to exert even appreciable influence on the properties of the metal, and none of the descriptions of British ores which have been examined contain an amount of sulphur sufficient to exercise any prejudicial effect on the irons produced from them. The proportion of phosphorus in iron is in a great measure due to the percentage of phosphoric acid in the ore employed, while at the same time it is probably to some extent regulated by the temperature at which the iron is reduced."

In the practical application of the formulæ given in the preceding part, our author goes into detail in a manner very useful to those who have to learn the designing and proportioning of the various parts of iron bridges. We have then a very comprehensive and full chapter on the form of iron and the processes of manufacture, amply illustrated. The Bessemer process is apparently not referred to; in fact, Mr. Humber does not dwell so much upon the production of the different forms of iron as upon their manufacture, into which he goes very minutely. As instances of methods of manufacture that may still be called recent, we extract the following:—

"We may here mention another special form of iron manufactured by Messrs. Howard and Ravenhill, of the King and Queen Ironworks, Rotherithe. It is necessary in the formation of links for suspension chains to make the heads of every link of such dimensions that they may be equally strong with the other parts of the bar, after the hole is bored for the insertion of the connecting pin. This was formerly accomplished by forming the links of round bars, the ends of which were bent round so as to form eyes which were completed by welding, but such welded joints are by no means to be compared with eyes that are formed in the rolling of the bar, and which is now accomplished by a method patented by the above firm. The principle upon which this process depends may be thus briefly described. Let AB and CD, Fig. 86, represent two strong rollers varying in diameter as shown; let a heated bar of iron, whose width is equal to that of the required link, be now passed between the cylinders in such a manner that its length is parallel to the axes of the rolls; then it is evident that the ends of the heated bar will be spread out, while the

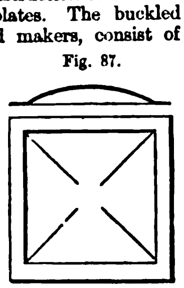
FIG. 86.



centre part remains unaltered; the bar is to be repeatedly passed between the rolls, which are brought nearer to each other before every passage, until the ends of the bar are reduced to the thickness of the heads of the required link, when the bar will present the appearance shown at *e f*; it may now be reheated and passed through a pair of roller bars, in order to reduce the central part of the bar to its required thickness and to extend the link to the proper length; it will then appear as shown at *g h*, having the extremities of the same thickness as the central part, but of greater width. By this mode of construction we have the same sectional area of head of the link after the hole for the connecting pin has been bored, as exists at the central part of the bar.

Another very great improvement in bridge construction consists in the invention of wrought-iron buckled roadway plates. The buckled plates, as commonly manufactured by the licensed makers, consist of square plates of wrought iron, very thin and slightly arched, with a very small rise, or curvature, from the springing at the edge of the plates in all directions to the centre, as shown at Fig. 87. Each plate is therefore a very thin and flat polygonal dome, or groined arch, the thrusts of an imposed load on which, in the direction of any two opposite sides, are borne by the tensile resistance of the outer portions of the adjacent sides of the plate. The flat margin circumscribing the plate is called the fillet. The resistance of square buckled plates, varies directly as the thickness of the plate, and inversely as the square of the line of bearing or distance between the supports. A buckled plate bolted or riveted down all round the sides gives double the resistance of the same plate merely supported all round, and if two opposite sides be wholly unsupported its resistance is reduced in the ratio of eight to five. Within the limits of safe load the resistance is nearly the same, whether the load be equally diffused or collected near the crown. The stiffness at any point of the plate as against unequal loading varies as the square of the thickness of the plate, and inversely as the curvature. The curvature (unless for some special purpose) should never exceed that which will just prevent the crippling load from bringing the plate down flat by compression of the material; less than two inches for the versed sine of the curvature has been found sufficient for a buckled plate four feet square and one-quarter of an inch thick.

Fig. 87.



The following remarks will give some idea of the actual resistance of buckled plates:—A three-foot square buckled plate of ordinary Staffordshire iron, one quarter of an inch thick, with a fillet two inches wide, and the total curvature amounting to one and three-quarter inches, supported only all round, requires nine tons weight, diffused over about half the surface at the crown, to produce failure, and double this, or eighteen tons, to cripple it if it be firmly bolted or riveted down all round its edge. A similar plate of soft puddled-steel will bear nearly double the weight, or thirty-five tons per square yard. The buckled plates used in the construction of New Westminster Bridge, each averaging seven feet by three feet, and being a quarter of an inch thick, were proved by lowering upon the crown of each a block of granite weighing seventeen tons, which did not produce injury; the plates have a curvature of three and a-half inches. In bridge-flooring the plates should only be subjected to one-sixth of the crippling load."

The practical section of the work concludes with a chapter on iron piers and foundations, in which we observe an account of Heinke's diving dress, and descriptions of the various methods of sinking cylinder foundations. These are, the open cylinder process, which may now be seen in progress at the Charing Cross Bridge, Potts's vacuum, and Hughes's air-pressure process, by which the excavators are enabled to work in the cylinder as in a diving bell. Screw piles are also noticed, and Mr. Brunlees' hydraulic method of sinking disk piles in sand is fully described.

The third section of the text consists of descriptions of the bridges illustrated in the volume of plates, and these descriptions and illustrations form, in our judgment, the most important and valuable, as they undoubtedly are the most attractive, portion of the work. The large scale of the engravings, and their full detail, render them especially instructive to the student or young engineer, and interesting to all. Those also who are desirous of reading specifications will find ample opportunity afforded them of doing so.

As a whole, the work is a very desirable addition to an engineer's library. We should be glad to see it in a second edition, because (as might perhaps be expected in so large a treatise) it seems in some respects not incapable of improvement, while there are parts that certainly require revision. Where original geometrical reasoning is essayed, the results (as pointed out in our former notice) are in some instances far from satisfactory. But, generally speaking, Mr. Humber's treatise does great credit as well to the industry of the compiler as to the competence of the writer.

The British Almanack for 1862, *and Companion.* London: Knight and Co.

Mr. Knight's "Companion" to last year's almanack, issued as an appendix to that just published for the present year, presents, as usual, a large amount of well digested matter on current topics. Thus the great national statistical event of 1861—the "Census"—is analysed at considerable length, and proves a very readable contribution, while that which promises (notwithstanding the Royal bereavement which the nation now so deeply deplores) to be the leading fact of 1862—the International Exhibition—is discussed in its several bearings upon art, manufactures, and commerce generally. The "Cotton Supply" too, present and prospective, an absorbing question in the existing crisis, receives its due share of attention, nor is the subject of "Popular Education" overlooked. In a second part we have as heretofore abstracts of important public acts recently passed, of which nearly forty are given; these include the Smoke Nuisance (Scotland) Amendment Act (June 7, 1861); the Commons Inclosure (July 22, 1861); Harbours (Aug. 1); Copyright of Designs (Aug. 6); and the Drainage of Land (Aug. 6). The "Abstracts of Parliamentary Documents" include finance, currency, trade, poor laws, colonial statistics, &c., to which are added a summary of the proceedings in parliament, a chronicle of occurrences during the past year, and other miscellaneous information, forming altogether an interesting and useful compendium for reference,

One constituent feature of the book is its annual architectural record of important public buildings completed and in progress, as illustrative of the state of art, progressive or otherwise, in the United Kingdom. First in this list is the New Foreign Office, and Mr. Scott's Italian design, which Lord Palmerston designates as one which, "although it may not be very magnificent or splendid, will be handsome enough for the purpose," and now immediately to be proceeded with, the houses which occupy a portion of the site being in course of removal.

"The alterations in the National Gallery, described at length in the 'Companion' of last year have been completed, and fully justify all that was there anticipated. The new room is of good proportions, though hardly wide enough to display properly pictures of the largest size. Without being as bald in appearance as the old rooms, it is quiet and chaste in the style of its ornamentation. As filled with the magnificent collection of the finest of our Italian pictures, the room has a most impressive appearance; but apart from the pictures, it must be pronounced successful. Further alterations and additions to the National Gallery have been rendered inevitable by the removal of the Turner pictures from the South Kensington Museum. By the terms of Turner's will his oil paintings were to be placed, within a certain time now nearly expired, in a room or rooms to be added to the National Gallery and called the Turner Gallery. Instead of this, rooms were, about three years ago, built for their reception at South Kensington. The legality of this proceeding having been questioned, a committee was last session appointed by the House of Lords to consider the whole matter. They met, received evidence, and reported that what had been done was wrong: that the pictures ought to be removed, and 'forthwith deposited and properly hung in one of the rooms of the present National Gallery, according to the plan which Mr. Wornum, the keeper, has stated in his evidence that he is prepared to carry out.' But as this is merely a temporary expedient, they recommend that steps should be immediately taken for erecting a permanent Turner Gallery, according to the plans of Mr. Pennethorne. The Turner Gallery of Mr. Pennethorne is only part of a larger design submitted by that gentleman, by which he proposes to increase the area of the present National Gallery from 20,000 square feet (which includes the Royal Academy) to 50,000 square feet, and thus afford ample space, not merely for the pictures at present possessed by the nation, but for the additions likely to be obtained for many years to come. For this extension, Mr. Pennethorne proposes to remove about half of the workhouse at the back of the Gallery, and to erect, partly over the adjacent barrack-yard, a suite of rooms, in such a manner that the ground-floor of it shall be built upon columns, so that it shall serve as a colonnade for the soldiers. The cost would be about 100,000*l.*, and it could be completed in about two years. Mr. Pennethorne proposes, however, to begin with the Turner Gallery, which would be about 136 feet long, would cost 25,000*l.*, and could be completed in nine months. The Government are understood to approve of this proposition, and application will probably be made next session to Parliament for the funds necessary to carry it into execution. The new buildings, being at the back of the National Gallery, and away from any leading thoroughfare, would not be of an ornamental character."

The International Exhibition comes in for a due share of recapitulation, and we are glad to endorse, as we believe the professsion will generally, the opinion that "in its present unfinished state, and, it must be confessed, also in the official drawings, the exterior bears a sufficiently unpromising aspect." But it must be remembered that it is desired, if it be retained as a permanent structure, to adorn the brickwork with polychromatic and terra-cotta ornamentation, which with its great mass may render it an imposing, if not a very magnificent structure. The great blots in the design are undoubtedly the two cupolas, which, placed at the extremities of so long and comparatively low a building, must have a tendency to overweigh and crush the centre; had the grand central dome been retained as originally proposed, the result might have been very different. Should the building be retained permanently it may be hoped that at some future time this great central feature will be added.

Among other public works to which reference is made may be mentioned the Westminster Crimean Memorial in the Broad Sanctuary, and the sculptural memorials of Wellington, Nelson, Havelock, Sir C. Barry, and Lord Herbert of Lea.

Several new churches, have been completed during the year, in London and its vicinity, the most remarkable in most respects being that in Garden-street, Westminster, by Mr. Street, which is thus commented on:—

"A marked feature of the exterior is the square detached tower which, like the body of the church, is of red and black brick with bands of stone. This, though Northern Gothic in detail, at once reminds us of the brick campaniles of Italy. Like them it has large and richly-ornamentd belfry windows (the somewhat stilted arches and trefoil cusps of which are decidedly Italian in feeling), and is finished with an elaborate cornice. Mr. Street has, in the upper part of this campanile, introduced in the centre of medallions, for the first time as far as we recollect, the small balls of coloured marble or granite which so frequently occur in Italian buildings, and in bright sunshine give such sharp sparkling points of light and shadow. The somewhat dumpy slate-covered spire, with the ugly little spirelets at the angles, is not only a very un-Italian (which would be no blemish), but a very awkward and inharmonious termination to what is else a very noble tower. The tower itself might, however, have been carried up as high as the top of the spire, and then crowned with some equally tall but less harsh and heavy terminal. The church, which stands in a dirty narrow street, and is surrounded by mean houses, would thus have made its presence known, whereas now it is scarcely seen from any part of the neighbourhood. The entrance to the church is through the tower, and this is connected with the north aisle by a short arcade or porch. Throughout the work is executed with the greatest care. The constructive colour and the ornamental are very vivid—too vivid, we think—but they harmonise well together, and are extremely effective. Mr. Street has, in this church, turned his studies among the mediæval brick buildings of the north of Italy to good account, without losing his own originality, or descending to direct imitation. He has produced at once an artistic and a conscientious work. Curious, perhaps, as a poor man's church, curious as a building constructed for the plain and solemn service of the Church of England; but undoubtedly, accepting the theory on which it is designed, as a building one of the most satisfactory and least commonplace, as well as suggestive, of the churches which have been erected in London for many years."

With the Westminster church is almost naturally associated that by Mr. Butterfield, now nearly completed in Baldwin's-gardens, Gray's-inn-lane. On the interior much praise is deservedly bestowed, but the effect of the exterior is described as "far from good,"—a decision with which we cannot agree. There is, to our mind, a simplicity, boldness, and dignity rarely to be found in modern buildings; nor do we object to the "ordinary" colour of the bricks of which the walls are mainly constructed. The interior, even in its unfinished state, is very fine. From its great length and width and unusual height, and the great span and height of the nave and chancel arches, it produces an impression of largeness of style and dignity, which nothing in the ornamentation has thus far had a tendency to lessen. The ornamentation is very elaborate. No expense is being spared in any part, the construction is throughout most solid, and for the decorations the choicest slabs of alabaster and Derby and Devon marbles have been selected. As in Mr. Butterfield's church in Margaret-street, there is no east window; the upper part of the east wall being panelled for the reception of frescoes, the lower being plated with alabaster, inlaid with patterns in black and coloured marbles.

Mr. R. Brandon's churches in Windmill-street and Knightsbridge elicit a modified commendation, in which we concur, for while they give evidence of considerable study and ingenuity, much of true Gothic feeling appears, nevertheless, to be wanting.

"Church restoration is epidemic. Wherever reparation has become necessary, what is called restoration is deemed a necessity also; and very often the restorer (or destroyer) is set to work where no repairs are required. We have been complained of for insisting on what is after all, it is said, a mere matter of taste. But it is really a good deal more. Besides the artistic error of replacing old work that has suffered from "the gnawing tooth of time" by new, and of removing the exquisite natural polychromy of centuries by the journeywork of scraping and chiselling, a constant object now in restoration is to sweep away whatever has been added since the Reformation, in order to restore the church to its original condition. The result is to destroy the historical character of the building, as that of the absurd cleansing and renovating process is to destroy its associations. By the double process we have a spruce new church, such as the architect of to-day might turn out to order in any quantity, instead of a building venerable in its time-worn garb, which the most instructed and the most ignorant alike gaze on with admiration and awe. This destructive restoration is commonly carried on most vigorously in our parish churches, the scene of the blundering, but less permanently injurious, church-wardens' 'beautifyings' in the days of our fathers and grandfathers. But its operations have by no means been confined to them. A month or two back we were horrified on visiting Lincoln Cathedral, in some respects the noblest of our mediæval remains, to see that its exterior is actually under a course of scaping and chiseling; and it is reported that a similar process has been carried farther at Winchester. As however, these proceedings, which appear not to be conducted under architectural supervision, have been strongly protested against by our leading architects and architectural associations, we may hope that they will not be persisted in.

Restorations of a more legitimate character, however, are going on in the cathedrals of Hereford, Lichfield, Durham, Llandaff, Worcester, and elsewhere, while improvements at Ripon and St. David's are in contemplation. What has been done at Bristol is not, we hear, altogether satisfactory. Chichester is about to rise, phœnix-like, from its ruins, and on its former model,—an extreme case of architectural *restoration*, if the word may be allowed.

"Hotel architecture," now so prominent a feature in our leading streets, and at our railway stations, is amply discussed, and an excellent engraving is given of the largest, and perhaps the most noteworthy, viz., the Grosvenor Hotel, Pimlico. Allusion is made to others at London-bridge, Piccadilly, and in various parts of the country.

On the whole, this lengthy article is well compiled and illustrated; and, in spite of a few errors which a professional eye will readily detect, may be accepted as an honest and impartial exponent of the subject on which it treats.

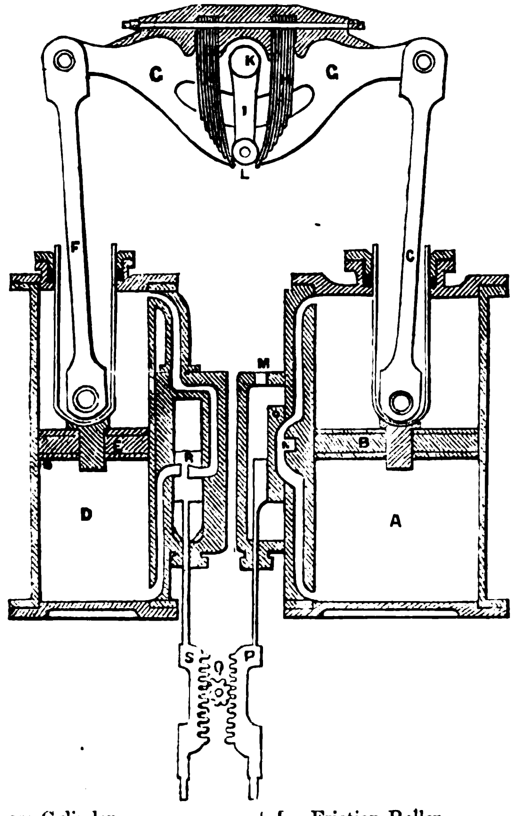
The Cathedrals of the United Kingdom; and *The Minsters and Abbey Ruins of the United Kingdom.* By Mackenzie E. C. Walcott, M.A. London: Stanford, Charing-cross.

The information placed now-a-days within reach of the tourist and other readers interested in our topographical history and antiquities, through the medium of guide books and similar publications, is something approaching to the illimitable. To the stores of this kind Mr. Walcott is a large and industrious contributor. If he were the producer of no other than the two works before us, they alone would entitle him to the fullest acknowledgement in this respect. It is to be regretted however, that, writing hurriedly from excess of work, he is not, occasionally, quite so correct an authority on some matters as might be desired, or as upon most he must be allowed generally to be. This is particularly apparent in the case of the first work we have named. Inaccuracies have here crept in, which doubtless owe their origin in a principal degree to a hasty throwing together of the matter collected and referred to. This especially applies to the heraldic descriptions. There are discrepancies and a confusion here in several instances. It is not always clear whether Mr. Walcott intends to give the arms as those of the deanery or the see, neither are they always in either case correctly blazoned. For instance, the arms given by Mr. Walcot to Bangor Cathedral are those appropriated by Berry and Edmonson, and also to the deanery; while those given by him to Bristol are the arms of the see, according to the same authority. For Canterbury, Mr. Walcott gives also the arms of the deanery, which are the same as the ancient priory, though it would appear as if he meant to describe those of the archiepiscopal see, since in noticing those of the archbishopric of Armagh, he says "arms the same as Canterbury." As respects York it would seem, though he differs in the blazon from Edmonson, that he intends again those of the deanery, for Willement gives as the arms of the present see, Gules, two keys in saltier, and a royal crown in chief, Or; the old archiepiscopal arms being the same as Canterbury and anciently of the other archbishoprics. For Chester the arms of the see are, on the contrary, apparently introduced—for Berry says there are no arms for the deanery, though incorrectly given according to Edmonson and Heylyn, who both give, Gules, three mitres labelled, Or; instead of Azure, three mitres, Argent. For Gloucester, the arms given do not appear to be either those of the see or the deanery, since for the former Heylyn gives, Azure, two keys in saltier patée fitchée, and Berry for the latter, Azure, on a fess, Or, three crosses of the first on a quarter of the second, the sun appearing in chief, environed with a demicircle wavy, Gules; on each side of the quarter a demi fleur-di-lis, conjoined to the side of the first, and as will be here seen a wholly different bearing. For Hereford, Or, five chevronels Azure, are given both by Berry and Edmonson as the arms of the deanery and the former, with Heylyn, gives for the see, Gules, three leopards' heads reversed swallowing as many fleurs-de-lis, Or, both differing altogether from Mr. Walcott. Again, for Worcester, Mr. Walcott gives, Argent, ten torteauxes, 3.3.2. and 1; on a canton, Azure, the Blessed Virgin and Holy Child, sceptred and mitred, Or. In this, as will be seen, the disposed numbers only make nine. For the deanery, which appears to be intended from the canton and charge thereon, the number should be twelve torteauxes, 3.3.3.2 and 1, and for the see, Argent, ten torteauxes 4.3.2. and 1. There are numerous other disagreements and parallel errors to this which it would have been better should have been avoided—and for the general reader it would certainly have been far more convenient that the plan which appears to have been adopted in the case of the Irish cathedrals, of giving the arms of the sees, should have been followed throughout, or at all events, that where this was departed from and those of the deanery intended, such should have been made clear. Want of space compels us to defer our concluding remarks on this, and notice of the second-named work, till next month.

TROTMAN'S STEERING GEAR.

The serious disadvantage attendant on steering by manual labour, even with the most perfect mechanical aids, is fully exhibited in vessels of large size, which has led to the suggestion of the application of steam to this purpose. Our improved naval tactics demand a more improved system of steering. A vessel should possess the power to steam backwards at the same rate, and with the same facility, as forwards; but that it is not so under the ordinary system of steering may be seen on our own small river boats, a second hand at the wheel being always required when any rapid movement is made astern involving a deviation from the straight course.

Fig. 1.



A—Steam Cylinder.
B—Piston.
C—Connecting Rod.
D—Hydraulic Cylinder.
E—Piston.
F—Connecting Rod.
GG—Cross-head.
HH—Spring-break set in Cross-head.
I—Lever attached to Rudder-shaft.
K—Rudder-shaft.
L—Friction Roller.
M—Inlet to Steam Chest from Boiler.
N—Exhaust to Steam Cylinder.
O—Slide-valve to ditto.
P—Valve Gear.
Q—Cog-wheel turned by the Steering-wheel.
R—Double-seated Break-valve to Hydraulic Cylinder.
S—Valve Gear to ditto.

In storms, the case of men being thrown overboard, and the helm becoming unmanageable for want of due power to control it, is not of uncommon occurrence. The duties of the steersman, particularly in large ships, should be more analogous to those of the engineer, in not having to perform manual labour, but to direct the vessel in her course.

The inventor had the benefit of the experience of the late Capt. Harrison, of the Great Eastern steamship, and of Mr. McLennan, her chief engineer, in ascertaining the requirements of the case, and the objections generally to machinery as an auxiliary in the hands of the steersman. The following are some of the requirements, and the mode in which they have been supplied, as stated by the inventor:—

Fig. 2.

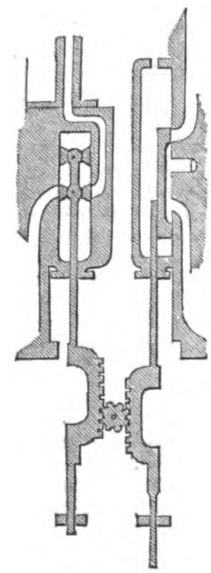
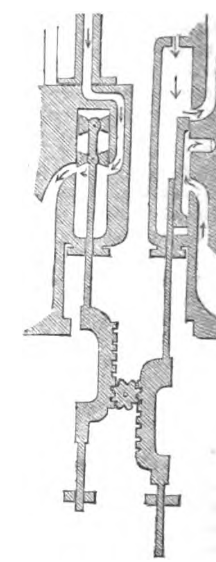


Fig. 3.



1st. A storm-wave striking the rudder while held by rigid machinery would inevitably carry it away. This danger is provided against by the spring break HH, Fig. 1.

2nd. It is necessary that the steersman should deliver the rudder over to its own free action at proper intervals. This is secured by the arrangement proposed, as when the valves are by the will of the pilot placed as in Fig. 1, the rudder is perfectly free to follow in the wake of the vessel.

3rd. The wheel has so long been the instrument in the hands of the pilot, that any system of levers (however effectual in regulating or controlling a power) would be rejected by pilots generally. This invention constitutes the wheel an integral part of the apparatus; so that the effect at present produced by manual labour can be secured by exactly the same movement on the part of the helmsman, with the absence of the labour now required.

4th. In steering a vessel (the steam not being up) the arrangement of this apparatus is such, that the ordinary system of hand-steering can be made available instantly by ungearing the steam apparatus and gearing the other.

The Spring Break.—The rudder-shaft is shown in transverse section at K, and has attached to it, at right-angles, the lever I. The rudder-shaft passes through and freely works in the cross-head GG; but is kept in a proper position by two powerful springs HH (fixed to the cross-head GG) acting on the lever I. In whatever direction, therefore, the cross-head moves, the rudder-shaft must move with it, on account of the lever I being retained between the two springs. The exceptional case, however, occurs when the cross-head is held rigidly by the cylinder, and the rudder is acted on by some undue force. Under such circumstances, the cross head remaining stationary, the springs yield to the lever I, and all return to their original position, when the undue pressure is removed.

The Steam Cylinder.—The steam from the vessel's boilers is the power employed to give motion to the rudder. The steam is admitted somewhat in the same manner as in the ordinary steam-cylinder, being introduced to the top or bottom, or entirely excluded at will, by means of a peculiar arrangement of the slide or D valve.

The Hydraulic Break.—This break consists of a cylinder and piston, supplied with a valve which opens or closes the thoroughfare from the top to the bottom of the cylinder. This cylinder being filled with water, the piston is only movable at the speed and to the extent permitted by the aperture made by opening the valve, allowing the water to circulate from top to bottom of the cylinder, or *vice versâ*. It will thus be seen that the two cylinders, being coupled by the cross-head, act one upon the other—the one finding the power, and the other regulating it. The positions of the valves in Figs. 1, 2, and 3, show the following course of action. Fig. 1: break valve open, steam shut off from boiler, rudder free. Fig. 2 shows the second position of the valves: the break valve is shut preparatory to the admission of the steam; and the still further movement of the valves shown in Fig. 3 admits the steam and opens the break valve to such distance as may be required; the reversion of the wheel at once shuts off the steam, closes the break, and frees the rudder, as in Fig. 1. The movement of the wheel in the opposite direction gives the reverse action to the machinery, as also to the rudder.

The inventor is Mr. Sanders Trotman, of Albert-street, Camden-town, London.

THE NEW STATION AT DOVER FOR THE LONDON, CHATHAM, AND DOVER RAILWAY.

(*With an Engraving.*)

The accompanying perspective view represents the New Station at Dover, now erecting for the London, Chatham, and Dover Railway Company, whose engineer, Mr. Joseph Cubitt, has availed himself of the architectural assistance and patented mode of construction of Mr. John Taylor, jun., architect, of Parliament-street, London; Mr. T. R. Crampton being the contractor. The general effect is that of great breadth and solidity; the Patent Facing Blocks being 14 inches by 6 inches, of a white brick or terra-cotta material, forming what may not inaptly be termed brick masonry. Colour is introduced by horizontal yellow bands and moulded brown stoneware drip bands, producing a novel and quaint effect, and affording, as may be seen by the diagrams, a most important protection. But it is the constructive and weather-resisting qualities which appear especially worthy of attention. It is well known that damp brick walls are caused by reason of the *through mortar joints*, and the absorbent nature of the bricks; but here we find, as will be seen in the diagrams given, the through joints intercepted. A complete change of material between the exterior and interior of the wall, and a continuous cavity or dry area immediately behind the external surface, rendering the wall warm in winter, and cool in summer. In good brickwork of the ordinary construction, great attention is paid to horizontal bond, but vertical bond seems scarcely to be thought of, and therefore we find walls strong enough for the required weight, but not stiff enough, hence the necessity for increased thickness. It will be seen that the courses of brick that bear upon the flange of the facing block cause it to act as a piece of angle-iron to the course of bricks above. The bond is alternate header and stretcher, or old English, and in combination with the dry area, produces the stiffest and lightest walls of the minimum thickness, giving economy in material and decreased requirements in the necessary foundations. The construction being thus far impervious to external damp, it only remains to prevent it rising up the walls by capillary attraction. This is done by the brown stone-ware damp-proof course, which combines in itself the advantages effected by the three following materials, viz., a three inch York slab to bed the foundations; a course of asphalte or slates in cement to suppress the damp; continuous gratings for the admission of air beneath the ground floor. A reference to the diagrams will show that it has perforations not only in itself, but through its joints, thus effectually cutting off all communication with the damp below. So complete is this, that a person standing on one side of the building and looking through the perforations may everywhere see what is passing on the other side. It has been proved to bear uninjured a weight of six hundred feet of vertical brickwork. On a future occasion we propose to give further illustrations of these important improvements in construction, as now extensively applied with good results, in the erection of churches, villas, and labourers' cottages.

NOTES OF THE MONTH.

Modelling Class at the Architectural Association.—In the course of last year's session of the Architectural Association, some of the members formed themselves into a class for the study and practice of architectural modelling, as we informed our readers at the time. This class has lately recommenced its meetings, with greatly improved prospects, and now assembles at the rooms of the Architectural Association, 9, Conduit-street, Regent-street, every Friday evening. The object is an admirable one, and has received the warm support of various friends of the association and of architecture; and a very large number of the members, including almost all the office bearers and members of the committee, have joined the class. Mr. A. W. Blomfield, M.A., president of the society, has been appointed president; and Mr. Ross is the instructor. This class offers an admirable opportunity for members of the architectural profession to acquire a knowledge of a very useful part of their calling, and one that is but seldom followed.

The Proposed New Bridge at Blackfriars.—The report made to the court of common council from the Bridge House Estates Committee, relative to the construction of a new bridge at Blackfriars, was printed on the 28th ult., for the use of the members of the common council. The bridge selected is the design of Mr. Page, and for grandeur of style and beauty will be worthy of the great city whose stream it is to span; the simplicity of its design is only equalled by its massive proportions. Provision is promised to be made for the traffic during the building operations, which are to be completed in two and a half years from the commencement, without even the erection of a temporary bridge, as has been the case at Westminster. The appendix to the report contains copies of the observations made by the engineers who have sent in designs, affording a large amount of useful and valuable information on the subject. We have already given in this Journal a detailed description of Mr. Page's design.

The Cathedral of St. Stephen, Vienna.—During the repairs and restoration of the cathedral of St. Stephen, at Vienna, important tracings of gilding and fresco painting have been found on the vaulting of the nave and choir; with which the entire building was once covered in the interior; but subsequently daubed over by a coating of grey wash. The three large windows which the municipality furnish will be ready immediately.

Sydney Houses of Parliament Competition,—Twenty-one designs were tendered in this competitiom, as our readers have already been informed. The commissioners appointed to decide on the awards selected six designs as being the most eligible, and directed the colonial architect to report upon the plans. Since he did so the commissioners have had one meeting; and the next mail for England will probably bring the names of the successful competitors. The following are the mottoes of the six designs selected as the most eligible:—"Palladio," "Hora e Sempre," "I bide," "Fide et Virtute,' "Follower of Wren," and "Sic fortis Etruri crevit."

The Cathedral of Worms.—The committee for the restoration of the cathedral at Worms have, according to their published accounts, spent, in the preceding twelve months, 12,964 guilden; and have, with this sum, entirely repaired the eastern cupola, which was much dilapidated. The interior of the middle nave has had its roof well underpinned, and the entire roof has been gone over, and wherever needed put into substantial repair.

New Iron Bridge, at Northenden, Cheshire.—The ferry-boat in use on the Mersey at Northenden is now superseded by a lattice girder foot-bridge, erected at the expense of Mr. Tatton, of Withenshaw Hall. This structure consists of two wrought-iron lattice girders spanning the river, which is 83 feet wide at this point. The girders are of ornamental design, 88 feet long, 6 feet deep in the centre, and 2 ft. 6 in. at the ends, and are placed 6 feet apart: the footway being composed of cross timbers and planking. Each end of the bridge is supported by a cluster of four pile columns, 8 inches diameter, driven 15 feet into the earth. The upper parts of the girders are connected in two places by cast-iron arches. At one of these arches there is an iron lattice gate. The footpath is carried from the ends of the girders to the top of the banks by iron beams and planks, and there are ornamental iron railings at the sides. The whole has been designed, constructed, and erected by Messrs. Edward T. Bellhouse & Co., of Manchester.

CLASSIFIED LIST OF PATENTS SEALED IN DEC. 1861.

*During the year 1862 a classified analysis will be given in this Journal of the Patents provisionally specified and sealed under the authority of H. M. Commissioners of Patents.**

1388 Arbuckle, G. V. B.—Armour coating for ships, fortifications, &c—June 3, 1861
1403 Braam, J. A. V.—Ordnance, and barrels of fire-arms—June 4
Manceaux, F. J.—Breech-loading arms and projectiles—June 5
1541 Page, T.—Working and discharging ordnance under water—June 15
1873 Bourne, J. F.—Construction and equipment of batteries—July 26
1452 Lancaster, C. W.—Sheathing for vessels—June 7
1621 Clark, W.—Propelling vessels—June 25
1811 Johnson, J. H.—Capstans and windlasses (com.)—July 18
1557 Walker, R.—Propelling vessels—June 18
1614 Moor, R.—Constructing and propelling vessels—June 24

1442 Harlow, R.—Fire-bridges and tubes of steam boilers—June 7
1463 O'Hanlon, P.—Marine and land steam boilers—June 8
1472 Armstrong, R.—Marine steam boilers—June 10
2654 Johnson, J. H.—Preventing encrustation of boilers (com.)—October 23

1450 Leopard, W.—Railway brakes—June 7
2571 Dixon, J., and Clayton, R. Railway wheels October 16
1465 Rymer, J.—Permanent way of railways—June 8
1579 Bousfield, G. T.—Brakes for railway cars—June 19
1757 Adams, W. B.—Locomotives and trains—July 12
1657 Lane, M.—Permanent way of railways—June 28

1399 Thomas, D. W.—Centrifugal machines (com.)—June 4
1499 Walker, W. H.—Floating hydraulic lift—June 12
1633 Mennons, M. A. F.—Caloric engines (com.)—June 26
1555 Miller, J.—Rotary engines—June 18
1643 McNaught, W.—Frames for diagonal steam engines—June 27
1693 Spencer, J. F.—Steam engines—July 3

1601 Hobson, W.—Steam hammer—June 21
1602 Hobson, W.—Steam pistons—June 21

1534 Kennard, H. J.—Excavating sand and gravel under water—June 15
1665 Clark, W.—Excavating machinery (com.)—June 29
1488 Stevens, C.—Crushing and pulverizing machine (com.)—June 11
1625 Stevens, C.—Brick-making machine (com.)—June 25

1402 Hancock, J. L.—Agricultural implements, &c.; and
Hancock, F. L.—Condensing engines—June 4
1409 Williams, J. A.—Steam agricultural implements—June 4
1521 Gregory, F.—Hay and chaff-cutting machines—June 13
1526 Bayliss, W.—Chain harrows—June 13
1528 Wedlake, T. W.—Hay-making machines—June 14
1667 Bragg, J.—Reaping and mowing machines.—June 29
1533 Leach, G.—Agricultural implements and steam-boilers—June 14
2617 Cambridge, W. C.—Harrows—October 19
1735 Priest, A., and Woolnough, W.—Machinery for drilling and hoeing—July 9
1628 Fowler, J., jun.—Steam-ploughing machines—June 25
1859 Gedge, W. E.—Drying and cleansing grain (com.)—June 20
1562 Gibson, A. W.—Barley and rice mills—June 18

1397 Prince, A.—Manufacture of gas (com.)—June 4
2504 Evans, F. J.—Generating gas—October 7
1669 Livesey, W.—Wet gas meters.—June 29
1453 Clarke, J. F.—Apparatus for regulating the supply of fluids—June 7
1762 Machwitz, ——.—Taps, or stop-cocks—July 13
1528 Summerscales, J.—Gas singeing apparatus—June 14
1581 Harris, W. J.—Dry gas metres (com.)—June 19

1640 Cowan, J.—Reburning animal charcoal—June 26
1646 Smart, J. C., and Aitchison, A.—Manufacture of charcoal—June 27
1636 Clark, W.—Distillation of combustible matters (com.)—June 29
2202 Bodmar, L. R.—Distilling apparatus (com.)—September 4

1508 Calland, J. A.- Electrical piles June 12
1512 Jobson, R.—Supports for telegraph wires—June 12
1800 Brook, Sir W.—Insulating telegraph wires - July 17
1539 Potts, F.—Supports for telegraph wire—June 15

1395 Hargreaves, S., Holden, R., and Holt H.—Apparatus for sizing warps or yarns—June 4
2867 Tongue, —.—Dressing fibrous materials—September 21
1403 Holdsworth, J. H. - Machinery for finishing piece goods - June 4
1427 Hamilton, T. and Hamilton J.—Cop tubes - June 6
1447 Wood, W.—Improvement in weaving-looms - June 7
1677 Paignon, J. P. E., Vandaux, J. M., and Gaguiere, G.—Pattern cards for Jacquard machine—July 2
1805 Elliott, A.—Improvements in looms—July 18
1458 Worrall, J. M —Dressing surfaces of cut pile and looped fabrics - June 8
1531 Langlade, P.—Tapestry and other weavings - June 14
1804 Tawell, S. - An addition to selvages of woven fabrics - July 18
1477 Mason M. - Flyers and spindles June 10
1520 Illingworth J.—Apparatus for sizing houses, &c.—June 13
1495 Smith, R. W.—Manufacturing looped fabrics—June 11
1505 Mason, H. - Spinning machinery - June 12
1522 Cook, S., and Hacking, W. H. - Plaiting or folding woven fabrics—June 13
1535 Pitfield, R. W. - Self-acting mules - June 15
1778 Topham, A. J. and J —Manufacture of lace—July 15
1918 Weight J.—Machinery for carding cotton (com.)—August 2
1556 Tiffer, F.—Carding cotton—June 18
1568 Dunn, J.—Spinning machinery—June 18
1568 Webb, T., and Craig J.—Ditto ditto
2204 Bayley, J. K.—Spinning machinery—September 5
1637 Higgins, J.—Ditto ditto - June 26
1609 Ormerod, R.—Fancy ribbons—June 22
1547 Mellowdew, T. - Dyeing velvet and other fabrics - June 17
1599 Harding T. R. - Carding machines - June 21
1615 Ferrabee, J.—Twilling machine - June 24

1352 Ronald, J.—Manufacture of cord, line, and other cordage—May 30

1507 Watt, J.—Pulping vegetable fibre—June 12
1822 Henry, M.—Improvements in paper pulp (com.)—July 19
1604 Le Harivel, A. L.—Papier mâché—June 22
1418 Nickols, D.—Paper cutting machinery—June 6
1674 Spence, L. H.—Paper bags and envelopes (com.)—July 1
1543 Gray, T.—Bleaching rags and fibre—June 17
1548 Routledge, T.—Manufacture of paper—June 17

1420 Coles, H. T.—Locks, bolts, claws, and grapplers—June 6
1455 Whines, J.—Spring boxes and hinges—June 8
1672 Potts F., and Cox, R.—Machine for cutting and piercing iron—July 1
1549 Clark, W.—Mica letters (com.)—June 17

1421 Salt, J. C. B.—Plates or surfaces for names or devices—July 11
1510 Napier, J.—Stereotyping—June 12
1590 Lesueur, A. N.—Panels of ceramic ware—June 20
1619 Lafon, J.—Chromolith impressions on glass or pottery—June 25

1524 Blackburn, B.—Lubricating axle-trees—June 13
1421 Mirimonde, L. J. P.—Lubricating axle-boxes—June 6
1542 Simpson, H. C.—New vehicle or car—June 17

1511 Walmsley, D., and Rostron, J.—Hoists for mills and warehouses—June 12

1482 Hawdon, M.—Moulds for casting metals—June 10
1715 Josling, T. T.—Bolts, rivets, and screw blanks—June 18

1718 Wilson, T.—Spanners and screw wrenches—July 6
1407 Standfast, S.—Substitute for brick and stone—June 4
1884 Amos, C. E.—Machinery for dressing slate—July 27
1653 Graham, J. W.—Machinery for shaping and dressing stone—June 28
1546 Lewis, J.—Machinery for cutting and boring wood, &c.—June 17
1523 Duncombe, Hon. C.—Machinery for sawing wood, &c.—June 13

1714 Roughton, L.—Apparatus for extinguishing fires - July 5
1545 White, D. B. Gauges for indicating depth and height of liquids - June 17
1670 Dingwall, W.—Fluid meters—July 1
1616 Howson, R.—Barometers—June 24
1570 Dixon, J.- Water-closets and cocks—June 18

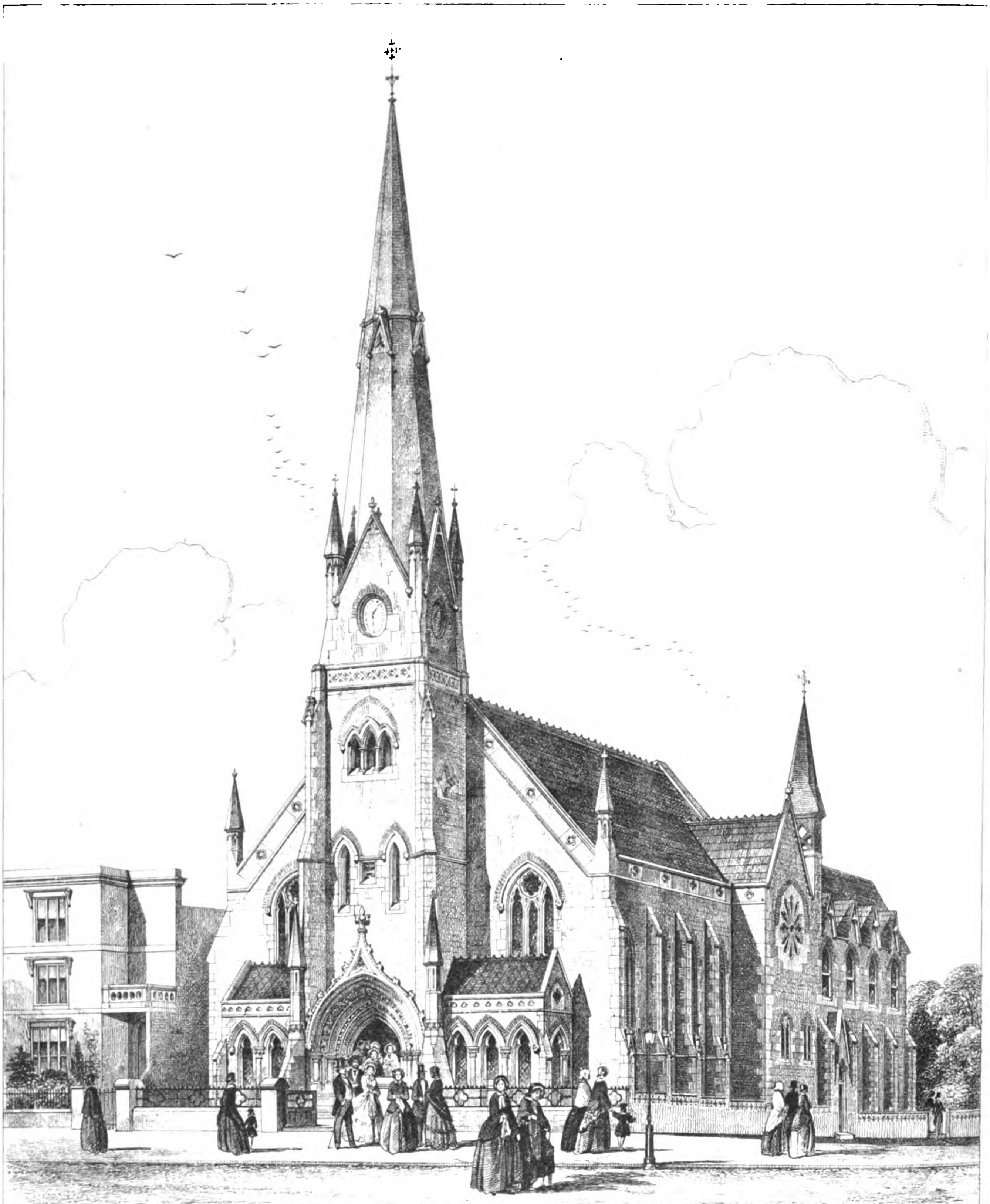
1645 Hamer, H.—Chimney tops - June 27
1504 Durrant, J.—Chimney tops - June 12
1588 Stevens, C.—Smoke-consuming furnaces (com.)—June 20
1592 Hodgson, C.—Fuel from peat - June 20
1503 Hodgson, C.—Drying peat in the bog - June 20

1611 McArdle, J. S.—Product from seaweed—June 22
2526 Schwartz, J.—Manufacture of sugar—October 9
1448 Croll, A. A.—Manufacture of sulphate of alumina—June 7
2540 Kernott, C. N., and Rucker, M. D.—Manufacture of ammoniacal salts—October 11
2707 Bennett, F. Manufacture of spelter October 29
1473 Brown, A.—Obtaining fresh water at sea—June 10
1671 Johnson, J. H.—Bottling aerated liquids (com.)—July 1
1493 Hughes, E. T.—Extracting oil from seeds- June 11
1580 Williams, J. F.—Compounds of india-rubber, gutta percha, and other substances—June 19
2482 Ghislin, F. G.—Compounds of india-rubber and certain vegetable substances—October 4
1600 Henson, W. F.—Floor cloth manufacture—June 21
2500 Calcott, W. - Apparatus for scenic effects—October 7
1400 Floyd, W. R.—Fastening or supporting knapsacks or packs—June 4
1514 Swan, C. - Travelling bag - June 13
1574 Clark, W. - Umbrellas and parasols (com.) - June 19
1639 Lion, A.—Fastening for bracelets—June 26
1613 Dance, E.—Crinoline fastener—June 24
1489 Stevens, C.—Varnish for leather (com.)—June 11
1656 Middleton, S., and Wright J.—Manufacture of boots and shoes—June 28
1583 Hannart, L.—Manufacture of gloves—June 20
2385 Cottrill, J.—Manufacture of needles—September 24
2251 Johnson, J. H.—Manufacture of cigars (com.)—September 9
1624 Stevens, C. Noseband for stopping runaway horses (com.)—June 25
1634 Tussaud, J. R.—Stuffing birds and animals June 26
1905 Wood, A.—Refrigerating storehouses—July 31
1608 Comrie, J.—Churns - June 22
1464 Martin J.—Ironing stove—June 8
1480 Langdale, J.—Washing machine—June 10
1551 Perry, J.—Washing machine - June 17
2766 Archer, J. Weighing machines November 4
1525 Downing, T. W.—Corks and bungs - June 13
1654 Rouse, H. J.—Hand lamps—June 28
1661 Dyer, J.—Ornamentation of cabinet furniture—June 29
1517 Lawford, H.—Folding-chairs and beds - June 20
1708 Hutson, J.—Improvements in bedsteads and furniture—July 5
1500 Dauncey, —.—Feeding apparatus for infants and invalids - June 12
2613 Marchall, J.—Acoustic instruments - October 19
1833 Cole, J., and Cole, J.—Construction of watches—July 20
1756 Smith, T. J.—Photographic albums—July 12
1606 Church, J.—Rest for pianofortes—June 22
1591 Brooman, R. A.—Manufacture of pianofortes (com.)—June 20
2099 Telford, R.—Casters for furniture—August 22
1519 Bing, E.—Sliding window sashes—June 13

* Arrangements are pending by which increased facilities, in connection with the management of this Journal, will be afforded to Inventors for securing valid Patents.

TO CORRESPONDENTS.

H. D. D. We know of no piles of any great length driven at an angle greater than 10 or 15 degrees from the perpendicular. A ram sliding down the hypothenuse delivers a blow of as much force as the same ram falling through the perpendicular, except the friction; the friction in lifting the ram perpendicularly is nothing, while the friction of the ram moving up and down the guides on an inclined plane is considerable; one-third the power with the best arrangement would be lost, to say nothing about steadying the pile in a slanting position to receive the blow. If H. D. D. will give us the dimensions of the pile, specify the nature of the soil, and say what machinery he intends to employ, we will enter into further particulars.



Feby 1862. J.R. Jobbins

RECTORY PLACE CONGREGATIONAL CHAPEL, WOOLWICH.

MESSRS LANDER & BEDELLS, ARCHTS GT JAMES ST W. C.

RECTORY PLACE CONGREGATIONAL CHAPEL, WOOLWICH.

(*With an Engraving.*)

The chapel illustrated in the accompanying engraving has lately been erected at Woolwich for the Congregational body, and is another example of recent ecclesiastical structures belonging to the Dissenting community which may be compared with the churches of the Establishment in architectural importance. The front portion of the building is the chapel for public worship, to accommodate 830 persons, having three galleries. In the rear are the week-evening lecture-room for 230 persons (used also as the girls' school-room), the boys' school-room for 135, an infants' room for 65, a superintendent's room, a library or gentleman's committee-room 20 feet by 13 feet, a ladies' commitiee-room 18 feet by 13 feet; two vestries, boiler-room, store-room, and other necessary accommodation, all separated from the chapel by a corridor 6 feet wide: the whole so arranged as to form a most complete building. It is designed from the Decorated period, and with its deeply recessed entrance and porches, presents an imposing appearance. The staircases to the galleries commence to rise out of these porches. The floor of the chapel is slightly raised as it recedes from the pulpit. The form is a parallelogram, with transepts 62 feet long in clear, 38 feet wide at the narrow part, and 47 feet in the transepts. The roof is semi-open—somewhat waggon-headed in form. The materials used are Kentish Rag in random courses, with Bath stone dressings; the walls internally are stuccoed: the whole of the woodwork is stained and varnished. The cost of the whole has been about £4000. The structure is from the designs, and was carried out under the superintendance of Messrs. Lander and Bedells, architects, Great James-street, London.

THE OFFICIAL PROGRAMME FOR THE DESIGN OF THE PARIS OPERA HOUSE.

The programme issued for the guidance of competitors in preparing designs for the second competition of the Paris Opera House is a document interesting both as an example of the detailed study which the requirements of a great public building ought to receive, and also as embodying a most perspicuous and complete account of all the essentials of a metropolitan theatre. By the courtesy of M. César Daly, the editor of the *Rèvue de l'Architecture et des Travaux Publics*, we are enabled to lay before our readers a translation of this document.

Programme

For the design of a new Opera House, as far as regards the administration and carrying on of the business of the Theatre.

1. The building intended for the Opera will include two main divisions:—

(1) The House, with all the arrangements for the Emperor, and all the accessories appropriated to the public.

(2) The Theatre, including all relating to the working of the stage and machinery, the rooms for the performers, the "green rooms" and rooms for instruction and rehearsals, stores and workshops, the library, the strong room, the offices, dwelling apartments, and generally all relating to the internal management.

First Division.—Buildings appropriated to the Public.

2. All the external arrangements must be calculated to facilitate access to the Theatre, and prevent those nuisances which too frequently defile the basements of great buildings, and, above all, the vicinity of theatres.

3. The architect must endeavour to discover the most effectual means of successfully counteracting the unfortunate habits of the public in this respect. We ourselves consider that the only means of securing cleanliness, and diffusing at the same time life and light around the Opera House, which is only open thrice in the week, from seven o'clock till midnight, is to surround it with galleries occupied for commercial purposes, the rents of which would also furnish a valuable contribution towards the expense of management, and consequently to the prosperity of the theatre.

4. Persons arriving in carriages must be able to alight under cover, and sheltered from cold. For this purpose a portico must be arranged, the dimensions of which will be so calculated that 300 carriages may be able, within at most a quarter of an hour, to set down their occupants at the door of a vestibule, which ought to be closed and warmed in winter.

5. Foot passengers, who form more than a third of the audience, ought to have the means of comfortably reaching, and as far as possible through covered galleries, this first vestibule, where will be the offices for the sale of tickets and boxes, both during the day and at the moment of entering the building.

6. Such of the audience as have omitted to provide themselves with tickets beforehand, ought to await, in this vestibule, the opening of the doors, without impeding circulation.

7. It is not absolutely necessary that the whole audience should pass one point and under the eye of one inspector. On the contrary, there would be an advantage in multiplying the entrances, and possibly in appropriating some of them exclusively to subscribers. But it must not be forgotten, that it is principally the subscribers who come in carriages, and that they occupy almost exclusively the boxes of the first two tiers all round the house. Hence it follows, that if a private door for subscribers is contrived, it ought to communicate with the most accessible part of the portico for carriages, and to lead directly to the grand staircase; for this staircase, as it ought probably not to be carried higher than the second tier, would become really useless if it were not appropriated to the subscribers who alone will occupy the boxes to which it will give access.

8. Adjoining the first vestibule ought to be provided:—(1) A guard-room for twenty to twenty-five infantry soldiers, with a private room for the officers in command. (2) A guard-room for ten cavalry soldiers, and a stable for their horses. (3) A station for constables (*sergens de ville*), and an office for police (about ten persons). (4) The dwelling of the custodian (*concierge*). (5) The hat and cloak room.

Staircases.

9. Three main staircases are necessary. (1) The principal staircase, which, for reasons to be subsequently given, ought to go as high as the second tier of boxes. (2) Two staircases, specially designed to accommodate the upper tiers, but capable of affording exits from all the stories of the house when the audience is dispersing.

10. These staircases must be wide, interrupted by frequent landings; and, according to our judgment, with straight rather than curved flights. Well-hole staircases, winding round a square space, appear as if they ought to be preferred, as the most favourable to the movements of a numerous and dense crowd.

11. Other side-staircases will be formed between the boxes and the stalls. These staircases of internal communication, so to speak, though mainly intended to assist the intercourse of the frequenters of the opera between the acts, must at the same time aid in facilitating the exit of the audience after the representation.

12. Lastly, it is important that the staircases, their approaches, and the passages which adjoin them, should be so arranged that, without barriers and without solid obstructions, the course of their movements should naturally set up between the different classes of spectators a separation corresponding with the various grades of seats. In this respect the features of the present house, though cramped, are felicitously arranged.

VENTILATION OF DWELLINGS AND HOSPITALS.

(*Continued from page 6.*)

Having in our last given some general views as to the condition of air in an ordinary dwelling-room of an ordinary house, we propose now to present some of the statements, relative to the same subject, of the Commission appointed to inquire into the warming and ventilation of dwellings.

The Commissioners instituted a series of experiments, with a view to investigate the condition and the movements of air in a room as affected by an open fire. The simple ascent of the expired products of respiration to the ceiling by their own heat must coincide with a powerful sort of circulation of air caused by the fire, and which, though ordinarily imperceptible, can be very clearly shown by the simple methods of supsending a very large number of light filaments of silk in all parts of the room, or of filling the room with smoke or coloured vapour.

The general result of the experiments instituted by the Commission upon this subject may be stated to be as follows:—

"The result of these experiments is, that the whole air in a room is in rapid circulation while the fire is lighted. It circulates less rapidly when it is extinguished, so long as any one part of the room is warmer than another. The experiments do but confirm what seems to follow from the admitted facts, that warm air is lighter than cold, and occupies a larger space; and they seem to show that an open chimney with a fire lighted will serve to remove foul air from dwelling-rooms, without any special opening communicating with the chimney from the upper part of the room."

The account of the experiments themselves is interesting, and a portion of it is subjoined.

"*Experiments made at the Board of Health to ascertain the movements of air in a room with a fire lighted in an open fire-place* (Arnott's), by J. F. Campbell, Esq.

1. A balloon filled with a light gas was weighted with pins stuck into a pen suspended to it, till it was as nearly as possible of the same specific gravity as the atmosphere in the stillest part of the room. It was found that the balloon so balanced, when placed opposite to and near the fire, expanded, ascended, and moved steadily along the ceiling, from the fireplace towards one or other of the windows; it there descended to the floor, and unless it got anchored to the carpet, it moved towards the fireplace and again ascended. It was found that any person moving in the room in the neighbourhood of the balanced balloon, any draught from a door or window, or any other slight disturbing cause, altered the direction in which the balloon moved, though the general course was as described. As the balloon was moved by the air, it follows that air near the fire, and acted on by it, ascends as the balloon ascended. It is continually ascending, and as it can neither escape nor accumulate at the ceiling, it *must* flow from the place where it ascends; that is, from above the fireplace towards the windows and walls, where it contracts and becomes heavier, falls by its own weight, and is forced downwards by fresh quantities of heated air expanding and following in the same track. In like manner, because air cannot accumulate on the floor, the descending currents at the windows, and those originating there from the coldness of the glass, must give rise to currents moving towards the fireplace near the floor, in the direction in which the balloon actually moved; and further, any person in the room must cause movements in the air such as were shown by the movements of the balloon. If, then, the air of a room be circulating thus rapidly, foul air cannot accumulate in any great excess at any part of it; but on the contrary, different qualities of air must be speedily mixed.

2. To show more clearly what the balloon had indicated, a number of filaments of floss silk (about six inches long, teased out, and made very fine) were fastened on the ceiling with wafers. A number of similar vanes were attached to pens, and these were fastened to a pole reaching from the floor to the ceiling, and others were fastened to the mantlepiece. Where the air was stagnant, the free ends of the vanes pointed steadily to the floor. Where it was descending, they pointed downwards and moved about; where the air was moving horizontally, the silk was bent in the same direction. Where the current was more or less strong, the silk was more or less bent, and showed the comparative strength of the moving power at different points. Where the air was ascending, the vanes pointed upwards. It became at once evident that the air was rising at the mantlepiece, and flowing rapidly along the ceiling, in lines radiating from a point above the fire, as shown on the Plan No. 1, and that the ventilator was not drawing air from the ceiling so as to interfere with the direction of vanes fastened close to and above it, which pointed directly away from it. By moving the pole to different positions across the room, the direction of the currents, as shown by the silk vanes, was found to coincide with that indicated by the balloon."

Notwithstanding the apparent interference with the action of the ventilating exit here indicated, the introduction of such an exit in all cases is recommended by the Commission, and in new buildings it is recommended that the opening shall not lead directly into the chimney flue, but into an adjoining foul-air flue, the air in which will be rarefied by the heat imparted to it by the neighbourhood of the smoke flue and its warm contents.

The mode of air-supply which is indicated by the Commissioners as seeming to them best suited to meet the requirements of ordinary dwelling houses appears to us, notwithstanding the great scientific eminence of the proposers, to be open to question. It is founded upon a plan suggested by the late Prof. Hosking, and has for its object the furnishing from a single opening a supply of air, of which a portion shall at once enter the fire to support combustion while the remainder shall be thrown into the room. The Commissioners remark—

"In order to effect an agreeable and pleasant ventilation, and prevent currents of cold air rushing from the doors and windows in the direction of the fire, it is to be recommended that the supply of atmospheric air for the support of combustion be provided from some independent source, such as an air channel or tube under the floor in communication with the external air. The ventilation of the room would then be carried on by proper apertures, independently of the supply of air to the fire. The commission therefore recommend:—That the area of the supply-pipe or channel be larger than the area of the smallest part of the chimney-flue, in order that fresh air in excess of that required for combustion may be supplied into the room to the amount of 15 to 20 feet per minute for each occupant, by which arrangement the fresh air introduced for the purposes of ventilation may be warmed or tempered before entering the apartment. That the supply air-channel be provided with a closing apparatus. That for the ventilation of rooms, exits should be provided for the spent air near the ceiling, either by perforations in the cornice at different parts of the room, by apertures made near the ceiling, or by one sufficient aperture leading into the chimney, with a rarefier in case of need, to such extent as to remove from 15 to 20 cubic feet per minute for each occupant. By thus pouring into the room a current of gently warmed air, and removing from it an equal amount of spent air, a much greater degree of ventilation could be borne without discomfort, than if the air supply were derived from accidental sources; all whistling of windows, pressure upon doors, and cold draughts would be greatly checked, if not quite prevented."

The supply-pipe is elsewhere described as terminating in an opening in the hearth, so that the air drawn from it into the fire shall enter the fire-grate from below, while the air entering the room (supposing any to do so) would pass close to the fire, and so be partially tempered, if not warmed. This plan does not seem to have been put to the test of actual experiment; and we are afraid that it might result in an action very much the reverse of healthy. Though the area of the air-channel supplying the fire-grate is proposed to be larger than that of the flue carrying off smoke, yet no means will insure that the air entering through the channel shall be drawn along it at the same speed as that going up the flue. Probably the action of the two would differ very much, and the fire would absorb the whole of the air sent in through the supply-pipe, discharging it all again into the flue at a higher velocity. If this were the case the body of air in the room, even if set in motion by the heat of the fire, would not undergo change, and the good and bad air would be mixed up together, and would circulate round and round, without getting removed and replaced. On this account we believe that the plans which introduce external air at a point remote from the fire-place, or at least so far removed from it as to render it almost impossible for the fire to absorb the whole quantity that they furnish, afford a more reliable prospect of real renewal of the atmosphere of the room than does the scheme of the Commissioners.

By far the larger portion of the Report from which we have now been quoting is devoted to the subject of the *warming* of dwellings—a subject which we have not included in the heading of this series of papers. We do not propose to enter now upon the consideration of the various sorts of stoves and fire-grates examined by the commission, or to reproduce their opinions, which are guardedly given, as to their comparative merits, although to persons interested on the subject we can recommend this part of the Report as interesting. We shall here, however, do no more than make two extracts bearing upon the question of heating: the first being the Commissioners' statement of desiderata—

"That the floor be at the highest temperature in the room. That the walls be higher, or as high in temperature as the general temperature of the room. That the general body of the air in the room be of a genial and equable temperature, at the same level, and gradually decreasing from below upwards to the ceiling. That the ceiling be at a temperature differing very little from the stratum of air immediately below, and should be the lowest in the room. That the range of temperature during the twenty-four hours be small, so as to prevent the loss of heat during the first part of the day, by heating air at a much lower temperature than is required. That the water present in the air be such in amount that no undue checking or accelerating evaporation from the skin takes place. That all heated air which passes upwards should pass away. That fresh air be admitted to supply the place of the exhausted air. That there should be a freedom from sensible currents of air, and a freedom from smoke.

On the other hand, we may consider that the reverse of these conditions is injurious to the health and comfort of the occupants, viz.—That the general body of the air be either at too high or too low a temperature. That either the floor or walls be cold, with respect to the general temperature of the room. That the ceilings be heated; unequal distribution of heat; bad ventilation; currents of air; presence of smoke. If there be a great departure from the proper degree of humidity at any temperature, the air will be either too dry if at much less, or too damp if at much more, for healthy and agreeable respiration, and more particularly to all occupants who are in any way affected with pulmonary complaints."

The second extract embodies recommendations deduced from an extended series of observations and experiments.

"In regard to fire-grates in general, from the preceding experiments, and from the information which has been collected, the commission is prepared to recommend:—

1. The use of reflecting surfaces to direct an increased amount of radiated heat into the room.

2. That the chimney-flue should be of small dimensions, and not more than 9 inches in diameter at the widest part, to diminish the quantity of air escaping up the chimney, and reduce its tendency to smoke.

3. That chimney-flues should not be situated in the outer walls of dwelling-houses, to become chilled by contact with the comparatively low temperature of the external air.

4. That the chimney-flue should be provided with a closing apparatus.

5. That the aperture for the escape of the smoke should be placed at

the back of the fire, to increase the intensity of combustion and promote the radiation of heat.

6. That fire-brick linings to grates should be in general use.

7. That sunk ash-pits and concealed ash-pans be employed to prevent dust, &c. being diffused in the room.

8. That the fire should not be on a level with the floor; this is made evident by the experiments with Leslie's grate.

9. That as a rule, the fire-grate is best situated which may be seen from the greatest number of points in the room.

10. That a good frontage of fire surface should be exposed; this does not necessitate any corresponding increase in the depth of the grate from back to front.

11. That those stoves be used that prevent the formation of smoke; the formation of smoke being a proof of imperfect combustion, and a representation of so much fuel wasted.

12. The commission strongly recommend that the fire-grate should be studied in its construction with the view to its effecting a better and more economical consumption of fuel, and a more equable distribution of heat, and not as a contrivance for the ventilation of rooms. The commission is decidedly of opinion, that so long as the fire-grate is studied with a view to this twofold application, it will not succeed well in the performance of either."

This report concludes with a suggestion for the improved construction of new dwellings in the respect of flues and air openings, worthy close examination by practical men. We cannot express ourselves as thoroughly satisfied of its feasibility in the exact form in which it is recommended by the commission, although there can be no doubt that it contains the elements of a radical improvement in house building.

It is proposed then that there shall be formed in such houses as will admit of it, one central smoke-flue, that all the fireplaces on all the floors shall communicate with it through short channels, and that it itself shall be straight and of circular section; probably for an eight-roomed house, not requiring to be more than 10 inches in diameter, and of glazed tubular tile. Round this flue, up which it is considered products of combustion would be passing at all periods of the year; an annular air-chamber is to be formed, and openings into this chamber are to be made at or near the ceiling of each room. These openings will serve to draw off the vitiated air out of the rooms as the neighbourhood of the current of hot air in the smoke flue will maintain an ascending current in the air chamber. To supply the fire, spacious air ducts are to be introduced, one under the floor of each room, leading from the external atmosphere to an opening in the hearth-stone.

An illustrative section of a house arranged as here proposed is embodied in the report, and it would be satisfactory to know that the scheme had been actually tried. We are not, however, aware of any instance where it is in operation, though portions of it, such for instance as the annular chamber surrounding a smoke-flue, have been in use for a considerable time. It is advised, we may add, to economise heat by employing double windows, or at least double glazed sashes. This is a very prudent suggestion, and would at a very moderate cost, increase the warmth, and consequently the comfort of dwelling houses, to a great extent.

(To be continued.)

THE STRESSES ON THE VARIOUS PARTS OF A BOWSTRING GIRDER.

When the arch is such as to have the points where the trussing is connected with it arranged in a parabolic curve, then it will be equilibrated by a continuous uniform loading. And under such a loading there is consequently no stress on the diagonals; the loading, if on the chord or main tie, will be transferred in a direct manner to the arch by the perpendicular pieces, supposing these to be capable of acting as ties, whether or not they act as such in the trussing. In calculating the strains to which the diagonals may be subjected, we have therefore to consider the effects of the moving load alone.

Assuming the arch to be as above described, and that the trussing is made up of equidistant vertical pieces, and the quadrilateral openings supplied with diagonal struts or ties, as in Fig. 2, we have this remarkable analogy (which was first mentioned by the writer in one of a series of papers supplied in May 1852, to the Messrs. Fox, Henderson, and Co., giving instructions for the calculation of the strains in various forms of bridges):—"*The maximum stresses on the diagonals, whether these be struts or ties, are in proportion to their lengths.*" So that we may, by calculating the stress in any one diagonal, at once arrive at a multiple or scale which will give us the stresses on all the others, by multiplying the calculated lengths by the former, or by direct measurement of the lengths with the latter.

We purpose first to show the mode of arriving at the amounts of the stresses on the trussing, the lengths of the parts, and the above important deduction; and to conclude with some remarks on the strains in the uprights, the arch, and the chord.

Let N = the number of bays in the span S, and each bay = s; also let w represent the share of the movable loading due to each bay, or trussed point of the arch; D = height of curve of arch.

Let us first take the case of the diagonals acting as ties, and the uprights as struts in the trussing. And to save undue length of explanation, we will assume a certain familiarity with the subject on the part of the reader. It is well known, then, that the maximum strains in the various diagonals will be produced in succession by the movable load gradually encroaching on the bridge in the manner of a long railway train, first from one extremity and then from the other; but it will be sufficient to consider it as encroaching in one direction only—viz., from pier P, Fig. 1, and this produces the maximum strains in all the diagonals shown in this figure; the effect of the load encroaching from pier Q on the other diagonals not shown in this figure being merely a counterpart of the first.

The points a, b, c, &c., being situated in a parabola, we can easily calculate the tangents of the inclinations or angles which the various parts and lines make with the horizontal direction. And as the proportions which these tangents bear to one another are not affected by altering the relation of the depth D of the girder to its span S, we may insert them as we have done in Figs. 1 and 2, in whole numbers obtained by multiplying the true values by $\frac{NS}{4D}$; let this = c.

The greatest stress on any diagonal such as b_1c, Fig. 1, is produced by loading all the points a, b, which lie between the pier P and the point above b_1, inclusive. Of the weight w at a, $\frac{1}{N}w$ must be transmitted to pier Q; and of the weight w at b, $\frac{2}{N}w$ must be transmitted to Q. Now bQ is the primitive line of pressure for the transmission of these portions of the weight to the pier Q, let bq be taken on this line to represent the resultant, which must contain a vertical component $= \frac{1}{N}w + \frac{2}{N}w = \frac{3}{N}w$, say =Q. The resultant bQ must be resolved into the directions of the arch and strut, that is into br and bs; draw qt horizontally, then bt = Q. Now bs represents the stress acting down the strut bb_1, and evidently also the vertical component of the maximum stress on the diagonal b_1c, therefore

$$\text{Stress on } b_1c = bs.\ \sec \text{ of } b_1cc_1 = bs\,\frac{b_1c}{cc_1} = (bt+ts)\,\frac{b_1c}{cc_1} \ldots \quad \ldots \quad (1)$$

It will be observed that $bs = bt + ts$, ts becoming *negative* for a point taken at or beyond the crown of the arch, as for point d in Fig. 1.

$bt : ts ::$ tan of inclination of resultant : tan of inclination of arch, ∴ $ts = bt\,\frac{\text{tan of incli. of arch}}{\text{tan of incli. of resul.}}$; substituting this value in equation 1 and putting Q for bt, we have

$$\text{Stress on } b_1c = \text{Q}\,\frac{b_1c}{cc_1}\left(1+\frac{\text{tan of incli. of arch}}{\text{tan of incli. of resul.}}\right) \ldots \quad \ldots \quad (2)$$

Now, to render this general for any diagonal, let n be the distance, counted in bays, of the lower end of the diagonal from the pier P, and we have

Q evidently = the summation of the series $(1+2+3+\ldots n)\frac{w}{N}$ carried to n terms ∴ $\text{Q} = (n+n^2)\frac{w}{2N} \ldots \ldots \ldots \ldots \ldots (3)$

$$\text{The tan of the inclination of resultant to Q} = \frac{n}{c} \quad \ldots \quad \ldots \quad (4)$$

$$\text{The tan of the inclination of the arch} = \frac{N-2n-1}{c}, \quad \ldots \quad (5)$$

which becomes *negative* for points at or beyond the crown.

Substituting these values in equation 2, we get

Stress in any diagonal $=(n+n^2)\frac{w}{2N}\cdot\left(1+\frac{N-2n-1}{n}\right)\times$ length of the diagonal ÷ the height of its upper end above the chord of the arch, or

$$=(N+nN-1-2n-n^2)\frac{w}{2N}\cdot\frac{\text{length of diagonal}}{\text{length of strut at }(n+1)}\quad\ldots\ (6)$$

The length of the upright attached to the lower end of any diagonal is expressed by the tangent of the inclination of the line drawn from the head of the upright to the pier Q, $\left(=\frac{n}{c}\right)$, multiplied by its distance from Q, $[=(N-n)\,s]$ $\therefore$

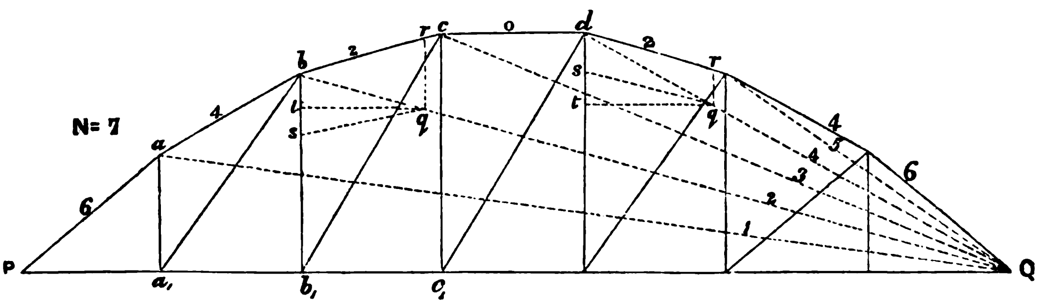
$$\text{Length of strut at } n=\frac{nN-n^2}{c}\,s\ \ldots\ \ldots\ \ldots\ \ldots\ (7)$$

And the length of the upright attached to the upper end of the diagonal will be expressed by substituting $(n+1)$ for n in equation 7; $\therefore$

$$\text{Length of strut at } n+1=N+nN-1-2n-n^2\left(\frac{s}{c}\right)\quad\ldots\ (8)$$

Substituting this value in equation 6, we get

FIG. 1.

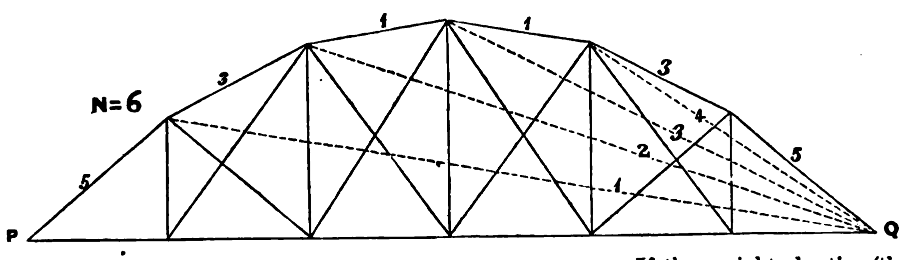


$$\text{Stress on any diagonal}=\frac{w.\,c.\,\text{length}}{2Ns},$$ and substituting for c its value $\frac{Ns}{4D}$, and for s its value $\frac{S}{N}$, we get

$$\text{Stress on any diagonal}=\frac{Nw\ \text{length of diagonal}}{8D}\quad\ldots\ \ldots\ (9)$$

And as $\frac{Nw}{8D}$ is constant, the stress is proportional to the length. When N is even, the longest upright is $=$ D, therefore if we form a scale such that a length equal to the central upright represents one-eighth of the total movable loading Nw, then any diagonal measured upon that scale will at once point out the stress it may suffer. When N is odd, and the arch either polygonal or curved, each of the central uprights will be $=D\left(1-\frac{1}{N^2}\right)$ so that we have the stress in any diagonal when N is odd $=$ $\left(N-\frac{1}{N}\right)w$. length of diagonal $\div$ 8 times the length of a central upright. And if we construct a scale such, that on it

FIG. 2.



a central upright will measure $\frac{N^2-1}{8N}w$, this scale will at once give the strains in the diagonals by simply applying their lengths to it. But we may repeat that whether N be odd or even, the stress on any diagonal is simply its length multiplied by the value of $\frac{Nw}{8D}$.

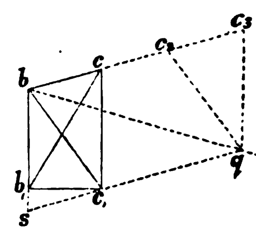
We have assumed in the foregoing investigation that the diagonals were supplied with ties, and that the uprights were struts. And now, to show that the same conclusions apply when the diagonal pieces are struts, and the uprights are ties, let us construct Fig. 3, the line sq being drawn through the point c_1 parallel to qc, and intersecting bQ in q, and bb_1 produced in s. And let us observe that to produce the maximum stress on b_1c acting as a tie, or on bc_1 acting as a strut, requires the same points a and b to be loaded. Let bq represent in magnitude, as it does in direction, the resultant from point b to Q; when bb_1 is a strut and b_1c a tie, the stresses are represented by the lengths bs and b_1c respectively, for $bs=cc_1$. But as we are now to treat bb_1 and cc_1 as ties, and bc_1 and cb_1 as struts, we must resolve bq, not into bc_3 and bs, but into bc_2 and bc_1; and the compression in strut bc_1 is evidently now represented by the length of the diagonal in the same fashion that the diagonal length cb_1 represented the tension in b_1c when it acted as a tie: so that the analogy holds good for both arrangements.

The Stresses on the Uprights.

1st. When the loading is considered as placed immediately on the arch, the maximum stress on any upright must be equal to the vertical component of the stress on the most strained of the two diagonals connected with its lower extremity; for it cannot be less than this, since it is through its agency that the stress is either delivered or carried onwards, according as the upright is a strut or a tie; and it cannot be greater, for if we, for instance, suppose it when a strut to suffer a greater strain, this assumes that the resultant to the other pier P is resolved into it and the arch, but any such resultant would, on the contrary, go to annul a portion of the tension previously existing in the tie leading from the head of the strut towards the said pier. The stress in the upright is therefore ascertainable by applying the already described scales to the length of its taller neighbour, or by multiplying that length by $\frac{Nw}{8D}$.

2nd. When the load is applied, not on the arch directly, but on the chord line, and assumed to be suspended by the perpendicular pieces, the strains in these as given above will be greatly modified. If they be struts, the greatest tension to which they may be subjected is produced when all the loadings are on, and is then $=w+w_1$ for each, w_1 representing the Nth part of the total dead weight: the greatest compression to which any one is liable is $=$ its own length $\times\frac{Nw}{8D}-w$.

FIG. 3.



If the uprights be ties (the diagonals then being struts), the maximum tension for each will be $=w+w_1+$ length of its longest neighbour $\times\frac{Nw}{8D}-\frac{n'w}{N}$, where n' represents the distance of the upright tie from the nearest pier, counted in bays.

The Stresses on the Arch and Chord.

The compression of the arch at the crown is $=$ the horizontal thrust of the arch, which is $=$ the tension of the chord, which is $=$ total sum of movable and dead weight on girder $\times\frac{S}{8D}$.

The compression in any other part of the arch is $=$ horizontal thrust $\times$ sec of inclination of that part.

Edinburgh. R. H. B.

ON THE PRESENT ASPECT OF THE FINE ARTS IN ITALY, WITH ESPECIAL REFERENCE TO THE RECENT EXHIBITION IN FLORENCE.*

By M. Digby Wyatt, Architect.

The name of Quintino Sella, the mathematician, economist, and orator, that of one of the most rising men of the present generation of Italians, will ever be held in esteem by his countrymen, if on no other grounds, from the honourable connection which must always exist between his memory and that of the signal manifestation of Italian capabilities, in an industrial point of view, which will mainly engage our attention this evening—the first made since the yoke which has so long impeded their satisfactory development has been at least partially removed from the shoulders of a race whose attachment to Fine and Decorative Art has become proverbial.

To the Cavaliere Sella, and to his exertions in the Italian Parliament, that nation is indebted for the conversion of an Exhibition, limited, as originally contemplated, to the illustration of Tuscan manufactures only, into one in which evidence, greater or less according to circumstances, is to be found of the artistic and industrial capabilities of almost every district of that united kingdom; whose existence as such every well-wisher to the cause of liberty, and every one who honours the ancient traditions of excellence in design still preserved in that favoured land, must ardently desire should be preserved.

The task of the critic who would attempt to minutely characterise individual productions so far removed from the eyes of those he may have to address as to render impossible any appeal on their parts from his judgment to material evidence, must, it appears to me, be alike unjust to those whose works may be criticised, tedious to those addressed, and too one-sided to be either interesting or profitable. I propose, therefore, this evening to take a broader view of the entire subject of the Italian Decorative and Industrial Arts than I should probably do if the means of rectifying any errors of individual judgment on my part were within the reach of those to whom I venture to offer the following observations.

The natural sequence of emotions most readily to be imagined as occurring to an educated Englishman on entering the Exhibition building at Florence would be, as it appears to me, somewhat as follows:—Firstly, his memory would revert to those old glories of the days of Florentine independence, of Genoese and Venetian magnificence, and of Roman Pontifical autocracy, in which the fine and decorative arts are known to have reached a pitch of perfection scarcely rivalled in the palmiest days of Greece and of the Augustan empire. He would naturally inquire what those old Italian arts and industries were, how far they co-existed and were united, and under what social conditions they were developed?

His second inquiry would naturally be, how much of that ancient power still lingers in the hands of the descendants of those by whom the original greatness was attained?

The third subject of investigation would probably be, after taking stock of the present, what materials still exist amongst the Italians likely to carry to a higher perfection than has been as yet attained in recent times the arts for which "Italia la bella" was once so famous?

Recognising, as no one can fail to do, the retarding influences which have so long operated to fetter and depress the wonted vivacity of that highly imaginative people, it is indeed an interesting problem to endeavour to trace the direction in which a greater degree of personal liberty than they have hitherto been permitted to enjoy may tend to revive those energies which have too long been overshadowed by a baneful condition of social oppression. From her past and her present may thus, to a certain extent, be augured an Italian future.

In all this, doubtless, there must be some moral for us; and the fourth aspect under which any Englishman, anxious for the augmentation of his country's greatness, would naturally regard the present evidences of capacity manifested at Florence, would be to consider what concurrent improvement his countrymen may derive from the lessons to be at present learnt in Italy?

Following this order of investigation, my remarks will be grouped in subordination to these four leading aspects, under which the subject may be regarded. We shall therefore consider first—and far too briefly for the grandeur of the theme—what the old Italian arts and industries were.

*Paper read before the Society of Arts.

It appeared to those in whose hands the initiation of the Great Exhibition of 1851 rested, as likely to prove an important element in preparing the way for a due appreciation of that great display, that a collection of works, illustrating the perfection to which industrial processes had been carried in ancient and mediæval times, should be submitted for general study and investigation by the public, previous to their being called upon to estimate the relative value of corresponding cotemporary processes. Many of those I have the honour of addressing cannot forget the success which attended that exhibition, inaugurated under the auspices and mainly through the direct action of the Society of Arts.

A similar idea seems to have struck the Italians, and to have led to the bringing together a very remarkable collection as specimens of ancient Italian technical art; mainly through the active exertions and public spirit of a Florentine medical man and distinguished connoisseur, the Doctor Guastalla, whose energy has already tended to infuse new life into the adminstration of the Florentine museums. Several of the princely Italian families co-operated in this work, the proceeds arising from which, it was determined, should be voted to charity.

Within the walls of a large house in the new Piazza dell' Indipendenza, were consequently crowded together a great quantity of objects, illustrating almost all those industries with the choicest specimens of which Italy was wont, from the end of the fourteenth to the beginning of the seventeenth century, to supply the factitious necessities of the most highly cultivated portion of the royalty, aristocracy, and rich *bourgeoisie* of Europe.

With such examples of these arts as we may be now thankful to possess in the Museum at South Kensington, it is little necessary for me to dwell in detail upon the classes of objects collected in the Casa Guastalla. It may be sufficient to say, that bronzes worthy, if not wrought by the hands, of men such as Ghiberti, Cellini, Donatello, Michael Angelo, and John of Bologna, were not wanting. Neither were the finest Venetian glasses, Milanese and Ferrarese arms and armour, Siennese and Florentine illuminations, Umbrian majolica, enamels of several kinds, goldsmiths' work, silver repouseé work, iron work, niello, medals, lavori di commesso, or mosaics, and coins, cuir bouilli, tapestries, rare tissues, lavoro all'Azzimina or damascening, tarsia or marquetry, and marble, ivory, and wood carving.

Where so much was beautiful, it seems almost invidious to dwell upon points of remarkable interest; but it would be treason to the royalty of excellence to pass over two or three objects especially celebrated in the history of art, and now brought under public notice after ages of seclusion, if not neglect.

The most interesting of all was probably that patera in bronze, which Vasari relates that Donatello worked for the noble Casa Martelli, to show how perfectly it was within his power to rival the exquisite fragments of antique bronze casting and chasing, which in his days were as much the rage among great Italian collectors, as majolica and "vieux Sèvres" have been lately among French and English. As perfect almost as it could have been when it left the hands of that rare artist, this beautiful piece of sculpture justifies all the praises which Cicognara has so lavished upon it in his 'History of Sculpture.'

Another specimen of little less historical interest, was the bust in marble representing Marietta Strozzi, wife of Celio Calcagnini di Ferraro, by that great sculptor (who unfortunately died too young to leave much behind him) Desiderio da Settignano. Jealously preserved in the family of her descendants in that palace, the architecture of which by Benedetto da Majano and Pollaiuolo has mainly stamped the Tuscan palatial style with its easily recognised distinctive features, there can be no doubt of the true descent of this beautifully preserved work of art.

Another item, small in bulk though great in artistic value, was also contributed from the same collection—a little key in chiselled steel, ascribed to Benvenuto Cellini, and, if not actually executed by him, eminently worthy of his most dexterous hand, and of all that skill which he appears to have acquired in the workshop of Paolo Arsago, the Milanese.

Probably, as far as unique curiosity is concerned, the most interesting groups of objects in this collection were the very important series of coins of different Italian cities and mints; the medals of illustrious personages, by Pisanelli, Sperando, Cellini, Pollaiuolo, and others; and a very curious collection of cut and stamped leather work, which the energies of the purchasers for the South Kensington Museum may, I hope, ere this have acquired for our admiration in this country.

Important as the objects in this collection unquestionably were, as filling up the detail of the still-life of those pictures in which the stately Gonzagas, Medici, Sforzas, Strozzis, and Dorias occupied the foreground, it is of course in the great monuments and permanent museums of the country that we learn to recognise how inseparable the perfection arrived at in these minor arts was from that greater sublimity attained in the noblest efforts of the architect, the painter, and the sculptor.

It is precisely in this union of imagination of the loftiest kind with perfect technical dexterity in art productions, on either the vastest or the most minute scale, that the great strength of the excellence of the finest Italian design in old time consists. All these relics, whether taking the form of gigantic churches, of stately palaces, of heroic works of sculpture, of extensive frescoes, of elaborate furniture, of pottery, glass, and even ornamental leather, show how absolutely indispensable to personal enjoyment art then was.

Every student of the "Divina Commedia" must remember the almost passionate terms in which Dante mourns over that transition from simplicity of life and manners to a luxurious indulgence of the intellect and senses, which no sumptuary laws, however stringent, were ever able to subdue. Long and vainly the nobles strove during the fourteenth and fifteenth centuries to preserve for themselves a monopoly in splendour, but wealth accumulating in the hands of the citizens ultimately broke up their ineffectual blockade. How, and with what results, may be traced in the chronicles of Villani and Corio; in the excellent "Discorso di Guglielmo Manzi sopra gli spettacoli, le feste, ed il lusso degl'Italiani nel secolo XIV;" and in Muratori's grand collection of writers, "rerum Italicarum."

Out of the superabundant gains of the industry and commerce of Florence, Sienna, Genoa, Venice, Lucca, Pisa, and Milan, and out of the accumulated riches drawn by an all-powerful priesthood from its spiritual tributaries in all parts of the world, one cannot fail to be struck with the very large proportion which was obviously expended in supplying this apparently insatiable craving for beauty. Sums of money which would frighten the nobles, commercial or hereditary, even of this kingdom, were lavishly expended on the great monuments of Italian art. Taking, for instance, such a city as Palermo, we find, even at the present day, not tens, but twenties and thirties of churches lined throughout with marble mosaic of the most costly description. The riches at St. Mark's at Venice, St. Peter's at Rome, the Certosa at Pavia, St. Anthony at Padua, and the churches of the Annunziata and San Matteo at Genoa, appear almost beyond estimation; while not only in monuments such as adorn these cities is the boldest dimension and the grandest scale adopted, but every inch of wall surface, and every piece of church furniture, however insignificant, is made as elaborate as human ingenuity and human hands can make it.

To such an exuberant extent was this apparent craving for enrichment indulged, that where, as happened in many cases, funds were wanting to complete the ambitious designs of the founder of some great monument, his successors, rather than leave the work altogether unfinished, have endeavoured to realise by paint and every kind of ingenious expedient the effect so ardently desired by the original founder of the edifice. Hence proceed many of those illusive perspectives which almost convert flat ceilings into airy cupolas, and carry out the eye of the visitor in the *salone* or grand apartment of the *piano nobile*, or principal floor of an Italian residence, through apparently interminable arcades, to an exuberant landscape alive with statues and fountains.

An amusing definition of what an Italian of the sixteenth century understood as indispensable domestic ornaments may be found in a little book written by Castiglione Saba, and entitled "Riccordi overro Ammaestramenti," for a reference to which, and indeed for the loan of which, I am obliged to the kindness of Sir Charles Eastlake. In one chapter the writer tells us how pleasing to the eye and how necessary are terra-cottas by such men as Paganino da Modena; musical instruments by Lorenzo de Pavia or Bastiano da Verona; that carvings should be supplied by Michael Angelo, Donatello, Alfonso Lombardi (one of the great Venetian Lombardi), and Cristofero Romano. Antique medals, he says, are necessary, as well as those of Giovanni Corona, of Venice. Verocchio and Pollaiuolo, we are told, should supply the bronzes; and cameos and intaglios should be by Pietro Maria, and especially by Giovanni di Castello.

We may pass over the list of worthy painters given by the author, but not so the terms in which he notices the marquetry works of Fra Damiano da Bergamo, and the armour and glass work, the current productions of Milan and Venice. To fittingly supply such necessities no artist was too proud, and there yet exist, more particularly in the great Florentine collection of drawings by the old masters in the galleries of the Uffizii, ample evidences of the powers in designing ornament as applied to industrial productions, possessed by artists whose more special fame rests upon that which we habitually contradistinguish from such classes of art by designating as fine art. To enumerate a few of these may not be unprofitable, by way of directing the attention of young artists to some of the worthiest masters of their craft.

As designers of wood and marble carving we note the names of Baldassare Peruzzi, the great Sienese architect; Giorgio Vasari, Raffaelle da Monte Lupo, Michael Angelo, Montorsoli, Guglielmo della Porta, Il Riccio (the author of the magnificent candelabrum in bronze at the Church of St. Anthony at Padua), Giovanni Battista Trotti, better known as Il Molosso, Lilio da Novellara, and an artist of exquisite refinement, Francesco Salviati. For stucco work we meet with designs by Giovanni Battista Cremonini, and Marco da Faenza; and for friezes with those of Gaudenzio da Ferrara, Giulio Campi and Amico Aspertini. For miscellaneous designs of all kinds we find beautiful studies by Pierino del Vaga, Francesco Zuccheri, Polidoro da Caravaggio, and Prospero Fontana. Cellini, Bernardino Pocchetti, Giulio Romano, and many others, bought their great accomplishments to bear upon the production of beautiful metal-work, while Pelegrino Tibaldi, Matturino, Morto da Feltro, Giovanni da Udine, Bacchiacca, Pinturicchio, Pietro Perugino, and many others, shone in arabesques and cognate descriptions of design. Their ability indeed to minister to the smaller wants of the great Italian nobles, led in many cases to the artists so exercising their lesser talents (if they may be so described) receiving commissions calculated to bring out their capabilities in the loftiest directions.

Any one desirous of tracing the important part which the requirements of industrial art played in the lives of many of the eminent Italian artists, and which I cannot now do more than point to, may find ample materials awaiting his investigation in the autobiographies of Ghiberti and Cellini, in the writings of Vasari and Baldinucci, in the "lettere Sanese" of della Valle, in the "Italienische Forschungen" of Von Rümohr, in the "Beiträge zur neuern Kunstgeschichte" of Förster, and last not least in the collections of original notes and documents illustrating the history of Italian art, by Gaye, Gualandi, Carlo Pini, and the brothers Milanesi.

Did time permit I would willingly dwell in detail on mosaic, sgraffito, intarsiatura, fresco, and gesso painting; terra-cotta, majolica, stucchi, niello glass making, and others of those arts (transmitted by the curious MS. treatises known as *secreta* from generation to generation) in which Italy so long enjoyed a monopoly of celebrity if not of actual production; but I feel that the second branch of our inquiry this evening is too important to be set aside for matters even of such interest as I do not doubt these ancient arts of Italy might be made to assume.

Turning from their yesterday to their to-day, we cannot but observe that, in almost every department in which their ancestors excelled, the modern Italians exhibit if not a considerable power of production, at least very respectable exceptional proficiency; and if not within the walls of the Florentine exhibition, at least in contemporary art-productions elsewhere, we may trace a partial revival of almost every ancient process known to the Italians of Medicean times.

It is probably in the purely Fine Arts that the principal degeneracy is to be recognised; in the strictly technical there exists by no means the same falling away. The reason for this may not be hard to trace in the amount of liberty which has for many years past been enjoyed by the lower orders, as compared with that moral and mental subjection in which the middle classes have been held. While every-day necessity, and the passage of interminable *forestieri*, have created sufficient demand to stimulate the capabilities of the workmen, the apparent hopelessness of their career has unquestionably deterred many, who from the middle classes would have supplied proficient artists and designers, from entering upon those severe studies by which alone excellence in the higher branches of art can be attained.

(To be continued.)

PUDDLED STEEL, HOMOGENEOUS IRON, AND STEEL IRON.

The question of the mechanical properties of puddled steel, as also the less highly carbonised products of iron, is one of growing importance. Cheap and ready manufacture and a high degree of strength are advantages claimed for this class of material, and its field of application is becoming largely extended. An accurate acquaintance with the limits of strength and laws of elasticity becomes therefore increasingly desirable.

We have before us a pamphlet by Mr. W. H. Barlow, F.R.S., M.I.C.E., giving an account of some experiments which he has conducted by permission in the Royal Arsenal at Woolwich, for the purpose of obtaining some reliable data upon this subject. The testing machine employed at Woolwich is a counterpart of that used by the United States Government for ascertaining the strength of cast-iron. It records accurately the amounts of the ultimate resistances to rupture by tension, compression, transverse strain, and torsion, but is not well arranged for exhibiting the progressive action of the three first-named kinds of strain. Consequently, as Mr. Barlow states, although the experiments may be relied on as far as they go, and point out the more important properties of the materials tested, they do not afford all the data that could be wished; as puddled steel rarely yields to rupture in the testing machine except under tension.

"Puddled steel is made direct from cast-iron by a process analogous to that used in obtaining common wrought-iron, but instead of expelling all the carbon, such an amount is left contained as to impart the quality of steel to the metal so treated. Considerable experience is required in the selection of suitable qualities of metal, and also to know the precise moment at which to stop the process of decarbonisation in the puddling furnace; and other conditions have to be observed in order to secure the success of the operation, but it is now accomplished with great certainty, and the result is the production at a very low cost of steel, which, although not of high quality, is nevertheless possessed of many valuable properties.

In addition to the experiments on puddled steel, similar experiments were made on homogeneous metal and steel iron, and on puddled steel melted and cast into ingots. Steel iron is a condition of the metal when the process of decarbonisation is carried further than in puddled steel; its fracture is fibrous, and it approaches very nearly to wrought-iron. The other materials above mentioned show a crystalline fracture, the crystals being very small, fine, and regular, like that of gun metal. The steel possesses also similar properties of malleability, although much harder and of much greater strength than gun metal."

The following Table (I.) is an abridgement of Mr. Barlow's summary of the experiments on tension:—

Table I.—*Summary of Experiments on the Resistance to Tension of Puddled Steel, &c.*

No. of Experiment.	Name of Material.	Name of Maker.	Ultimate Strain per square inch.	Mean.	Remarks.
			lbs.	lbs.	
52 to 56	Puddled steel	Mersey Iron Works... ...	84,152 to 109,117	95,233	Fracture crystalline.
19 „ 23	Homogeneous metal... ...	Firth & Co.	88,640 „ 115,133	100,994	Fracture crystalline.
29 „ 34	Puddled steel	Naylor and Vickers... ...	100,931 „ 133,054	116,336	Fracture crystalline.
57 „ 61	Puddled steel melted and cast into ingots...... ...	Naylor and Vickers	84,652 „ 124,492	101,758	Fracture crystalline.
8 „ 12	Steel iron...	Atlas Works...	67,487 „ 71,158	69,456	Fracture fibrous.

From these results the author draws the following conclusions:—

"From the above experiments it appears that the ultimate tensile strength of puddled steel, homogeneous metal, and puddled steel melted and cast into ingots, is nearly double that of wrought-iron. The variation of strength in the different samples is not greater than is found to arise in wrought-iron.

Several specimens taken out and re-measured after receiving strain, indicate that permanent set first begins to be perceptible at 20,000 lb. per square inch.

Puddled steel and homogeneous metal broke with a fracture presenting a minute crystalline appearance; and there were two distinct forms of fracture, one being in a plane at right angles to the line of strain, and the other a cup-shaped fracture more or less perfect.

The material called 'steel iron' showed a fibrous fracture, and was of much less strength than puddled steel and homogeneous metal. In this material it was evident that the process of decarbonisation had been carried too far, and that it differed but little from iron of good quality."

From the summary of experiments on compression we extract the mean results (Table II.):—

Table II.—*Summary of Experiments on the Resistance to Compression of Puddled Steel, &c.*

No. of Experiment.	Name of Material.	Name of Maker.	Pressure per square inch.	Amount of Compression.	Rate of Compression per ton per square in. in terms of length.
			lbs.	inch.	
47 to 51	Puddled steel (mean length 1·323 in.) ...	Mersey Iron Works ...	21,908	·0032	·000247
35 „ 38	Puddled steel (mean length 1·368 in.) ..	Naylor and Vickers ...	20,196	·00325	·000263
24	Homogeneous metal (length 1·295 in.)...	Firth & Co.	22,514	·003	·000231
62 „ 65	Puddled steel melted and cast into ingots (mean length 1·4175 in.)	Naylor and Vickers ...	21,998	·00575	·000413
13, 17, and 18	Steel iron (mean length 1·102 in.)	Atlas Works	23,574	·00533	·000459

"The samples tested were all about 1¼ inches in length. The approach of the steel pistons between which the samples were compressed was carefully measured, and the results as recorded are correct as showing the compressions of columns of the length employed. The amount of compression per ton per inch is however so great, and being moreover inconsistent with that which may be inferred from the experiments on transverse strain, it is to be presumed that the result is affected by the short length of the samples. The effect of the pressure is to enlarge the diameter at the centre of the sample.

Fig. 1 represents the sample No. 24 before pressure was applied, and Fig. 2 is the same sample after receiving a pressure of 51 tons per inch,

Fig. 1.

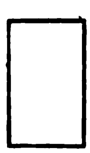


Fig. 2.

and similar effects though in a less degree result from smaller pressures. It is known that in long bars subjected to compression the centre portion is not proportionately expanded, and it follows that the decrease of length in short columns will not be proportional to that in long ones. It is evident, however, that the puddled steel and homogeneous metal are less compressible than cast puddled steel and steel iron. Puddled steel, whether cast or otherwise, could not be crushed with any pressure the machine was capable of exerting; the only effect was to produce an alteration in the form of the sample. This property would indicate that if great pressure were to be resisted it might be advantageous to submit the material to great compression before using it. The effect of the pressure appears to produce a re-arrangement of the particles, and when so re-arranged, they are capable of sustaining greater pressure than in their original form."

"By comparing these experiments (Table III.) with those of Prof. Barlow on wrought-iron bars 2 in. square (see Barlow on the Strength of Materials) it will be seen that the deflection under transverse strain is greater in puddled steel, when of like dimensions and under like circumstances, in the ratio of 10 to 11. But the weight it is capable of sustaining before the increments of deflection with equal weights cease to be regular is, as nearly as possible, double that of wrought-iron. Hence, so far as these experiments go, it would appear that a bar of puddled steel may be bent about twice as much as a bar of iron of like dimensions, without impairing its elasticity, or without causing a greater permanent set."

TABLE III.—*Summary of Experiments on the Resistance to Transverse Strain of Puddled Steel, &c.*

No. of Experiment.	Description of Material.	Name of Maker.	Mean Breadth.	Mean Depth.	Deflection produced by 7500 lb.	Value of E.*	Weight at which Deflection ceases to be regular.
			in.	ins.	ins.		lb.
39	Puddled steel	Naylor and Vickers	1·935	1·9275	·055	......	16,000
40	do.	do.	1·925	1·9600	·040	.. ...	16,000
41	do.	do.	1·985	1·9750	·040	... ..	18,000
		Mean	1·945	1·9542	·045	2,870,500	16,666
42	Homogeneous metal	Firth & Co.	1·955	1·960	·030	......	14,000
43	do.	do.	1·965	1·970	·060	......	14,000
44	do.	do.	1·960	1·980	·035	......	18,000
		Mean	1·960	1·970	·042	2,979,200	15,333
2	Puddled steel	Atlas Works	2·110	2·085	·037	......	16,000
3	do.	do.	2·055	2·050	·042	......	16,000
		Mean	2·082	2·062	·040	2,568,000	16,000
					Deflection produced by 5800 lb.		
4	Puddled steel	Atlas Works	·975	1·985	·062		8,000
5	do.	do.	1·035	2·020	·055		9,000
		Mean	1·005	2·002	·058	3,100,200	8,500
					Deflection produced by 2300 lb.		
6	Puddled steel	Atlas Works	2·010	1·005	·065	......	3,500
7	do.	do.	1·975	·960	·083	......	3,500
		Mean	1·992	·982	·074	2,838,000	3,500

[* The value of E is obtained from the formula $E = \frac{l^3 w}{32 b d^3 s}$

See 'Barlow's Strength of Materials.']

In the above experiments the weight was applied at the centre in each case, and the distance between bearings was 20 inches.

Specific Gravity.

"The specific gravity was ascertained to be as follows:—

Puddled steel	1st sample	....	7·7805
Do. do.	2nd do.	....	7·7836
Steel iron	1st do.	....	7·7431
Do. do.	2nd do.	....	7·7580

TABLE IV.—*Resistance to Torsion.—Puddled Steel.*

Weight applied at 25 inches from centre.	Firth and Sons. Diameter 1·763 inches.		Naylor & Vickers. Diameter 1·864 inches.		Naylor & Vickers. Diameter 1·861 ins.		Naylor & Vickers. Diameter 1·876 inches.	
	Deflection.	Permanent set.	Deflection.	Permanent set.	Deflection.	Permanent set.	Deflection.	Permanent set.
lb.	Degrees.							
100	·25	...	·00	...	·00	...	·10	
200	·20	...	·25	...	·15	...	·40	
300	·50	S. 0	·50	...	·30	...	·30	
400	·59	...	·75	...	·40	...	·50	
500	·70	0	1·00	0	·45	·10	·60	·10
600	·75	...	1·00	...	·60	...	·70	
700	·85	·15	1·125	·25	·70	...	·80	
800	1·00	...	1·150	...	·70	...	·90	
900	1·20	R.S. ·20	1·25	·20	·90	·10	1·00	·20
1,000	1·40	...	1·30	...	·90	...	1·20	
1,100	1·60	30	1·40	·30	·90	S.	1·30	
1,200	...	...	1·50	...	1·25	...	1·50	S.
1,300	...	...	1.50	·30	3·55	R.S. 2·00	1·50	·30
1,400	...	...	1·60	...	...	...	1·90	
1,500	7·35	...	1·60	·40	...	...	2·00	
1,600	8·85	...	1·95	R.S.	...	...	2·20	
1,700	11·80	...	2·55	·90	...	...	2·30	·30
1,800	15·50	...	3·10	...	...	...	2·50	
1,900	19·40	...	4·15	...	...	...	Broke in putting on 1,900 lb.	
2,000	...	...	5·60	3·00				

The strength of puddled steel in resisting torsion will be best understood by a direct comparison between the results in the Table (IV.) and those obtained by Major Wade on samples of the same form and dimensions in cast and wrought-iron. The following table (V.) is an abstract of such of his experiments as afford a direct comparison. In both sets of experiments the weight was applied at the end of a lever 25 inches long.

Good puddled steel and homogeneous metal appear to be very similar in their mechanical properties; their tensile strength being nearly double that of wrought-iron, the fracture being without fibre, and possessing a fine crystalline or granular appearance. Both materials are ductile, and may be condensed and consolidated under the hammer. Both materials also, although bending under transverse strain as much as wrought-iron with equal weights, are capable of bearing nearly twice as much strain as wrought-iron before producing a greater amount of permanent set.

It is to be regretted that the testing machine in her Majesty's Arsenal at Woolwich is not adapted to receive bars of sufficient length for determining the modulus of elasticity. The very short length of the samples which the machine is capable of receiving in applying tensile and compressive strains renders it impossible to arrive at correct conclusions from them in respect of the amount of extension and compression per ton per inch."

Mr. Barlow's experiments are an important contribution to our knowledge of puddled steel and the other materials tested. The ultimate strength under tension appears more uniform than might have been anticipated, which speaks well for the skill of the makers. We hope that, having gone thus far, Mr. Barlow may on some future occasion be enabled to ascertain by experiment the modulus of elasticity, and other data which still remain undetermined.

TABLE V.—*Table showing certain Results obtained by Major Wade on the Torsional Resistance of Cast and Wrought Iron.*

Description.	Weight applied, 1000 lb.		Weight applied, 1500 lb.		Remarks.
	Deflection.	Permanent set	Deflection.	Permanent set	
CAST IRON—					
No. 1, 2nd fusion	2°·2	0°·2	5°·9	2°·2	Mean of four experiments
Ditto, 3rd fusion	1·7	0·0	3·0	0·3	One experiment
10 parts No. 1 and 4 parts No. 3, 2nd fusion	1·5	0·0	2·4	0·1	Ditto
8 parts No. 1, and 6 parts No. 3, 3rd fusion	1·5	0·0	2 3	0·1	Ditto
Equal parts Nos. 1 and 2, 2nd fusion	1·9	0·1	3·8	0·9	Mean of two experiments
Ditto, ditto 3rd fusion...	1·2	0·0	2·4	0·0	One experiment
Mixture of 8 parts No. 1, 3 parts No. 2, & 2 parts No. 3, 2nd fusion	1·4	0·0	2·5	0·1	Mean of four experiments
Ditto ditto ditto 3rd fusion	1·6	0·1	2·5	0·2	Ditto
WROUGHT IRON—No. 1	...	0·0	17·5	16·1	One experiment
Ditto No. 2	...	0·1	16·6	15·4	Ditto
Ditto No. 3	...	1·2	39·7	37·7	Ditto

ON THE CONSERVATION OF ANCIENT ARCHITECTURAL MONUMENTS AND REMAINS.*

By G. G. Scott, R.A.

It may perhaps appear that I should offer some apology for occupying your attention with a subject at once so trite and so uninviting as that which I have chosen as the title of this paper. If so, I would say in reply, that it was intended for our opening meeting, and that those meetings seem to me to demand, as the leading subjects to be discussed at them, matters of vital importance to our art, rather than of an amusing or highly interesting character; and that I hold the subject I have chosen to be, however trite, one of the most pressing importance.

I assume as my starting point that every member of this Institute appreciates the immense value—to any country which possesses a history and a civilization—of the monuments and remains by which that history and civilization are illustrated.

The value of such monuments of the past is greatly enhanced when they illustrate the rise and development of a special style of art; still more so when that style of art is one of great and acknowledged merit; and yet more than all when it is one which has proved worthy of revival and re-development.

Those among us whose taste and education have led them to a more special appreciation of the art of the ancient world will feel how strongly these remarks apply to the precious monuments and relics of Greece and Rome, and of the countries over which their arts and influence extended. These illustrate a history and a civilization the most wonderful in its character: they illustrate also the development of a style of art the merits of which no one has ever presumed to question, and which has been revived and re-developed in more recent ages; and, as a natural consequence, every relic of these arts, however fragmentary or obscure, is searched out, delineated, and, when possible, protected and preserved, with an amount of zeal and assiduity proportioned to their importance, and which does honour to that modern civilization which so keenly appreciates and rejoices in that of the past.

Should not however the same feelings, and the same care, zeal, and assiduity be extended to the monuments of our own race and our own country? Have we not a history as glorious and, to us at least, as interesting as that of the great nations of antiquity? Have we not a civilization as noble as theirs? and should not the monuments which illustrate that history and civilization be as precious in our eyes as those of Greece or Rome?

Added, however, to the value which these remains ought to possess in our eyes as Englishmen, they possess *intrinsic* claims parallel to those of the works of the great nations of antiquity. They illustrate the development (and especially our own share in it) of a style of architecture as marked in its character as theirs; and the merits of which, though long neglected, are now appreciated and acknowledged by most of us; and have, just as in the case of the Classic styles, led to its revival and re-development.

Let it be clearly understood that I am entering upon no controverted questions,—I am instituting no comparison between the intrinsic merits of the two phases of art,—nor asking any assent to more than the fact of their revival. On all such questions we may hold our individual opinions, and yet may all agree to what I wish to lay down as the groundwork of what I desire to say, that our architectural monuments possess claims upon our care and conservation precisely parallel in their nature to that which we accord to those of classic antiquity, but with these two preponderating points in their favour,—that they *are our own* monuments, and that *we* are the parties responsible for their conservation.

I would next bring under your consideration the melancholy fact that, though our country is studded with these relics of the past, they are every year being reduced in number; and that those which remain are constantly subjected to the danger of destruction or deterioration from many different causes; among the chief of which I may enumerate,—

I. Natural decay and dilapidation, which are greatly enhanced by the destructive climate to which they are exposed, and still more by neglect.

II. Wilful destruction and ruthless mutilation, together with alterations suggested by the passing requirements of the day, or by individual caprice.

III. The yet more destructive inroads of *over restoration.*

These three causes or classes of causes threaten, in a degree so imminent and so alarming, the existence, the integrity, and the authenticity of our ancient architectural remains, that I feel it to be high time that this Institute, together with all local architectural and antiquarian societies, should take it into their serious consideration, both severally and jointly, what measures can be adopted to arrest the evil before it be too late.

Our ancient architectural remains may, for the most part, be classified under the following heads:—

I. Mere antiquities—such as Stonehenge, the cromlechs, and many of the remnants of Roman structures; though the latter often contain objects of art, as mosaics, pavements, &c.

II. Ruined buildings, whether ecclesiastical or secular, such as abbeys, castles, &c.

III. Buildings still in use, as churches, houses, inhabited castles, &c.

IV. Fragmentary remains embodied in more modern buildings, such as those which usually exist within the precincts of cathedrals, and often in old houses and country mansions; to which class may be added a vast amount of interesting and valuable fragments, mainly of domestic architecture, and often—though of a simple and even rustic character—of great practical importance to the student of our old architecture, to be found among our country villages and in the scattered houses of the farmers and the peasantry, as well as other miscellaneous remains.

On the first of these classes,—that of a purely antiquarian character,—I will not trouble you with any remarks, as I think that our antiquaries are sufficiently alive to their value, and exercise a wholesome vigilance in respect of them. It is not in general this class of ancient remains which is most in danger, though it behoves every one who has it in his power to do his very utmost for their preservation.

The second class, however,—that of ruined structures,—is one which demands much and careful consideration; and it is one towards which the salutary vigilance of our Institute and of kindred societies might with great advantage be directed.

The very condition of a ruin of necessity involves liability to rapidly increasing decay and the probability of speedy destruction; and it so happens that two great events in our history—the dissolution of monasteries in the sixteenth and the dismantlement of castles in the seventeenth century, have reduced two important classes of architectural edifices to this hopeless condition.

As regards ruined castles, it fortunately happens that the massiveness of their construction enables them in many instances to offer a fair amount of resistance to the elements; and that the simplicity of their architecture causes them to lose less from mere decay than structures of a more decorative kind. Such is not, however, always the case; and I would most strongly press upon those who have the charge of those stern historical relics to guard them against the effects of time and mutilation; and upon antiquaries and antiquarian societies to make periodical examinations into their condition, and to advise their proprietors as to such timely works of reparation and sustentation as may arrest the hand of time, without tampering with their antiquity: and if their natural guardians refuse the necessary protection, to raise funds by private subscriptions for the purpose.

When we come, however, to ecclesiastical ruins, the case becomes infinitely more pressing. Unlike the great works of defence just alluded to, these edifices were not erected with a view to resisting any but the ordinary causes of destruction to which buildings are subjected. Their structure is comparatively light, and in principle trusts for stability to the nice equipoise of arches and abutments, and presupposes the protection of a roof. It is, therefore, a matter for wonder that, after more than three centuries of exposure, unroofed and uncared for, and though often used to supply materials for surrounding building, their ruined forms should, in so many instances, have reached our time in a condition which enables us in any degree to appreciate their merits or their design.

Happily, however, though great numbers of them have ceased to exist, very many precious remains are left to us; and these, instead of being, like those of castles, stern and almost forbidding in their undecorated grandeur, are for the most part exquisite and highly-finished architectural productions, equally valuable and equally beautiful with our glorious cathedrals; and, in their own phase of art, as classic and as perfect as the remains of antique art which we so much cherish.

Now, the two points to be considered are, first, can we expect these precious fragments to endure much longer? and, if not, what can we do to promote and prolong the continuance of their preservation?

* Paper read before the Royal Institute of British Architects.

On the first question I fear that the reply cannot be very satisfactory. Those who have for any considerable course of years been in the habit of revisiting any particular ruin, can scarcely fail to have observed how sensibly and how surely the course of decay, disintegration, and downfall has progressed, even where there has been no deliberate mutilation. The decay of the surfaces seems to have of late years redoubled its speed. I have revisited buildings,—and particularly ruined buildings,—where twenty years earlier I had been able to make minute sketches of delicate carved work, and found the carving now become unintelligible. In many of the best preserved ruins we find the surfaces of the mouldings and carving covered with an ever-fresh pulverulence. If you visit a building in this exposed condition, after a hard winter, you are sure to find fresh spots where the details have fallen off through the recent frost; and in every ruin there occur, from time to time, slips and downfalls of greater or less importance; showing that, long as they have resisted the assaults of time and weather, there are limits to their duration, and that those limits are by no means distant.

How many of our ruined buildings have lost large portions within the memory of man. The Abbey of St. Augustine, at Canterbury, has lost its great tower within no very distant period; and I myself remember the newspaper notice of the fall of the central tower of Whitby Abbey, carrying away with it large portions of the surrounding building: indeed, such downfalls, if their statistics could be collected, would be found to reach an alarming number and amount; while the silent and yet more fatal progress of decay is every day and every hour eating into the most beautiful and most precious architectural details.

And how could it be otherwise, when walls constructed of small stone and rubble-work are exposed, with no protection but ivy and wall-plants, to the constant action of the most destructive of climates; when every shower penetrates the crumbling mass, and every frost has its full swing in its disintegation; and even the more solid stone, from being kept in a constant state of saturation with water, has every cause of destruction in full and continued operation upon it,—and all this for centuries together?

Nor have these been the sole agents of destruction. Many, indeed the great majority, of our noblest abbey churches, and even some cathedrals, have been taken down for the value of their materials; and those which were left as ruins were, for the most part, spared more because there was no market for their material than for any care for their preservation; and it naturally follows that they would become the quarries which would supply all the petty buildings around them. Perhaps the most remarkable case of this is at Reading, where the walls of the abbey have been stripped of their ashlar, both without and within, and the rubble core only left; yet such is its extraordinary strength, that it still holds together in perfectly solid and compact masses; and where fragments of the tower long since fell they remain to this day, protruding from the ground at the same angle at which they first reached it, and look like masses of rock cropping out of the earth. This has been continued in many instances up to our own day; and even now it is occasionally found in a certain degree to hold good, as at Easley Abbey, in Yorkshire, where the lower part of the buttresses appear to have been comparatively recently pulled down, as being the parts most easily got at; while the upper stages, being out of reach, are left unsupported, and dragging over the walls which they were built to stay.

For the most part, however, it is neglect and the want of timely care which we have now most to complain of. I heard the other day of a considerable portion of a ruined abbey in Norfolk falling down, and this on the property of a great lord, who, I am sure, would have taken proper precautions had his attention been called to it by anyone qualified to give an opinion. The proprietors of these melancholy yet glorious remains, though valuing and caring for them as picturesque ruins, frequently seem to forget their value as works of art; and to prefer risking their falling to pieces bit by bit, to the trifling interference with their picturesque effect which would be incurred by a little timely reparation.

Now, what I wish to bring before you as the practical result of what I have been saying, is the absolute necessity for such reparations, if we desire to hand down these precious architectural relics to our successors.

In defining what the nature of such reparations should be, one may use the words of Mr. Ruskin:—

"Take proper care of your monuments, and you will not need to restore them. . . . . . . Watch an old building with an anxious care; guard it as best you may, and, at *any* cost, from the influence of dilapidation. Count its stones as you would jewels of a crown: set watches about it, as if at the gates of a besieged city: bind it together with iron where it loosens: stay it with timber where it declines: do not care about the unsightliness of the aid, better a crutch than a lost limb; and do this tenderly, and reverently, and continually; and many a generation will still be born and pass away beneath its shadow. Its evil day must come at last; but let it come declaredly and openly, and let no dishonouring and false substitute deprive it of the funeral offices of memory."

The great objects of such reparation are, protection against the penetration of water into the walls; support, to prevent downfall from the failure of foundations, abutments, or the sustaining work, whatever it may be; and, lastly (if such a thing be found to be practicable), the preservation of the architectural details by some indurating process which will arrest their decay. None of these need, if judiciously carried out, materially or permanently affect the picturesqueness of the ruin: and I need hardly say that they must be done so as in no degree at all to infringe upon the authenticity and genuineness of the work. The case is wholly different from restoration; protection and preservation being the sole objects.

It would, however, be dangerous even for such works as these to be carried out by ignorant persons. They demand the careful vigilance of the antiquary and the architect, to see that the value of the remains is not injured. It seems to me that there ought to be a kind of vigilance committee appointed for every district by our Institute, in conjunction with antiquarian societies, whether general or local; that these committees should not only themselves take every opportunity, whether collectively or by their individual members, of inspecting every architectural ruin within their district; but should take public measures for inviting information and suggestions respecting them; that they should from time to time report to the proprietors of such remains, and suggest what reparation is needed; and that they should take measures for obtaining funds for them when they find that such aid is necessary. They should also obtain permission to direct what is to be done, and to have a *veto* upon anything which would be injurious.

For protection againt the admission of wet from the top of the walls, much could be done by coating them roughly on the parts invisible from below with a concrete of cement and fine gravel; by resetting loose stones in cement; by filling in with the same material cavities and open joints, cracks, &c.; always taking care, as far as possible, to do this in a manner little, if at all, visible from below. In extreme cases, where arches threaten ruin, it may be desirable to go the length of erecting centres below, and rectifying them, and filling in the joints with cement.

When any large mass of a wall threatens to fall, shores should be applied, the foundations examined and strengthened, if necessary, loose stones keyed in, open joints filled, and, in very bad cases, bonded; but this should be done under the eye of a person who has a feeling for the work, both on its own account and as a picturesque object, so as to avoid any unsightly tampering with the old work. The only cases where such is necessary seem those in which the shattered piers or walls are insufficient for the weight they have to bear. In such cases they must be underbuilt, buttressed, or propped in the same way. Here it will be best to make the new work rough and of old materials, but in no degree to mask it, but rather to make it manifest that it is only added to sustain the original structure. It is clear that in such cases it will be best to call in an architect, provided he is one who has an earnest care for the conservation of the work, and a full appreciation of the value of its authenticity.

I may here mention that the west front of Croyland Abbey, which threatened immediate fall, has been of late rendered, as I hope, permanently secure by means of repairs, such as those alone suggested, carried out under the influence of the Lincolnshire Architectural Society.

The importance of applying to the finer details a preservative and indurating solution, if such is to be found, is almost as great as that of the upholding of the masses: the pulverisation of the surface seems in many cases to be going on at a constantly accelerating pace, and threatens the speedy loss of the true forms of the mouldings and the sculpture. At Fountains Abbey, perhaps the best cared-for of all these remains, I have observed the constant disintegration of the mouldings from this cause: if we could save them by such a process, it would be worth anything.

In the interior of Westminster Abbey, I am gradually indurating the mouldering stone in its present state, and securing it (as I hope) from further decay; and it is not unreasonable to hope that a process will be found which will do the same for external work.

Besides, however, doing what is possible for the conservation of these invaluable remains, we ought also to see that there is no part of them which has not been thoroughly and carefully represented and measured. I think a society ought to be formed, or a united effort made by different existing societies, for the perfect delineation of our ruined buildings. A good deal has been done by Mr. Sharpe, Mr. Potter, and a few others; but the thing has never systematically been taken in hand.

Now that we understand and appreciate the value of the remains of our ancient architecture, it is a standing disgrace to us that we allow them to remain without perfect and authentic illustrations being made of the whole, and of every detail; and where it can be done without disfigurement, and without endangering the tender and pulverising surface, a cast should be taken of every carved and sculptured portion, which should be deposited in some permanent national collection, with a full description of the parts to which it belongs.

Photography may also be most usefully brought to bear upon the subject, but must not be implicitly trusted to, on account of the uncertainty of its duration; but whatever the modes adopted, it will be monstrous if we allow the most valuable of our ancient architectural remains to become disintegrated, and their exquisite details lost, without having placed upon record perfect and absolutely authentic representations of every portion of them. Let us prolong their existence to the utmost limit, but, at the same time, provide against their dissolution by perpetuating their designs, in some form which will exist after the glorious originals have passed away, or become unintelligible from decay.

I now come to the third class of ancient remains—buildings still in use.

Here we come at once within the region of controversy, of animadversion, and regret; for here we have united in one *all* the causes of destruction and deterioration,—natural decay, neglect, wilful destruction and mutilation, and the now so prevalent operation of *over-restoration*.

I must beg, before I proceed, that it may be clearly understood that, in any criticisms I may express on the course followed by others, I do not wish or expect to exempt myself from equal blame where I deserve it. We are all of us offenders in this matter; and to abstain from speaking plainly, lest we should be ourselves blamed, will be a course at once cowardly, and treasonable against those principles which one every day more strongly sees to be right, however conscious one is of continual departure from them.

In speaking of ruined buildings, I have fully and cordially adopted Mr. Ruskin's principle of mere *sustentation*. For such remains it is clearly right. This, however, cannot be strictly acted upon in dealing with churches and other buildings still in use. Viewing them solely as original architectural remains, one would desire, were it possible, that the same abstinence from all but mere upholding should be applied to them; but, in the first place, it is clearly wrong to treat the houses of God as mere architectural specimens, to be stereotyped in their present state of mutilation and decay for our study and instruction; nor, if it could be proved right, would it be possible to convince their guardians that such a course should be followed; nor, in the case of houses and other secular buildings, to induce people to inhabit and make use of ruins to gratify our sentiments towards them.

It may then be laid down as an absolute certainty, that buildings whose use is continued must be kept in, or put into, a seemly state of reparation; and it is, therefore, both our duty and our interest, instead of opposing what cannot be prevented, to do our best to lay down laws for ourselves, and suggest them to others as guides in carrying out the works which of necessity must be done.

The great principle to start upon is, to preserve the greatest possible amount of ancient work intact; never to renew a feature without necessity; but to preserve everything which is not so decayed as to destroy its value as an exponent of the original design; never to add new work, except in strict conformity with the evidences of its original form; never to mask over or smarten up old work for the sake of making it comformable with new; never to "restore" carved work or sculpture, but to leave it to speak for itself; and, generally, to deal with an ancient work as with an object on which we set the greatest value, and the integrity and authenticity of which are matters which we view as of paramount importance.

These principles, are, however, much more readily laid down than acted upon;—so much so, that to one who holds them, the process of restoration is one of continual disappointment, vexation, and regret; for, labour as you will to act up to first principles, innumerable hindrances stand in the way of their realisation. Sometimes the stone is found to be so utterly disintegrated, that it is with the utmost difficulty—here a bit and there a bit—that you can trace out by laborious study what were the original details; and to attempt to keep these bits seems as hopeless as to preserve a body which falls to dust as you look at it. Sometimes, when this is by no means the case, a barbaric builder or clerk of works, or an over-zealous clergyman, interferes in your absence, and destroys the very objects you have been most labouring to preserve.

A conscientious representative having been blamed for incurring extras in one place, makes up for it in another by introducing, before one is aware of it, a sweeping clause, which condemns quantities of work one meant most religiously to preserve; and, from one cause or another, one is always finding one's intentions more or less frustrated. Still, however, this is better than acting on no principle at all; or must be better than openly to advocate and act upon those which are decidedly wrong.

However this may be, there is no doubt of the fact that our churches and old buildings are everywhere losing their value, through misdirected and reckless, or at least overdone restoration; that it is high time that some public protest be made against it, and some course adopted for its prevention; and that each of us in our own practice should institute a rigorous examination as to what he has done and is doing, with a view to a stern falling back upon true principles, that the churches yet unspoiled may yet be saved.

Here, again, I would suggest the vigilance committee already hinted at. It could do much, though the works in this case are so many, and so widely spread, that it seems impossible for *all* to be watched.

After all, then, we must look to the architects employed. If they will not labour in the right direction, I fear there is but little hope: and yet, without some stern supervision, I believe that the majority of them *will not do so*; and, further, that they will always be able to adduce such plausible and practical reasons for their destructiveness as to convince their employers that they are in the right.

I am, however, very uncertain whether we do not *all* go upon a very wrong principle in our dealings with ancient churches. I could almost wish the word "*restoration*" expunged from our architectural vocabulary, and that we could be content with the more commonplace term "*reparation*."

We have got into the way of assuming that the "restoration" of a church must, in its own nature, be the signal for pulling it to pieces from top to bottom. Not only must substantial repairs be attended to, the foundations underpinned, the strength of the walls looked to, decayed timbers spliced or new ones here and there inserted, the most decayed stones carefully cut out and replaced, the covering made reliable, and the fittings put in seemly order, following and retaining every remnant of what is ancient, the stonework cleaned from its thick coatings of whitewash, and the roofs divested of the concealment of modern ceilings;—but, beyond all this, *everything must be meddled with;* the seating all taken up, floors removed, plastering stripped from the walls; the whole church left for some months at the mercy of the elements by the removal of its roofs; windows which do not please the clergyman or the squire replaced with more pretentious ones—indeed, the whole thing overhauled, and *radically re-formed* from top to toe.

We all of us, however conservative our views, adopt something approaching to this as the normal and necessary view of a restoration; and the chief difference between us is that, if the architect be at heart earnestly conservative, the church comes out from the ordeal with a certain amount of its ancient self remaining, but with very much of a new garb, or very much of its ancient look and very many of its interesting ancient features gone; but if his feelings are not conservative, so much the more is there of novelty instilled, and so much the less of antiquity retained in the restored church.

Now this is really beginning to tell in a fearful manner upon the value of our ancient churches, and the interest with which one visits them. One perfectly longs after an untouched church, though one knows that the state of them is by no means such as a man of good feeling can look at without shame. Still in them are found our old churches, as they have been traditionally handed down to us. True it is, that the exterior is in part mutilated and even disgraced by barbaric alterations; yet one feels that the old work which remains is genuine and untampered with. True, the interior is coated with whitewash, thickened out indefinitely by the repetitions of centuries; but beneath it we know that the old stonework is as the very workman left it; and that, if carefully scaled off with one's knife, we shall find the distemper decorations of perhaps two or three periods in its thickness. True, the roof is decayed, patched, and perhaps hidden by a plaster ceiling; but we know that its timbers were wrought by the very men whose architecture we are studying; and that it is of the utmost value as an original specimen of their work. The floor, it is true, is sunken, worn, and patched with brick; but it contains the half-effaced memorials of those who lived while the church was new, and when parts of it were being built; and in certain corners remain the ancient encaustic tiles. The windows again are filled with patched and irregular glazing; but in the heads of the lights are remnants of the stained glass which once filled the whole. The bells are perhaps cracked; yet on them you will find the beautiful fretted border, and the pious, though it may be superstitious, legend.

And what is the state of a restored church? The external stonework is in good repair, but the antiquity of its details is dubious. The windows are of nice chronological accordance, but they fail to tell the church's history. The internal stonework has thrown off its coating of whitewash, but it has been reworked, and all the toolmarks of the old masons scraped off by the unpitying drag, or chipped away and replaced by modern toolings; the plastering is done to perfection, but it projects in strange unnatural notchings round the stone dressings, and has replaced what was a storehouse of the relics of old decorative painting; the roofs are of sound oak, or display all the smartness of stain and varnish, but the old timber-work we valued is gone, and what now appears is not even like it. The floor is, perhaps, of the uniform neatness of a Staffordshire farmer's kitchen, or, it may be, displays all the glories of encaustic tile; but the memorials of the dead have perished, and the works of Mr. Minton (to which they have fallen victims, have scornfully ousted those of his teachers, while the local patterns of old times have given way to those which one now finds stereotyped from one end of the country to the other. The windows are nicely glazed with cathedral glass, and some of them with stained glass of reasonable merit, but the one has thrust out the fragments of ancient glass-painting, while the other has scorned all endeavour to follow out and take example from their designs. The bells have been capitally recast by Mears and Warner, and their tones are, no doubt, musical; but if you go up to look at them, you find the ancient fretted border replaced by some vulgar beadings, and the pious and beautifully lettered legend by the names of the founders and the churchwardens, in lettering which would do honour to a haberdasher's shop front.

This is a fair statement of an average church restoration; but there are many worse, as well as many better cases. The great majority, I grieve to say, are very far worse. We find in some of them reckless and often ignorant and senseless destruction of old work, united with an intense want of feeling in all that is done anew; so that the church has become equally sickening from what it has lost and what it has gained. In others, again, we find an *utter blank* of interest—a church reduced to a state of unredeemed lukewarmness. I have recently been especially struck, in making a little tour, with the prevalence of this last-named type among restored churches: a nauseating blank,—neither anything interesting left, nor anything good introduced; and yet I was self-condemned at considering that the process, viewed as a whole, was much the same as that we are all in the habit of applying to our restorations, the chief difference lying in the degree of conservative feeling and of artistic skill with which it is applied. My great perplexity is to decide whether our entire system should be reconsidered and altered, or whether the whole question is one of details and of individual cases, each to be decided on its own merits.

Now let us consider for a moment what *should* be the beau-ideal of a restored church.

First of all, we have all its structural dilapidations so far repaired as to secure it against actual danger, and to insure its stability. The external stonework would be so far repaired as is necessary to bring out the architectural forms where seriously decayed and mutilated, and to render the structure of the walls sound and durable. This would be done, not on a wholesale principle such as could be described in a specification, but in a tentative and gradual manner: first replacing the stones which are entirely decayed, and rather feeling one's way, and trying how little will do, than going on any bold system. Every new stone will thus be a perfect transcript of that which it replaces, and this will, as far as possible, extend to its dimensions and the mode of workmanship; for there is a character even in the proportions of ashlar stones,—still more in the mode of working them. Where a part is wholly or in any great degree wanting, it is questionable whether it would be supplied beyond the extent of existing evidence; when later features have been interpolated, it is yet more questionable whether they would be removed: such questions must depend upon circumstances, such as the merits of the original and the interpolation, and upon the question whether the latter is in a state to demand thorough reparation, and whether the original features preponderate and give their character to the building. Such questions, too, would have been entered upon with a strong leaning against alteration; and this would show itself clearly in the result.

The interior would, it is true, be divested of its whitewash; but where this would not come off by fair means it will be more or less left on, for a little discolouration of the stone is of infinitely less moment than the obliteration of the ancient tooling, so that in cleaning it no hard tool must ever be brought to bear upon its surface. Where the stonework had been coloured or decorated in distemper, the traces of this would be preserved with a loving care, no matter how indistinct or fragmentary they may be.

The plastering may to some extent be renewed; but wherever the old colouring could be preserved portions of the plastering would be left, and the new would be, like the old, *thin*, and not projecting beyond the stone dressings. The roofs, if ancient, will have been studiously repaired, so as to preserve every fragment which can be made to do its duty, even though the roofs may not be of the original date or pitch.

The floor, though levelled and made free from damp, will retain all its monumental slabs in their true places, and the remainder will be made in a great degree subordinate to them, and of the material which, so far as can be ascertained, was before used, whether stone or tile. If old encaustic tiles remain, they will receive all due honour and protection, and new ones will be founded on their patterns.

The seating will probably be the carrying out of such parts of the old seating as may have remained, all old screens, &c. &c. being carefully preserved, and that in their own proper places. Where ancient features, as niches, &c., have been ruthlessly destroyed, they will have been carefully traced out, and either exposed to view and left to speak for themselves, or, if sufficient traces are left and fragments found (which is often the case) to warrant it, they will have been studiously and with religious accuracy restored to their original forms, no old part being disturbed, and every old fragment worked in.

The fragments of old stained glass would retain each its own place, and if new glass be introduced where such remains exist, it will be made to carry out the design which they suggest. In a word, the old church will, by a studious and tentative process, have been brought into a seemly state without any smartening up of old weather-beaten surfaces, and without any loss of ancient or traditional character; while in such fittings or necessary features as there was no ancient guide for, it will be felt that the restorer united the ability to carry out the spirit of the old work with a desire to limit himself to the smallest possible sphere in the exercise of it.

This seems the true ideal; but, as I have before said, it is by no means easy, and often impossible, to realise it. The extent and intensity of the decay of the materials, the shattered condition of the walls, the extent of barbarous mutilations, and the necessity for enlargement or other practical alterations to meet present wants, all militate more or less against it; yet the ideal suggests the *spirit* in which the work ought to be undertaken, even when it can only be partially attained; and I fear that it is not by any means the spirit with which such works really are undertaken. On the contrary, it seems as if many promoters of restoration, and those they employ, laid themselves out to destroy interesting features, even when a general restoration is not carried out. I passed the other day through a village (Edenbridge, in Kent) where a few years before I had sketched a window of great peculiarity, such as I had only seen one other instance of; it was one whose tracery was arranged especially to give scope to a crucifixion in the stained glass. I went to look at it again, when, to my dismay, I found that it had been singled out from among all the windows in the church for destruction, and a window of the vulgarest form substituted. Again, in a church near Reading there were many beautiful remains of painted glass of the beginning of the fourteenth century, in the heads of the window lights, which I took much trouble to get tracings of. The church was "restored," and they all disappeared.

The noble church of Cley-upon-Sea, in Norfolk, had, when I saw it three or four years back, an original roof of the fourteenth century; certainly much decayed. It has now, I hear, been replaced by one of the meanest and most contemptible kind, not having the smallest reference to its ancient type. Wherever old frescoes are found, the clergy set themselves especially against them. In a church I was myself engaged upon in Cheshire, the whole walls were found covered with large figures and other decorations of a most interesting character. Their destruction was decreed. I interfered, and threatened the builder's foreman with dismissal if he carried out the sentence; but they cleverly allowed the question to go by default, and let them be destroyed by exposure to rain, while the roof was uncovered. In another place, the gentleman who paid for the restoration set himself earnestly to preserve a most remarkable fresco; but, while his back was turned, a workman, supposed to be bribed by another parishioner, chiselled it off. Even at Eton College, where the walls above the stalls were found to be covered with two ranges of oil-paintings, in the manner of the Flemish school of the fifteenth century, the Fellows of the college had one whole range chiselled off from each side of the chapel, and the other range concealed by canopies which had never existed on the old stalls. This act of Vandalism I saw myself being perpetrated. And so it is all through the country; the most interesting features of our old churches are being weeded out through the carelessness, the prejudices, or the deliberate barbarism of those who have to do with them. Nor can the architect in all instances prevent this. I have now a church in hand where, an enlargement being necessary, I had arranged it with special reference to preserving a curious fragment of extreme antiquity; but the builder, who could not conceive why so scrubby a bit should be retained, took it down, asking no questions, and, in spite of my earnest remonstrance, has gone on finding one bit after another of old work to be too far gone for retention, and has let the old wall-painting, for which the church was celebrated, perish from exposure; indeed, having no clerk of the works, I was obliged to threaten the builder with extreme severity to induce him to spare anything at all. The fact is, that unless one is always at the spot, or has there a representative imbued with the right feeling, there is little chance for a building when once any portion has to be rebuilt; and sometimes, I fear, when the architect is on the spot, he does much the same thing, and perhaps even avails himself of his proximity to press with the greater success his anti-conservative suggestions and arguments. I will here offer a few suggestions which may possibly be of some utility.

1. I have found it in some degree useful to have a code of rules and suggestions drawn out and lithographed, for the guidance of clerks of the works and builders who are engaged in restorations. I take the liberty of laying one of these papers on the table, but will mention that they are of little use, unless constantly pressed personally upon the attention of the parties concerned.

2. The great enemies to careful restoration are contracts. The best course would be to carry them out by day-work, feeling one's way in the most timid and careful manner, and always striving to do as little as is practicable. When contracts are necessary, a series of small contracts is better than one general one.

3. It is highly desirable to avoid uncovering a roof all at once. When re-roofing or re-covering the roofs is necessary, it is best to do it in small parts, and keep the rain out by temporary expedients as you go on.

4. It is often the case that the exterior of window tracery is hopelessly destroyed, while the internal half remains sound. In such cases I hold the proper course to be the renewal of the outer half alone, attaching the new work by plugs and cement. We thus retain one-half in its original form, and insure the correctness of the other half.

5. Patching and piecing, if done carefully, are infinitely preferable to more wholesale renewal. The various cements which we have at our command enable us to introduce the smallest pieces into decayed or mutilated mouldings, which was formerly impracticable. Where the injury, however, is unimportant, it is better to leave it untouched.

6. Never trust a clerk of the works or any unpractised hand, to obtain the sections of mouldings, or the forms of other features to be restored. It is often difficult enough to persons whose eyes and whose instincts have been sharpened by the habit of studying ancient features through a long series of years; to those who have had no such advantage, it is simply impossible, and one need not be astonished to find them, even with nearly perfect copies before them, producing forms scarcely resembling the original at all. I have often known them, even when they have passed a saw-curf (according to their somewhat barbarous custom) through a moulding, and ruled off its section, produce a result totally at variance with the old moulding.

7. Where an ancient feature has been destroyed, never attempt its restoration till the parts round where the original existed have been thoroughly opened out and explored, and, where possible, in your own presence. Old fragments are in such cases nearly always discovered, and usually in great abundance and near their proper sites.

Thus, fragments of a destroyed window are usually found in the wall which blocks up or surrounds the old opening. Blocked up niches, sedilia, or piscinæ, commonly contain each their own *debris*. Often, however, these are not quite sufficient to perfect a design, and the skill of the architect is taxed to the very utmost to judge what the rest would be. This resembles the labours of the palæontologist, who reconstructs the skeleton and the animal from a few broken bones; and, as in his case, the work is impossible to any but one thoroughly acquainted with his subject.

This is, indeed, a most important branch of the subject, and is by far the most interesting and cheering phase in restoration. In the hands of an experienced and painstaking restorer, it often happens that a design which had been almost utterly lost is in a very great measure recovered; but this can only be done by long and patient study of the fragments discovered; and the work should be indefinitely postponed, until these can be thoroughly explored and thoroughly studied. Too much stress cannot possibly be laid upon this. It is the very pith and marrow of restoration. If neglected it is destructive to the work, though if carried out fully it is the great redeeming fact which compensates for many of the annoyances which restoration involve.

In such cases all the fragments which can be by any means grafted into the restored work, should be brought in at whatever cost. In difficult cases let the architect stick to it hard and fast, until his difficulty is solved; and let him set as lightly as possible by the conjectural theories which, one by one, occur to him, for he may almost depend upon it that they are wrong. With the single exception of Professor Willis, I never met with a man who could make guesses on which a moment's reliance could be placed. He does so simply because he has a wonderful intuitive power of putting together evidence in his mind, which few possess, and still more because he never makes a guess until he has collected and thoroughly weighed his evidence. He has swarms of imitators whose practice is the very reverse. To begin with, they only half understand their subject, and they build upon this defective foundation a superstructure of guesses running ahead of the evidence, and adhered to religiously after proof has been found of their fallacy.

To those who have not such intuitive perceptions, the only course is not to guess at all, or to set so loosely by your theories, that they may, one by one, go to the winds without a moment's regret, as fast as adverse evidence presents itself. I remember once investigating the design of a very much altered and mutilated window, when, after constructing a most satisfactory theory, a little bit of evidence turned up, which not only let it all down with a run, but involved the whole question in new obscurity. An excellent young assistant who was with me, exclaimed, in a fit of impatient vexation, that he wished to goodness we had not found that nasty feature, for it had spoiled all our work. I replied, "Never regret evidence, however vexatious; for depend upon it, it must lead to a right conclusion, or, at least, prevent wrong ones." However, I could not at the time see my way through it; but some time afterwards, while away, a new thought occurred, and I went back and told my assistant, that if, on cutting into the wall at a certain point, he found a certain feature, I could unravel the whole mystery. This was searched for, and found, and the whole of the evidence at once fell into its place; and the only remaining wonder was, how we could have been so stupid as not to think of so obvious a thing before. At other times, however, the result is so completely different from what we could possibly have anticipated, that one's wonder rather is, how one could have ever been so conceited as to venture upon any conjectures at all.

Nothing can be more delightful and instructive than this class of investigation. One sometimes finds objects of the greatest interest, and unfolds designs of the greatest beauty and originality, of which not a trace was before visible. Were it not for this, the work of restoration would be almost unmitigatedly painful, from having constantly to meddle with and to replace genuine but hopelessly decayed work: these discoveries, however, and the beauties they unfold, afford a delightful and consolatory compensation.

How doubly distressing, then, is it to see evidence of this kind discovered, but ignored and destroyed, without one hint being taken from them, as is too often the case!

After animadverting, however, upon our own misdeeds, I think I may be excused in speaking somewhat plainly as to the fearful loss of authentic work of the most precious, indeed of the most *inestimable*, value, which is going on throughout the length and breadth of that country which boasts itself to have been the birthplace of Pointed architecture; and where, if that high claim can be established, it follows, as a necessary consequence, that every original fragment, and every authentic detail, or—more correctly speaking—the originality and the authenticity of every fragment and every detail, should be guarded with a jealousy proportioned to their value as the most trustworthy and the most genuine illustrations of the rise and development of that wonderful style of art.

It is perfectly inexplicable to me, how the very same persons can at one time bring cogent arguments to prove that their country was the nursing mother of Mediæval art, and at the next should deliberately, and without necessity, take down from her noblest architectural monuments original details of the most exquisite description which imagination can picture, and which have suffered comparatively little from time, and replace them by modern copies. Yet this is the course of proceeding going on from one end of France to the other—and that, not by one architect in particular, but, in a greater or less degree, by all the architects who are engaged in the restoration of the ancient monuments of France.

In that country we have to applaud the generosity of the Government in undertaking on so munificent a scale the restoration of its ancient architectural remains. We have not, as sometimes with ourselves, to lament the employment of persons of dubious capability; for the works are generally in the hands of men of the greatest eminence, and of undoubted skill and knowledge: nor have we to complain of any want of artistic power in the carrying out of the works; for in this we must acknowledge ourselves to be in many cases surpassed. What we have to lament, to deprecate, and to protest against is, that inexplicable absence of appreciation of the value of the authenticity and of the actual *bonâ fide* genuineness of old work, which leads them to reject without scruple or remorse the most charming original work for some mere trifling defect, and to feel perfectly satisfied with a copy which, however skilful, must be lifeless from the very fact of its *being* a copy; and which, even if as good as the original, must be utterly devoid of the interest and historical value which attaches to it. The extent to which this feeling, and the course which results from it, extends itself is as lamentable as it is inexplicable, and absolutely threatens to replace half of the ancient monuments of the country by mere copies of them. True it is that these copies are admirable in execution, and careful and studious in their correctness; but who cares for a copy if he can get the original? or who will ever look at the details of the French cathedrals as exponents of Mediæval art when they know them to have been executed in the nineteenth century? And it is not the examples of Pointed architecture alone which are being thus tampered with, but even the curious Byzantine remains in Southern France, and the Classic monuments at Nismes. When I was preparing, some time since, a lecture for the Royal Academy on the rise of Pointed Architecture, I had a great desire to see a drawing of any capitals which might exist at Perigueux; and, on making inquiry of a friend who had just been there, he said, "Oh! I could have got you one if I had known, for the old ones were lying about among the old materials." One hears a story of an American who, after looking at the new works always going on at the Colosseum, remarked with very just irony, "It'll be a very fine building when it's finished." And I learn from our excellent secretary, Mr. Lewis, that the very same thing is going on now at the Amphitheatre at Nismes!

Even Carcassonne, so famous and so interesting as a city, almost deserted before the close of the Middle Ages, and consequently a wonderful genuine specimen of a Mediæval city, is, as I learn from Mr. Lewis, being renewed and made into a (no doubt very learned) model of that of which it was the dilapidated original!

A visit to the Hotel Cluny affords a practical commentary upon this system of restoration by renewal. We see there capitals from the Sainte Chapelle of an exquisite subtlety of conception and sculpture, such as to bid defiance to any one who would think of transferring their spirit to a copy; and yet thrown aside and laid on the grass-plot, in all weathers, though to the casual observer almost as perfect as if new: one sees there the real angels whose counterfeits blow the trumpets of the Resurrection over the great portal of Notre Dame: one sees the central pillar of one of the same portals looking nearly as well-conditioned as its modern supplanter: one sees also balusters from the parapets of the Sainte Chapelle as good as new; and many other exquisite details rejected from the restored edifices, one knows not why. The stoneyards near many cathedrals tell the same story; indeed, wherever a great restoration is going on, you may see the genuine old details, often scarcely corroded by time, lying in rejected and neglected heaps hard by.

Now let me ask, in the name of good sense and good feeling, why the great learning, skill, and judgment of the often illustrious architect to these works is not rather directed to the conservation *in situ* of every fragment of the noble architecture which they understand so thoroughly, rather than to its supplantment to make way for mere copies, which, however admirable, possess no real value as genuine exponents of the style? If they would take the contrary course, I can aver without fear of contradiction, from the talent and learning they display, that their works would be worthy objects of the pride of their own countrymen and of the gratitude and admiration of every lover of Mediæval art, instead of being, as now, causes of regret and disappointment to all? But, it may be asked, what business is this of ours? Why do we not correct our own errors, and leave architects of other countries to do as they like? I reply, that the French architect and art-historians, by showing (whether we fully admit it or no) that theirs is the mother country of Gothic architecture, have thereby made its production the property of Europe and of the world; and that, on their own showing, all lovers of Gothic architecture have an almost equal claim upon them for their authenticity and their conservation.

I have dwelt so long upon the principal heads of my subject that I must but slightly touch upon that which remains: I mean the preservation of the miscellaneous remnants of antiquity which form my third class.

These are, more than any other, subjected to the constant inroads of Vandalism. Even the reverend conservators of our cathedrals care little for the fragmentary remains by which they are surrounded; and often rather wonder at the weakness of those who lift up their voices in their favour. The very same men who take an enlightened interest in the preservation of every portion of the church, cannot be brought to care about the equally interesting though simpler structures, whose vestiges are intermingled with their own residentiary houses; and would have no scruple in destroying the most interesting antiquities to provide for some passing matter of convenience.

At Worcester it is only a few months since the ancient Guesten Hall was threatened with destruction. At Ely the huge Abbey Barn was destroyed only a few years back; and nearly everywhere the same spirit may be found to be at work. It is the duty of an Institute like this to protest against it, as they have lately to their honour done in several kindred cases.

One can hardly expect better things of a town council, when chapters of cathedrals set the example; but one must, in passing, protest against the deliberate barbarism which has within a few years destroyed the curious old town-halls of Hereford and Leominster.

Our country villages, and the country itself, are full of small fragments of ancient architecture, often not of very early date, but of most valuable character, and which are every day threatened by the hand of innovation. I refer not only to works of high antiquity, but to timber houses, old brick (or other) chimney shafts, old gable-houses of stone or brick, and a thousand other fragments of old buildings, which add so much to the character of our villages, &c., and are also so suggestive for rural architecture. These ought to be jealously preserved and watched by those who have it in their power to do so. Village and churchyard crosses, the remains of old domestic architecture in our towns and cities, old manor-houses, hospitals, schools, colleges, &c. &c., and a thousand other classes of building, demand equal care; and, last of all, I would mention old *bridges*, which are far more numerous than one would suppose, and which are less seen than most classes of antiquities, from the fact that we pass *over*, and therefore cannot get a view of them. These have very frequently been preserved intact on one side, and widened on the other: a process one cannot object to, as the roadway which they provide is usually too narrow for our present uses. Though not great engineering works, they have a noble character, and occasionally attain to considerable span—as in the case of one at Durham, which approaches 100 feet. Amusingly enough, a modern engineer, in widening it by an arch of the same span, has failed in making his work stand so well as the old one.

I have however made my paper far too long, and must sum up briefly, as follows:—

I. Our old architectural monuments are of the utmost value and interest to us as Englishmen and as architects; and their conservation is a matter of vital importance.

II. What with neglect, Vandalism, natural decay, and ill-judged restorations, the existence, the integrity, or authenticity of these invaluable remains is threatened from all sides; and fearful inroads upon them are every year being made.

And finally, it is the paramount duty of an institution such as ours—the only one of a permanent character by which architecture is represented—to take the initiative in laying down, in conjunction with other architectural and antiquarian societies, a code of rules for the treatment of buildings requiring restoration; and to take such measures as their united wisdom may suggest to promote the true, faithful and authentic conservation of these monuments and remains.

In conclusion then, I beg to propose that a standing committee be appointed for this purpose; and that they be empowered to act in conjunction and to communicate with other societies, with a view to secure their co-operation in carrying out this most important object.

THE STATICS OF BRIDGES.*

III.—*The Suspension Chain.*

The chain and the arch have so much in common, that the study of either furnishes considerable light as to the properties of the other. Yet they present such marked points of difference that each must be separately examined. A comparison of results will show that the law of equilibrium is essentially the same in the two cases, and that the distinction lies in the mode of its operation; the reaction of the arch arising from compression, and that of the chain from tension.

If the true Line of Pressure of a wrought-iron arch-girder were determined—by a process which we have not yet brought forward; and if the girder were then turned upside down and employed as a tension rib, the same Line of Pressure (inverted) would apply, and all the forces of reaction and transverse strain would remain, changed in quality, but nearly unaltered in intensity and distribution. Here we have only to convert compression into tension, or *vice versâ*, and the investigation of the one case applies equally well to the other.

But in comparing an ordinary arch with an ordinary suspension chain there is another point of difference. The chain possesses the property of perfect flexibility; or (since even a girder is flexible) we may rather say that the chain is altogether devoid of rigidity. To the arch, on the other hand, more or less rigidity is essential.

Tension leads the chain into the form adapted to the load, and causes it to settle in a position of stable equilibrium. Were the loaded chain inverted, so as to stand as an arch, the form remaining unchanged, equilibrium would still exist, but it would now be instable instead of stable. An arch must therefore possess rigidity, since without this the compressive forces would at once cripple it. It would be neither capable of adjusting itself to the curve of equilibrium, nor even of maintaining itself in such a curve under the slightest disturbance. Permanence of form, secured by rigidity, becomes therefore necessary in the arch; and its Line of Pressure is a purely theoretical curve, rather governed by than governing the constant and determinate form of the structure. To the common suspension chain, on the other hand, mutability of form is essential, all that is needed being simply to leave the chain free to adjust itself; and the Line of Pressure becomes no longer a mere theory, but the actual outline of the structure for the time being.

The study of the catenary is in this respect less ideal and more tangible than that of the arch. But although thus in a general way simpler to apprehend, it is beset with two peculiar difficulties of detail. The first, that we have to consider the length as well as the form of the chain. The second, that a disfigurement of the curve alters to some degree the distribution of the load. Neither of these difficulties attend the investigation of arches, because in them the form of the structure is constant and perfectly distinct from that of the Line of Pressure.

These remarks will make it apparent why the chain demands a separate and special investigation. Upon this we now propose to enter, keeping the line of argument parallel, as far as practicable, with that made use of when discussing the arch. And this even at the risk of some seeming repetition.

It has been seen in a previous section that if as in Fig. 5 (vol. xxiv. page 61) a weight W be suspended from the junction of two bars or links, as AB and BE, opposite moments will be induced in the links, the tendency of which is to part the links at B and to draw in the piers P, Q. Equilibrium can only result when this tendency is effectually resisted. The resistance or reaction causes horizontal strains at A, B, and E, which are accompanied with a tensile strain on the links.

The link BE being free to turn at B and E, the tension must be in the direction of its length BE; and (neglecting the weight of the link itself) the tensions at B and E must be equal: both these suppositions being essential to the equilibrium which is assumed to exist.

Resolve the tension at B into RB horizontal and ER vertical: then ER must be equal to that portion of the weight W which derives its support from BE; again, the reaction of the pier at E is equal to this tension and in an opposite direction, and resolvable into BR horizontal and RE vertical.

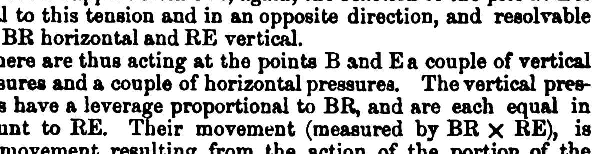
There are thus acting at the points B and E a couple of vertical pressures and a couple of horizontal pressures. The vertical pressures have a leverage proportional to BR, and are each equal in amount to RE. Their movement (measured by BR × RE), is the movement resulting from the action of the portion of the weight W which derives its support from E tending to depress the link BE. The horizontal pressures produce a moment of reaction also measured by BR × RE, the leverage being proportional to RE, and the amount of each pressure being equal to BR.

By treating the pressures operating on the link AB in a similar way, it will be seen, that the horizontal strain at A is equal to that at B, and consequently equal to that at C. In other words, the horizontal strain is everywhere the same. And the amount of this horizontal strain must be such as to give a moment of reaction for either link opposite and equal to the moment induced in it by the load.

These two principles, namely that the horizontal tension is everywhere the same, and that the moments of reaction are equal to the movements of the load, are of universal application, and govern the equilibrium of an assemblage of links, or of a chain, as well as that of the simple arrangement that has just been examined. This may be shown in more detail, as follows.

In Fig. 28 a set of links, 1 2, 2 3, 3 4, and 4 5, are shown, hanging from the piers A and B, and connected with these piers and

Fig. 28.



with each other by pins round which they may turn freely; weights,* w_2, w_3, and w_4, being hung from the pins 2, 3, and 4: the links are supposed to have settled in the position of equilibrium.

This being the case, the tension of each link must be in the direction of its own length. And since equilibrium exists in every part of the system, the pressures acting on the pin 2 must be in equilibrium. These pressures are three, namely, the opposing tensions of the links 2 3 and 2 1, and the vertical pressure of the weight w_2.

* Continued from page 349, vol. xxiv.

* In this case the links are supposed either as having no weight, or as having their weight included in w_2, w_3, and w_4.

These pressures must therefore be as the sides of the triangle 1 2 0, of which the sides 2 0 and 0 1 are parallel to the links 2 3 and 2 1, and the remaining side 1 2 is vertical and of a length representing the weight w_2. The lengths 2 0 and 0 1 will therefore measure the action and reaction corresponding with the tensions of the links 2 3 and 2 1. In other words, the reaction of the link 2 1 is equal and opposite to the resultant of the action of the weight w_2 and the tension of the link 2 3. Again, the pin 3 must be in equilibrium under the three pressures arising from the tensions of the links 3 2 and 3 4 and the action of the weight w_3. These three pressures must therefore be as the sides of a triangle drawn parallel to their directions. One side of this triangle we have already, for the reaction of the link 3 2 on the pin 3 must be equal and opposite to its action on the pin 2, and must therefore be represented in magnitude and direction by the line 0 2. The other two sides are found by drawing 3 0 through 0 parallel to the link 3 4, and producing the vertical line 1 2 to intersect 0 3 in 3. 2 3 0 will then be the triangle of pressures: the tension of the link 3 4 will be measured by the side 3 0, and the weight w_3 by the side 2 3.

In the same way, if the line 4 0 be drawn parallel to 4 5, meeting the vertical line 1 2 3, produced in 4, 3 4 will represent the weight w_4, and 4 0 the tension of the link 4 5.

This diagram makes it clear that the horizontal strain is everywhere the same; since the horizontal strain on any link is equal to that on the adjacent links. For instance, the tension of the link 2 1 is measured by the line 0 1, equal and opposite to the resultant of the tension of 2 3 with the vertical pressure w_2. The tensions of 2 1 and 2 3 must therefore have the same horizontal element, the only difference being in the vertical element, which (for 2 3) is increased by the weight w_2.

Draw the horizontal line 0H. 0H will represent the constant horizontal strain. 1 0 measures the action of the link 1 2 on the pier A, and is resolvable into 1H (the portion of load borne by this pier) and H0 (the horizontal strain); 0 4 measures the action of the link 5 4 on the pier B, composed of H4 (the portion of load borne by B) and 0H (the horizontal strain.) The resultant of the reactions of the two piers is therefore 4 1, equal and opposite to the downward pressure of the load.

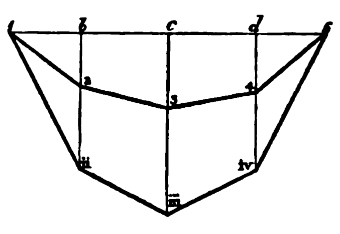
Resolving 0 2 into 0H and H2, and 3 0 into H0 and 3H, it will be seen that the weight w_3 (= 2 3 in the diagram of pressures), at the lowest point, is supported partly by the vertical action H2 of the link 3 2, and partly by the vertical action 3H of the link 3 4.

The diagram of pressures proves that the strain on each link is the resultant of the whole weight supported by it (measured from H where the load divides) and the horizontal strain.

The portion of load supported from the pier A and carried by the links 1 2 and 2 3 has a downward moment about A, which is counteracted, as was seen in the simple case of the two links in Fig. 5, by the resistance of the links to extension and the horizontal reaction of the pier. It is this which causes the horizontal strain. The horizontal strain must therefore be just sufficient to give a moment of reaction equal to the moment of the portion of load hanging from A.

This moment of reaction is equal to the horizontal strain H0 multiplied by the leverage or rise from 3 to 1, which is the same as the line 3*c* in Fig. 29.

Fig. 29.



If therefore 1 ii. iii. iv. 5 in Fig. 29 be the curve of moments, H0 × 3*c* must be equal to iii. *c*.

Again, since 1 2 is in equilibrium, the reactionary moment of this link must be equal to the moment of the corresponding portion of the load. This reactionary moment is equal to H0 multiplied into the leverage 2*b*. Therefore H0 × 2*b* must be equal to ii. *b*. In the same way it may be shown that H0 × 4*d* must be equal to iv. *d*.

In fine, the ordinates of the curve of equilibrium are proportional to the ordinates of the curve of moments, the constant proportion determining the amount of horizontal strain.

The simplicity of this result is due to the constancy of the horizontal strain. The strain on every link being resolvable into the weight supported and the horizontal strain, the former enters into the moment of action of the load (as found by the process given in Section I.), leaving the latter alone to enter into the moment of reaction.

The equilibrium of a loaded chain depends on the same principles as the equilibrium of an assemblage of links such as shown in Fig. 28. The number of links may be conceived to be indefinitely increased, and the length of each link indefinitely reduced, the weights w_2, w_3, and w_4 being correspondingly divided and distributed, until the curve of moments, instead of consisting of a few straight lines, becomes as nearly as possible a curve in the usual sense of the word: but it will still hold good that the ordinates of the curve of the chain are proportional to those of the curve of moments, and that the horizontal tension is everywhere equal.

Take for instance a loaded chain or cord AQPB (Fig. 30), and let A*qp*B be the curve of moments of the load. Take any two points (as Q and P) in the chain, and let VQ and VP be the directions of tension at Q and P. Let W be the load distributed over the chain from Q to P, the centre of gravity of W being somewhere in the vertical line GV.

The portion of chain QP is then in equilibrium under the following pressures:—

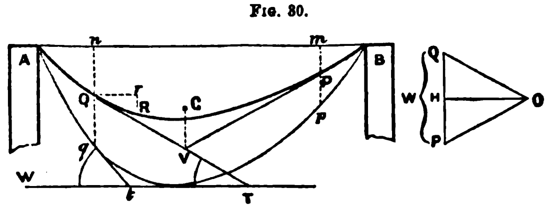
I. The tensions at Q and P, in the directions VQ and VP.

II. The vertical pressure W, which, as it affects P and Q (without reference to the form assumed by the intermediate chain), may be considered as acting in the vertical line GV, passing through the centre of gravity.

There are therefore three pressures in equilibrium, namely, the tensions at Q and P, and W. Their directions VQ, VP and GV must therefore (as drawn) meet in one point V.

Construct the triangle POQ to the scale of weights adopted for the curve of moments, having the side QP vertical and of a length

Fig. 30.



representing W, and the sides PO and OQ parallel to VP and VQ. PO must then be the measure of the tension at P, and OQ the measure of the tension at Q.

The horizontal elements of the tensions at Q and P must therefore be of equal amount, as will be seen at once on drawing the horizontal line 0H, which is the measure of horizontal pressure in the triangle POQ.

This proves that the horizontal tension at any two points in the chain AQPB is the same; or in other words, that the horizontal tension is everywhere equal. It also shows that the tension at any point, as at Q, is equal to the resultant of the horizontal tension H0 and the supported weight QH.

The same reasoning as was employed in the case of the assemblage of links (Figs. 28 and 29), may be applied to show that H0 × Q*n* (the ordinate of Q) is equal to *qn* (the corresponding ordinate of the curve of moments): that H0 × P*m* is equal to *pm*; and generally, that the ordinates of the curve of equilibrium are proportional to the corresponding ordinates of the curve of moments.

Draw the tangents QT and *qt*, forming the angles QTW, *qt*W, with the horizontal line. It follows from the constant proportion which we have shown to subsist between the ordinates of the two curves, that H0 + tan of QTW = tan of *qt*W. But (from the known properties of the curve of moments) tan of *qt*W is equal to the load supported at Q (read off on the vertical scale for weights and moments), or to QH;

$$\therefore \ \text{H0} \times \tan \text{QTW} = \text{QH},$$

$$\text{or } \tan \text{QTW} = \frac{\text{QH}}{\text{H0}} = \tan \text{H0Q}.$$

Therefore, QT must be parallel to 0Q, and consequently coincides with QV.

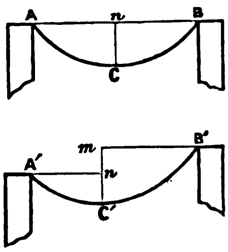
In other words (what is almost self-evident) the tension at any point is in the direction of the tangent of the curve of the chain; and QTW being the inclination of this tangent to the horizon, the weight supported divided by the horizontal tension gives the tangent of QTW.

These are the general properties of the curves in which loaded chains, (including in the load the weight of the chain itself,) find their equilibrium. It is readily seen that the chain will always assume the proper curve, or resume it after any disturbance, because the equilibrium of the chain is always stable. Suppose the moment of the load supported by the portion AQ of the chain (Fig. 30) to preponderate, it would at once cause an increase of the ordinate Q*n* (the leverage of the horizontal strain), and thus increase the moment of reaction. If, on the other hand, the horizontal strain began to preponderate, it would diminish its own leverage Q*n* and also increase A*n*, and thereby increase the moment of the load. The same applies to any other part of the chain, as QR; here R*r* is the leverage of the horizontal strain (being the difference of the ordinates of R and Q), and the moment of QR is the difference of the moments of AR and AQ.

The position of the lowest point of a chain, or the point where the load divides, which is also the point of greatest moment, partly depends on the relative heights at which the ends of the chain are fixed.

In Fig. 31, ACB is a chain, of which the ends A and B are on the same level AB; and C is the lowest point. Draw the vertical line C*n*. Then the moments of reaction of AC and BC are equal, since each is equal to C*n*×(horizontal tension). Therefore the moments of action must be equal, or the moment of the load supported by AC must be equal to the moment of the load supported by BC. As soon as the centre of gravity of the load is found, the position of C*n* can therefore be at once determined, in the same way as if the load were carried by a beam.

Fig. 31.



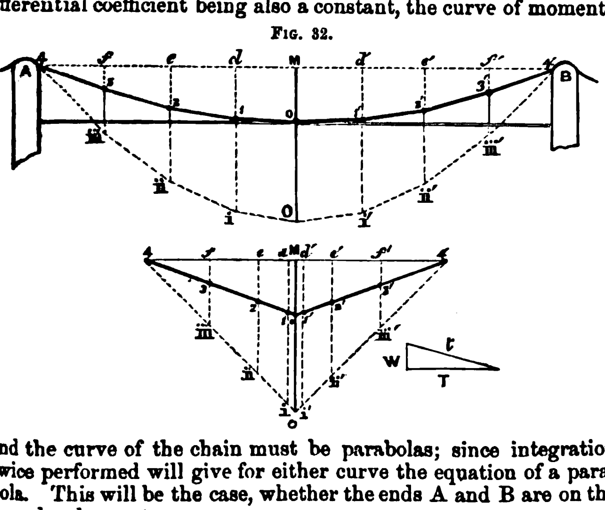
A′C′B′ represents a chain, of which the end A′ is on a *lower level* than the end B′, C′ being the lowest point of the curve. In this case, C′ has two ordinates, C′*n* and C′*m*; C′*n*× (horizontal strain) will be the moment of reaction for A′C′, and C′*m*× (horizontal strain) will be the moment of reaction for B′C′, which thus exceeds the former by the difference of level, *mn*, multiplied by the Horizontal Strain.

The moment of the load supported by B′C′ must therefore exceed the moment of the load supported by A′C′ by an amount equal to *mn* × (Horizontal Strain). It is plain that C′ must be nearer to A′ than if A′ had been on the same level with B′. This change of position of C′, of course, quite alters the curve of moments. The case bears much resemblance to that of a load on a girder, continuous over the pier B′, and having the end at A′ free.

The altered curve of moments will, however, agree with the original curve in its second differential coefficients, which do not depend on the position of the vertex (or point of greatest moment), but on the horizontal *rate of loading at each point.*

When the horizontal rate of loading is constant, the second differential coefficient being also a constant, the curve of moments

Fig. 32.



and the curve of the chain must be parabolas; since integration twice performed will give for either curve the equation of a parabola. This will be the case, whether the ends A and B are on the same level or not.

We shall now endeavour to show how to apply these principles in practice, and lay down the curve of the chains of an ordinary suspension-bridge under a given distribution of load; at the same time determining the constant amount of Horizontal Strain and the different degrees of tension at the several points.

In Fig. 32, AOB is the curve of the chains of a suspension-bridge of 64 feet span, the intervals between the suspension rods being 8 feet. It is proposed to determine this curve, the horizontal tension, and the strains on the links, for a uniformly distributed load of 10 cwt. per foot forward. The versed sine OM is 7 feet.

The points of suspension A and B being on a level, and the rate of loading being uniform, the point of greatest moment must be in the line MO, the ordinate drawn at the half span. From this line number the ends of the links 1, 2, 3, to 4 (at A); and 1′,2′,3′, to 4′ at B. The total load on each of the 8 foot sections of the platform will be 8 times 10 cwt., or 4 tons. Then compute the ordinates for the curve of moments in the manner already shown in Section I.

No.	Weight.	Aggregate Weight.	Multiplier for Total Moment.
0, 1	4	4	64
1, 2	4	12	60
2, 3	4	20	48
3, 4	4	28	28

To get the figures in the Aggregate Weight column for either half of the chain, work from zero forwards; to find the values of the Multipliers for Total Moment, work back towards zero (or towards the centre of the chain). Then, the half interval being 4 feet, 4 times the multiplier will be the moment expressed in tons at 1 foot leverage at any required point. Thus, at 3, or 3′, the moment is 4×28; at 2, or 2′, the moment is 4×48; at 0, the moment is 4×64. The ordinates of one-half of the curve of moments (which is in this case symmetrical), will therefore be 4×64, 4×60, 4×48, 4×28, and 0. Choose a convenient scale for moments, and by it plot the ordinates MO, *d*i. and *d*′i.′, *e*ii. and *e*′ii.′, *f*iii. and *f*′iii.′ (the ordinates at 4 and 4′ are each zero;) then 4 iii. ii. i. O i.′ ii′ iii′ 4′ is the curve of moments.

The ordinates M0, *d*1, &c. of the curve of equilibrium of the chain must be proportional to those of the curve of moments. It follows, that if the ordinates be shifted to such horizontal intervals as to transform the curve of moments into a straight line, the curve of equilibrium will become a straight line too.

Take the straight line 4M4′, equal (or proportional) to twice MO; M4 and M4′ being each equal to MO, set up the ordinate MO equal to the greatest ordinate of the curve of moments, and join the points 4, O and 4′ by the straight lines 4O and O4′. On 4M, measuring from 4, mark off 4*d*, equal (or proportional) to the ordinate *d*i. of the curve of moments, 4*e* equal to *e*ii., and 4*f*, equal to *f*iii. In the same way, measuring from 4′, get the points *d*′, *e*′, and *f*′. Then the ordinates *f*iii., *e*ii., &c. drawn through these points to the straight lines 4O or O4′, will be equal to the ordinates of the same names of the curve of moments. 4O4′ is therefore the curve of moments straightened out, and the curve of the chain becomes reduced to two straight lines on this diagram.

Now we have one ordinate of the curve of the chain, namely, its versed sine M0, which is 7 feet. On the central ordinate measure off this length M0, and draw the straight lines 40 and 04′, cutting the other ordinates in the points 3, 2, 1, 1′, 2′, and 3′. 404 will then represent the curve of equilibrium of the chain straightened out; and the lengths *f*3, *e*2, *d*1, *d*′ 1′, *e*′ 2′, and *f*′ 3′, transferred to the equi-distant ordinates on the first diagram, will give the true curve 4, 3, 2, 1, 0, 1′, 2′, 3′, 4′.

In the preceding process, the curve of moments in the first diagram, and the same line straightened in the second diagram, have been given, in order to make the reason of the whole thing clear. In actual practice, neither the one nor the other will be plotted, all that is necessary being to set the ordinates in the second diagram at such distances as will transform the curve of equilibrium into two straight lines. This is accomplished by making the distances 4M, 4*d*, 4*e*, and 4*f* proportional to the numbers 64, 60, 48, and 28, given by the table as Multipliers for Moments. Or, more simply, by making the intervals M*d*, *de*, *ef*, *f*4 proportional to the several Aggregate Weights 4, 12, 20, and 28 found in the third column of the table.

It remains to determine the horizontal strain and the tension of the links.

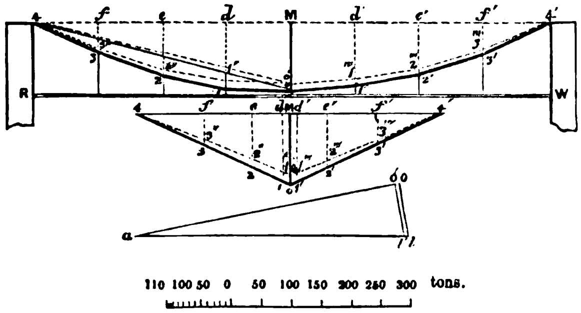
The greatest moment is 4×64, or 256 tons. This moment exists at the half-span, where the ordinate of the curve of the chain is 7 feet. The horizontal strain must accordingly be such as when multiplied by 7 feet will give a moment of reaction equal to 256 tons.

Therefore, the horizontal strain is $\frac{256}{7} = 36\frac{4}{7}$ tons. This has to be divided between the number of chains supporting the platform. If, for instance, there are two chains, one on each side of the roadway, the horizontal strain on each chain will be $18\frac{2}{7}$ tons.

To find the tension of any link, draw the triangle having a vertical side W; a horizontal side T of a length representing the horizontal strain; and the other side *t* parallel to the link in question. The length *t* will represent the tension of the link.

If, the amount and distribution of the load being given as before, the *length* of the chain were given instead of the versed sine, one or two trials would become necessary in order to determine

Fig. 33.

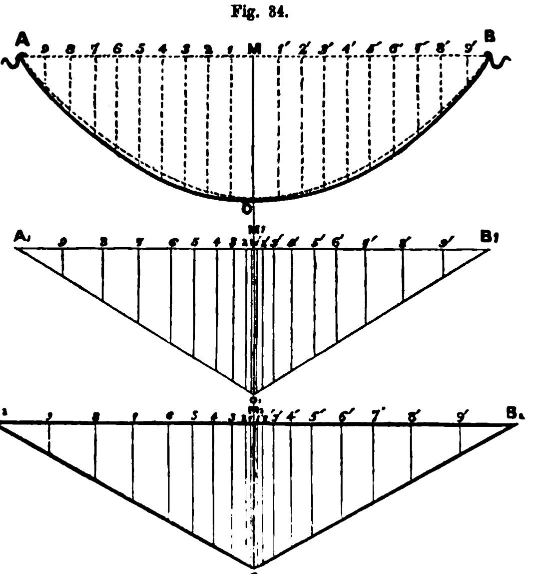


Horizontal Scale for Distances of Ordinates.

the curve of equilibrium. In Fig. 33 a bridge is taken as an example, in which the load, and the manner of its distribution on the roadway RW is given, the position of the line M0 of greatest moment found, and the length of chain from 4 to 0 required to be equal to a stated length *al*.

Take the line 4M4′, setting up ordinates at 4, *f*, *e*, *d*, M, *d*′, *e*′ *f*′, 4′, at the distances derived from the table of moments, in the same way as in the preceding case; the plotting of the line of moments being dispensed with. This position of the ordinates will have the effect of straightening out all the curves of equilibrium for chains

Fig. 34.



of different lengths, which will thus be represented in this diagram by straight lines converging from 4 and 4′ to various points in M0, or in M0 produced.

Assume for the trial the point 0′, and having drawn the straight lines 4 3″ 2″ 1″ 0′ 1‴ 2‴ 3‴ 4′, transfer the ordinates *f*3″, *e*2″, &c. to the equidistant ordinates on the elevation of the bridge, giving a trial curve of equilibrium 4 3″ 2″ 1″ 0′ 1‴ 2‴ 3‴ 4′.

On measuring this curve from 4 to 0′, it is found to be equal to *al*′, differing from the fixed length *al* by an error *l*′*l*.

Draw the triangle *al*′0′, having for one side *al*′, and for anothe side *a*0′, equal to the chord line 4 0′. Then by drawing the line *l*0 parallel to *l*′0′ (and producing *a*0′ if necessary), form the similar triangle *al*0. Take the length *a*0 thus determined as a chord to be swept from 4 to intersect M0 in 0, which will give a corrected versed sine M0. Transfer this versed sine to the diagram for straightening, and draw to the point *o* thus found the straight lines 4 3 2 1 0 1′ 2′ 3′ 4′. The ordinates being transferred will give on the elevation the curve 4 3 2 1 0 1′ 2′ 3′ 4′. If the previous trial curve was not very far from the right length, this curve will be a very close approximation. The process can be repeated if necessary.

In the preceding cases, the distribution of the load has been supposed to be known. But sometimes this distribution will be so dependent upon the curve taken by the chains, that we do not possess an accurate knowledge of it at the outset. This will be the case with a suspension bridge as far as the weights of the links of the chains (supposed to be included in the load) are considered. It is more appreciably shown in the catenary, or curve in which a chain hangs by its own weight alone; or in such a system of links of fixed lengths, weighted at their ends, as Fig. 28 exhibits.

To take an instance. It is required to find the curve of equilibrium for a chain between the points A and B (Fig. 34) with a versed sine equal to MO; the chain being of uniform weight.

The first step is to construct the diagram A_1 B_1 O_1 for a straightened line of equilibrium with a versed sine M_1 O_1 equal to MO, and working on the assumption that the horizontal distribution of the weight is uniform. Transferring to the first figure the ordinates thus obtained, the dotted curve AOB is produced, (which is in this case a parabola,) as a first approximation to the required catenary.

Measuring on this curve the several lengths of the arcs from ordinate to ordinate (which will not much differ from the lengths of the corresponding portions of the true catenary), take the lengths so found as the basis of a table of moments, from which construct the second triangle $A_2B_2O_2$ (the versed sine remaining the same), the ordinates in which, being transferred as in the previous instance, give rise to the full lined curve AOB, which will be very near to the required catenary.

Since this curve exhibits the real distribution of weight more accurately than the parabola, it is a guide to the construction of a more exact triangle for the line of equilibrium; and in this way the steps of approximation may be repeated as often as desirable. The limits of error will, however, rapidly narrow at every step. Thus in Fig. 34, the true catenary, if plotted, would probably not be easibly distinguishable from the full lined curve AOB, which is but the second step in approximation.

The case would have been more difficult, or it may be more correct to say, more tedious, had the length of chain AOB been given, instead of the versed sine MO. The mode of approximation just indicated would then have to be used alternately with that employed in the previous case, illustrated in Fig. 33.

To recapitulate: a chain, or a cord, or an assemblage of links free to turn at the points of connection, suspended between two points, and sustaining simply vertical pressures, seeks a position of stable equilibrium in which the moment of reaction gives rise to a constant horizontal strain. The tension will everywhere be in the direction of the tangent to the curve, and may be resolved into the weight supported and the horizontal strain. The ordinates of the curve of equilibrium will be proportional to the moments of the load; and the artifice of placing the ordinates at distances proportional to the partial moments reduces the determination of this curve to the drawing of two straight lines: thus rendering it practicable to solve by construction (either at once, or by a series of rapid approximations) all cases that can arise. The lowest point of the curve will be on the ordinate of greatest moments, the position of which is governed both by the distribution of the load and by the relative levels of the points between which the chain is suspended.

Note.—In a few impressions of the foregoing article, the following errors have escaped correction:—

Page 47, col. 2, lines 38, 39, for "movement," read "moment."
" " " line 54, for "movements," read "moments."
" 48, col. 1, line 31, for "2, 3," read "2, 1."
" " col. 2, line 14 from bottom, for "HO + tan," read "HO × tan."
" " " line 4 from bottom, for "the inclination," read "the angle of inclination."

OPENING ADDRESS AT THE INSTITUTION OF CIVIL ENGINEERS.

By John Hawkshaw, F.R.S., President.

Gentlemen,—I beg to thank you for the honour you have done me in electing me to the office of President of this Institution. In undertaking the important duties it involves, I can safely promise not to fail in their discharge from any want of interest in your proceedings, nor from any lack of zeal for the advancement of the objects of the Institution.

The profession of which we are members has from my earliest days been an object of attachment to me, and were I actuated by no other motives, the love I bear to it would prevent me becoming lukewarm to its interests. For my deficiences I trust to your forbearance, and rely on the help of the many friends I see around me.

It is important to notice at the outset, that the wide range of subjects which the profession of a civil engineer embraces renders it imperative on every member of it to avail himself of all the help he can obtain. He requires the assistance of many departments of science and art, and must call into employment important branches of manufacture. He can perform no great work without the aid of a great variety of workmen, and it is on their strength and skill, as well as on their scientific direction, that the perfection of his work will depend. The personal experience of one individual cannot fit him for the exigencies of a profession which is ever extending its range of subjects, and is constantly dealing with new and complex phenomena; phenomena which are all the more difficult to deal with from the fact that they are generally surrounded by such variable circumstances as render them incapable of being submitted to precise measurement and calculation, or of being made amenable to the deductions of exact science. Consequently, nothing is more certain than that he who wishes to reach the perfection of his art must avail himself of the experience of others, as well as of his own, and that he will not unfrequently find the sum of the whole little enough to guide him. And let no inventive genius suppose that his own tendencies or capabilities relieve him from this necessity.

There is, I believe, no such thing as discovery and invention, in the sense which is sometimes attached to the words. Men do not suddenly discover new worlds, or invent new machines, or find new metals. Some indeed may be, and are, better fitted than others for such purposes, but the process of discovery is, and always has been, much the same. There is nothing really worth having that man has obtained, that has not been the result of a combined and gradual process of investigation. A gifted individual comes across some old footmark, stumbles on a chain of previous research and inquiry. He meets, for instance, with a machine, the result of much previous labour: he modifies it, pulls it to pieces, constructs and reconstructs it, and by further trial and experiment he arrives at the long-sought-for result.

While, however, it is necessary, if our progress is to be safe, that we should proceed with due caution, it is exhilarating to notice, that in the matters to which our profession relates, progress is more apparent than it is in most other pursuits. The great range of objects which it embraces, and which seems ever extending, partly, no doubt, accounts for this.

We are called upon to construct the great highways of nations, and to build the steamboats that bridge the seas. We make the machines by which man seeks to lighten labour and to accumulate force, or to give to that force new directions. We build docks, harbours, and lighthouses, to receive, shelter, and warn the mariner; and, as if in contrast to works so useful and so humane, some of us are occupied in the warlike objects of defence and destruction. And at this day, young members can look back far enough to distinguish the rapid progress that has been made in those matters to which the civil engineer has to devote his attention.

Thus, it is hardly thirty years since travelling began to be transferred from common roads to railways. In the comparatively short period that has since elapsed, in a less space of time than one generation of man, about seventy thousand miles of railway have been made in different countries, at an outlay of about eleven hundred millions of pounds sterling, and involving an amount of engineering works exceeding in magnitude and importance all the previous engineering works of the world put together.

In effecting this great change, English engineers have taken a prominent part, about one half of the vast outlay above referred to having been expended under their direction, and they may, I think, feel a pardonable pride in the great works which they have helped to construct, and which are destined to produce an amount of beneficial change and advancement in the habits and culture of mankind, which the most sanguine man of the present day will probably fail fully to estimate.

Simultaneously with this change, and tending to the same ends, there has been the improvement of steam navigation. I crossed the Atlantic in 1835, in what was then considered one of the swiftest packets; but in those days the Atlantic packets depended wholly on sails, and the voyage occupied twenty days. Many years have not elapsed since it was denied that steamers could cross the Atlantic at all. They do so now in nine days. The progress that has been made in steam navigation in the last few years is truly remarkable. The steamboats plying between Holyhead and Dublin, which were then, as now, among the fastest afloat, had, ten years ago, attained a speed of seventeen miles an hour. Last year those boats were superseded by others, the Leinster, Munster, Connaught, and Ulster, which attained on their trial trip a speed of twenty miles and a half per hour.

Great progress has also been made in the application of the screw-propeller to steamships, which for vessels of war and other purposes possesses advantages over the paddle, though it has not hitherto accomplished an equal speed.

In 1848, the fastest screw line-of-battle-ship in the navy could not steam more than about seven and half knots, or eight miles and two-thirds per hour, whereas the Warrior, though clothed with an outer coat of iron armour four inches and a half thick, at her trial in October last over the measured mile in Stokes Bay, attained an average speed of 14·356 knots, or 16·533 miles per hour, beating the Howe, which previously had attained the highest trial speed of any of Her Majesty's line-of-battle ships; the displacement, power, and speed of the two ships being as follows:—

Name.	Displacement.	Indicated Horse Power.	Speed per hour. Knots.	Miles.
Warrior	8852	5469	14·356	16·533
Howe	4770	4523	13·565	15·623

Since 1848 the speed of this class of ships has been nearly doubled. The build and construction of steamboats has also, during the same period, received much attention, and been greatly improved.

The doubts which prevailed until very lately, whether iron was the best material for line-of-battle ships, seem now nearly dispelled, although the rapidity with which iron fouls will, unless some remedy can be devised, always be a source of trouble. The precise and best mode of constructing iron ships of war is still an interesting problem; and many improvements may still be expected in an art which is yet in its infancy. Hitherto a large amount of wood has been combined with the iron. The Warrior has a thick lining of timber between the inner skin and the outer armour-plates. A material so soft as wood can hardly increase the capability to resist shot; and there seems great difficulty in combining, to any good purpose, two materials differing so much in strength and density. Besides which, wood rots, and is, in ships especially, a perishable material. The probability is that iron will supersede the use of wood in a still greater degree, and that, by the adoption of improved modes of construction, the whole of the iron used in the structure of ships of war will be made to add to the strength of the ship, as well as be useful for its defence. This is not the case in the present mode of construction. The armour-plates of the Warrior add very little to the strength of that ship. There seems to be no good reason why the upper and lower decks, and every portion of the hull of such vessels, should not be of iron. Greater strength would be thereby attained to resist diagonal and cross strains, and much greater longitudinal stiffness would be secured. Ships of war should be constructed practically, as far as it is possible, as if welded out of one piece of iron; and if they are ever to be used as rams, this mode must be adopted, for it is evident that the present methods of construction would be quite unsuited for such a purpose.

That war-steamers and other steamships can be made stronger, and may be made to steam faster than they yet have been, there is no doubt. No one can have taken the trouble to examine the present methods of building without seeing that it is easy to increase their strength without impairing their efficiency in other respects.

With regard to the speed we ought to obtain, it is with steamers as with locomotive engines, a question just now of what velocity we can afford to pay for, rather than of what rapidity we can physically attain. There is no doubt that the speed of either could be accelerated beyond any point yet reached, and probably beyond any point that the nation at present could afford. The speed of steamboats and of railroads will have to be determined from time to time, and will vary with circumstances, with place and time, with the accumulation and distribution of wealth.

For cost, after all, greatly if not rigidly regulates progress; whether it relate to civil, to military, or to naval affairs. A hundred years ago no nation could have afforded railways of fifty miles an hour, nor steam-boats of twenty miles an hour. The reasons for this are obvious, though often overlooked. Passengers, for instance, can afford a higher rate of speed than goods and minerals; and some descriptions of merchandise require to travel faster than stone, coals, &c. Again, some passengers can better afford to pay for speed than others. Even now it is only on certain lines that there are a sufficient number of passengers who are able to pay for express trains, and where consequently the appointment of such trains can alone be justified. We have not yet, as it respects steamers (except for short distances) secured an equal amount of passenger traffic; and until this be the case, they must be built and worked for passengers and cargo. Moreover, wherever time is an element of importance, the exigencies of trade and the convenience of the public require frequent opportunities of travelling and of transport from place to place. This circumstance determines the number of passengers and weight of goods to be conveyed each journey from each place, and, combined with other circumstances, establishes a law which for the time being regulates the load on every railway, in every steam-boat, and along each line of communication. Thus, large and powerful as locomotive engines have become, they convey on the London and North-Western and Great Northern Railways an average load of less than 70 tons of merchandise; and though the Lancashire and Yorkshire Railway has a larger mileage of merchandise traffic than either, the average load, owing to the close proximity of towns, and the greater necessity for frequent trains, is only about 45 tons. The same principle applies to steam-boat traffic. Again, however superior for naval warfare a steam line-of-battle ship may be to one with sails, yet England, rich as she is, could not at the present day undertake to support a navy which should wholly dispense with the use of sails, which should move to and from and among her distant dependencies by the power of steam alone, and which consequently would always be dependent upon, and therefore would always require to be supplied with a sufficiency of fuel.

With respect to the speed of railways, there is at present an anomaly, which before long will require more attention than at present has been bestowed upon it. Thus, to make way for passenger-trains, goods and mineral trains which might move more slowly are in many cases hurried on, manifestly to the prevention of due economy.

Besides, though I deem it possible that railways ultimately will be made for greater speeds than those at present adopted, I am of opinion that on some lines the companies have attained a rate of travelling which is in advance of their appointments in other respects—such as with the condition of their road, and with the state of their finances. Railway companies already feel that great speed demands larger expenditure upon their permanent way—their rolling stock—for telegraphic signalling—and for other matters, without which the continuance of such speeds becomes positively unsafe: and if the whole of the expenditure which great speed thus entails upon companies were fairly met, it is questionable whether the present speed of railways is not now, in many cases, fully greater than can be afforded.

Goods and minerals on busy lines are, there can be no doubt, carried at a speed which is neither demanded by the public nor is economical to the company; but which is often rendered unavoidable from the necessity of keeping out of the way of swift passenger trains, and by the difficulty of interpolating goods and mineral trains among the frequent trains of a large passenger traffic.

But is there no remedy for this? The travelling public demand from railway companies the highest rate of speed they can exact; and that, as I have observed, is sometimes greater than the state of the road and other matters warrant. Would any good result from the introduction of Government interference to regulate speed? I think not. Such a measure might strike at the root of improvement, and the evil is one which will work its own cure, and for which a remedy may be provided in different ways.

It has been urged that the time of travelling between two points may be shortened as well by diminishing stoppages as by an increase of speed. But this mode of dealing with it again becomes a question of cost; for if local traffic is not to be neglected, diminishing the number of stoppages involves more trains, more expense therefore; and the difficulty of applying this remedy will increase with the growth of traffic. It may have to be met, in certain cases, by constructing lines to carry goods and minerals only, at a slow speed; and ultimately perhaps in other cases, at some future day, by making railways to carry passengers mainly, if not solely.

In grouping engineering works we may class the electric telegraph with railways and steam-boats. All three are agents of intercommunication, and tend to the same important ends. And while the vast importance of each cannot be overrated, the electric telegraph is perhaps, in the peculiarity of its operation, the most wonderful of all. It was about the same time that the Liverpool and Manchester Railway was started that the minds of a few individuals were first devoted to the subject of using electricity as a medium of communication for messages.

Messrs. Cooke and Wheatstone's patents were taken out in 1837, but the first public telegraph was not established till 1839, when a communication was made by wire on the Great Western Railway between London and Slough. Since that period, in this country alone, telegraphic communication has been extended over about 14,500 miles; in the rest of Europe, over about 100,000 miles; and in the American States, over about 48,000 miles; and the total extent of telegraph at this moment cannot be less than 200,000 miles. On land this most useful discovery has been uniformly successful. Like railways, it has grown (in England, by public support alone) into a great institution.

Ocean telegraphy has been less fortunate in its results. Short lines across the narrow seas have been laid and maintained, but at a serious amount of cost. To some extent, no doubt, the failure of deep-sea telegraphs may be attributed to ill-conceived arrangements, and to faulty designs and workmanship; but the very nature of such an undertaking as laying telegraph wires across the Atlantic precludes the possibility of acting on previously-acquired experience, and makes the requisite experimental trial one of serious cost.

The labours of the late Commission appointed to inquire into this subject have made the necessary scientific conditions for forming a good ocean cable better, and perhaps sufficiently understood. But they leave the ultimate cost of maintaining a permanent and available communication across 3000 miles of ocean (as, in fact, the great attendant contingencies compelled them to leave it) a question for the future to decide.

A communication with America once well established would call for numerous wires. To meet contingencies, risk of accidents, and stoppages, a single cable would hardly be sufficient. With ample provision in these respects, a communication between the two countries could be maintained, but at a cost not at present admitting of calculation. There are some things physically practicable, but which in a commercial and monetary sense are for a while unattainable, and the accomplishment of this great object may therefore be delayed. It is to be hoped, however, that it will not be finally abandoned.

Simultaneously with the rapid advance which has been made in the works to which I have referred, there has also been great progress in another branch of engineering with which civil engineers have latterly become connected.

That new branch is gunnery. In a very few years, mainly in consequence of the labours of Sir William Armstrong and of Mr. Whitworth, the range of artillery has been doubled. The weight of the gun in proportion to that of the projectile has been reduced to one-half, and the capacity for powder of the elongated as compared with the round shell has been more than doubled. This great advance in the destructive power of cannon has rendered most of our old fortifications useless. New fortifications have therefore to be built, adapted to the longer range and greater destructive power of the new artillery. These fortifications require to be placed more in advance of the places to be defended, and to be constructed with very superior powers of resistance to those which hitherto proved sufficient. The old walled towns, which were formidable enough in former days, would to-day, in case of a siege, afford little security to the inhabitants who dwell within them; the old defences therefore have to be removed, and replaced, where necessary, with those more suitable to modern requirements.

We are clothing our ships of war in iron mail, and it seems probable that iron in some cases will be largely used in modern fortifications. Not that earthwork and stonework will cease to be useful. These are valuable for the staple of most forts, but neither of them make good embrasures, and for that purpose iron offers great advantages. By its use greater strength can be secured at those points where power of resistance is specially wanted. By its use also the size, and consequently the exposure, of the embrasures will be diminished, and much greater facility be given for working the guns and training them through larger angles.

There are some cases, however, in which forts may with advantage be principally, if not wholly, built of iron. I hope to see that material adopted for the superstructure of the large seaforts at Spithead, the construction of the foundations for which has been intrusted to me. There can, I think, be no insuperable difficulty in constructing iron forts so as to be impregnable to a ship's battery, though in the absence of knowledge as to what may be the ultimate powers of guns, it is not easy at present to arrive at safe conclusions. The difficulty of doing the converse of this, viz. of building ships so as to be impregnable to the fire of such artillery as may and ought to be placed in the new forts, will be a problem not so easily solved.

No plated ship yet built could keep afloat under the fire of guns throwing shots of 200 to 300 lb. weight; and it seems difficult, in the case of ships which require buoyancy, sufficiently to increase the thickness of their armour-plates to keep pace with the probable advance in weight and size of the new cannon.

Naval commanders rely a good deal, and perhaps up to a certain point correctly so, on the mobility of their ships; but ships cannot be so efficient if, to prevent being struck, they be always kept moving about. If never hit, they will of course receive no damage; but if ships are to resort to such manœuvres to avoid the enemy's fire, they do not seem adapted to bring great actions to a speedy conclusion. And how are such manœuvres to be managed with damaged rudders and disabled screws? Naval engagements will, in my opinion, be settled hereafter much as they have been heretofore—the victory will be with the heaviest metal and the greatest daring. And after the various discussions that have been raised on this point, fixed and floating batteries will be found each to have their uses; and it is, I think, a limited view of the question that leads to an undue exaltation of one over the other. If land batteries are, as some have urged, so innocuous to ships, why was Cronstadt not taken?

A very important question, viz., the use of iron for ships and forts, and war purposes generally, is now undergoing the investigation of a committee specially appointed for the purpose, and it is to be hoped that their labours will lead to some important conclusions.

As it respects the question of armour-plates, or of iron to be used for similar purposes, it would not seem that the hardest iron will prove the most suitable, unless it be combined with the greatest toughness. The force of impact is in a sense infinite. A ball cannot be arrested instanter in its flight. The thing struck, or the ball that strikes, must, one or both, possess some elasticity or ductility; or, if not, one or both must go to pieces. Of course the object to attain, as it regards both ships and forts, will be to devise a structure that will best arrest the shot; but we have not yet arrived at the best mode of doing this.

The use of iron is extending on every side. Its manufacture is also, I am glad to say, improving. There was great room for its improvement. Several processes for converting it largely into steel, or into a metal approaching steel in character, are also now in use, and promise to afford an article at a moderate price double the strength of ordinary iron. These discoveries will tend still further to extend the use of iron.

Should it turn out that steel, or homogeneous iron as it is sometimes termed, uniform in quality, and of double the strength of ordinary iron, can be manufactured in large quantities at a moderate price, and can be easily manipulated; then, many things that are now with difficulty accomplished will be greatly facilitated, and some things which cannot be done at all will be rendered practicable.

Bridges of greater span could be constructed. Screw shafts, crank-axles, and other parts of steam-engines at present of unwieldy size, would by its use be reduced to more moderate dimensions. There seems to be no limit to the size of guns, except that of the strength of the material, and the power of welding, forging, and handling them. Cannon, as we know, have already been greatly increased in power by adopting a superior material in their construction. Could we hit upon an inexpensive mode of doubling the strength of iron, the advantages to all sorts of machinery might be equal to those that would flow from the discovery of a new metal, more valuable than iron has hitherto been.

We are, I believe, in the infancy only of discoveries in the improvement of the manufacture of steel and iron. Until lately, the nature of the demand for iron retarded rather than encouraged improvements in its manufacture. Railways consumed iron in vast quantities, and railway companies cared nothing about quality. They were driven to seek a tolerably good material for engine and carriage tyres, but as it respected the vast consumption in the shape of rails, they were implicitly guided by the lowest prices. As long as this system continued it suited the ironmaster to manufacture a cheap article in large quantities, and they therefore gave themselves no concern to establish a better state of things. But heavy engines, high speeds, and an enlarged traffic are gradually working a change. We are beginning to find that iron of the very best quality has hardly endurance enough for rails or locomotive tires: that there is no economy in laying down rails which require taking up again in a year or two; and in short, that the increased strains arising from the accelerated motion of railways, steamboats, and machinery generally, are necessitating a better material.

In marine steam engines, which have received much attention, and where great attempts have been made at perfection, paddle-shafts, crank-axles, screws, and other portions have, as before intimated, already attained an unwieldy size, and the vis inertia and weight of such masses of metal are of themselves no slight impediment to the improvement of steam navigation, and would be greatly obviated by the use of a stronger material.

Fortunately for this country, just at the time that the use of iron is extending, and improvements in its manufacture are developing, fresh discoveries are made of the raw material, and men seem to stumble, as it were by accident, on new fields of iron ore, in places where those mineral riches have laid dormant for centuries, to await a new era and another age, when ships like knights of old are to go forth to battle in complete armour, and when the civil engineer has assumed the duties which devolved on the smith and armourer of former times.

Having noticed some of the advantages that may flow from a greatly improved quality of iron or a cheap manufacture of steel, or of a metal approaching steel in character, I may call attention to the great facilities that have arisen from the use of iron cylinders in sinking and securing foundations.

Before this invention, masonry built under water had to be performed by divers with helmets, or by means of diving-bells. That mode of construction does not admit of the best work. The stones are laid without mortar, and depend for their security on their large size, and on a good arrangement of bond. It is true that concrete work (which however is inferior to masonry) could be built under water without either divers or diving-bells; by passing the concrete though the water to its destination in boxes or by means of shoots, and giving it the requisite form by casings of timber or iron. This mode of building has long been adopted on the shores of the Mediterranean, and the docks and quay-walls at Genoa have been built in this manner.

But the use of iron cylinders not only admits of masonry or brickwork being built in mortar under water in any form, and with any bond, but enables the engineer to excavate under water and to examine the ground before he begins to build, and to proceed with his work with as much deliberation, method, and security, and almost with as little delay, when 70 or 80 feet below the water level, as he can do on dry land.

Hitherto this method has been mainly confined to the use of circular cylinders, sometimes used (as was done by Mr. Brunel in the case of the Saltash Bridge) as a means of building the requisite pier of subaqueous masonry, the iron being afterwards taken away, and sometimes to enable the requisite piers of concrete, brickwork, and masonry to be executed, and by allowing the iron cylinders to remain afterwards to protect the interior work. In other cases, the cylinders themselves are used to support the incumbent weight, and they then act simply as piles.

But it appears to me that this method of building may be extended with advantage much farther than it has been. It is adapted to almost any form of pier, and might in certain cases be usefully applied in building continuous walls; and I know of no system that is likely to afford greater help to the engineer.

I have already said a few words on the progress of invention. This method of building is an illustration of the slow progress of really useful things.

In 1841 a patent was taken out for "improvements in the means of and in the apparatus for building and working under water;" and soon after the construction of the Rochester Bridge, where cylinders were sunk under air-pressure, an action was brought against Messrs. Fox and Henderson, the contractors for the bridge, for an infringement of that patent. I happened to be engaged on that trial; and the fact was then brought to light, that many years before, the late Earl Dundonald (then Lord Cochrane) had taken out a patent for a similar purpose, very perfect in most of its details, for the drawings attached to Lord Cochrane's patent showed an air-lock almost identical with that now in use, and contained all the requisite arrangements for success. Lord Cochrane proposed to use it for overcoming difficulties similar to those encountered in the execution of such works as the Thames Tunnel; he proposed in fact to excavate such works under air-pressure.

This is another instance of the fertility of mind of that extraordinary man, who, great as he was as a sailor, would probably have been equally eminent as an engineer; and I here offer as a tribute to Lord Dundonald's memory this recognition of his early attempts to introduce the important system to which I have just been referring.

But we live in an age when men's minds turn to mechanical inquiries, and when probably they were never more fruitful in mechanical resources. It is almost needless to give examples of this fact. The locomotive engine is a familiar instance, and railway machinery generally affords many illustrations. The beautiful cotton-combing machine invented by Joshua Heilman, of Alsace, which was first used in the cotton manufactories to separate the fine from the coarse fibre, and has since been applied to wool, flax, and silk, and which acts almost with the delicacy of touch of the human fingers, is another illustration. Scheutz's calculating-machine is another remarkable instance, and many other cases might be named.

There is one subject, however, connected with mechanics which has hitherto been barren of result, about which men will occasionally occupy themselves, viz., the discovery of a new motive power. The steam-engine, however, remains the only tame giant that is usefully subject to the will of man. The little that has been done in the way of its improvement, since it left the hands of Watt, speaks volumes to the sagacity, industry, and untiring perseverance of that great man.

The late Mr. Kennedy, of Ardwick House, who was on intimate terms of personal friendship with Watt, on one of his last visits to Soho, asked him if he had discovered anything new in the steam-engine. "No," he replied, "I am devoting the remainder of my life to perfecting its details, and to ascertaining whether in any respect I am wrong." What the labours of that life produced we all know, and the patient concentration of will on his great object reminds one of Newton's similar labours in the perfection of his theory of gravitation, and evinces in the one case as in the other the truly great and philosophical mind, which is capable not only of discerning the dawnings of a great truth, and of appreciating its magnitude, but also of patiently pursuing its evidences until the whole is made clear as noon-day.

At present it seems improbable, so long as motive power is to be obtained through the intervention of heat, and until a cheaper fuel than coal can be found, that the steam-engine will be superseded by any other machine. Electric-magnetic machines are perhaps the least likely of all inventions to supersede the steam-engine. The consumption of a grain of zinc, as Mr. Joule has shown, though much more costly than a grain of coal, does not produce more than about one-eighth of the same mechanical effect.

It would not, however, be at all safe to predict that considerable improvements may not yet be made in the steam-engine, or in engines to be worked by coal. The consumption of fuel in the best steam-engines has been reduced to 2½ pounds of coals per horse-power per hour; but such an engine does not utilise one-fifth part of the absolute mechanical value of the coal consumed, and so long as this is the case it would be unwise to assume that we have attained the utmost limits of improvement.

On another great branch of engineering, that of docks and harbours, I am not aware that much that is novel can be noticed. The progress of such works is generally too slow to admit of much change in short periods of time. An interesting discussion on the subject of harbours took place during a preceding session of this Institution. A considerable portion of that debate turned on the question of how far such works should be made permanent in the first instance, and how far they should be constructed so as to bring them into use with the greatest rapidity and at the smallest amount of cost, reckoning, of course, on rebuilding them at a future period. This is one of those questions which it would be vain to discuss with any hope of coming to general conclusions. In its naked form (apart from the question of harbours) it is one of the most simple and elementary questions. For it would not be difficult to show that, if money alone be worthy of consideration, then, as it respects public buildings of all sorts, the cheapest system would be to discard solidity and ornament, and to adopt structures of a more temporary character; the plan in fact which is always adopted in new countries. But wealthy nations, like rich individuals, will spend more on themselves and also more on their public works and buildings than the absolute wants of a nation demand, and the fact is that men are not governed by monetary considerations only, but also by a sense of what is or is not appropriate. We have, however, some exceptions to this rule. There are, for instance, the tattered and ragged margins of the Thames, where, in the greatest metropolis of the world, mud banks swelter, and crazy buildings reel and totter against each other, but which it is proposed at a somewhat late hour to remedy.

Having thus touched upon the several points that occur to me as deserving of notice, I will conclude by remarking that no man can look back on the last twenty or thirty years without feeling that it has been the age of engineers and mechanicians. The profession to which we belong has in that period of time done much to change the aspect of human affairs; for what agency during that period, single or combined, can be compared in its effects, or in its tendency towards the amelioration of the condition of mankind, with the establishment of railroads, of the electric telegraph, and to the improvement in steam navigation? For in constructing railways, telegraphs, and steam-boats, and their adjuncts, docks and harbours, and moulding and fashioning the face of the material universe to the wants of man, in overcoming its barriers, overleaping its valleys, and spanning its seas, engineers annihilate both space and time, bring into juxtaposition nations and people, and accelerate beyond all human expectation personal communication, and that interchange of ideas which is all important to the advancement of civilization and knowledge.

Distance and separation have led and will always lead to misapprehension and prejudice—to ignorance and mistrust—to rebellion and war; and engineers may feel, when labouring on the great public works that facilitate the intercourse of nations, that they are not merely conquering physical difficulties, but that they are also aiding in a great moral and social work.

LECTURES ON ARCHITECTURE AT THE ROYAL ACADEMY.

The following, one of a series of lectures "On Architecture," was delivered by Professor Sydney Smirke at the Royal Academy, on Thursday, the 9th ult.—

Lecture I.

Early in the seventeenth century an Italian writer, Teofilo Gallaccini, composed a treatise of some ingenuity and merit, "On the Errors of Architecture;" and certainly he succeeded in bringing together a mass of architectural errors (horrors I might say) so shocking as to reflect no small discredit on the practitioners of his day. That day, it is true, was one of great darkness in his art. By an unfortunate accident it coincided with the date of the greatest activity, influence, and wealth of the followers of Ignatius Loyola; when churches and seminaries arose in great profusion over a large part of Christendom; hence that era was then and still remains distinguished from all preceding and succeeding times by the prevalence of perhaps the worst architecture that has yet been devised by human ingenuity. Not that the Jesuit's style of architecture, as it has been called, may not be admitted to be sometimes picturesque and bold—so much so, indeed, as to be occasionally most theatrical in its effects; but so entirely were all the rules of composition, I should almost say of common sense, ignored and outraged—so entirely was the sober truthfulness of our art disregarded—that I feel satisfied that I am confining myself to strict truth when I say that to the society founded by Loyola our art owes indirectly more of its degradation and decay than to any other school or individual whatever. Of course, I do not impute personally to himself any influence over the style which the buildings I refer to tended to propagate: I only regard him as the founder of a religious society, who became the unconscious instruments of establishing a vicious school of architecture at a very unfortunate epoch of architectural activity. The author to whom I have above adverted had the great merit of seeing more clearly than his contemporaries the faults of contemporary art; and he deserves to be recorded among our worthies for his boldness in contending against the monstrous errors and absurdities that had sprung up with a luxurious rankness and rapidity which are really remarkable.

The very commencement of the sixteenth century, namely, the age of Bramante, of Raffaelle, of Peruzzi, and Giulio Romano, was, as I have on a former occasion shown, in many respects worthy of being regarded as the culminating period of modern architecture; and the end of that same century saw the art, if not at its lowest ebb, at all events in a state of deplorable impurity. It is an old remark that all evil is but the corruption of what is good; and it seems to be in the nature of a law that no sooner has a point of excellence been reached than a process of deterioration commences. Fortunately, there would appear to be a co-existent law of social adjustment; for no sooner have we reached a state of apparently hopeless and helpless imbecility, than a glimpse of better things appears, to restore our hopes and to redress the balance. The course, in short, of most human affairs may be correctly represented in a diagram by a series of anticlinal lines, persistent in their ever-varying irregularity.

Such, at all events, appears to have been the course of our art. The great effort of the distinguished artists whom I have named appears to have been—first, to make themselves thoroughly acquainted with the principles which guided the architects of the great Classic period, and then to devise such departures from the style of that period (still, however, adhering to the principles on which that style was founded) as would enable them to adapt their structures to the greatly altered habits, and to the new civilisation, of their own days.

There can be little difference of opinion among us as to the consummate genius and wonderful dexterity with which these modifications of the ancient manner were effected. Perhaps one of the most prominent modern modifications was the introduction of a regular fenestration, by which that essential feature, the window, was so treated as to render it a fertile source of beauty and interest. It is true evidences are abundant to prove that, whatever may have been the case in still earlier times, windows with architraves and other somewhat ornamental adjuncts of like nature were a recognised feature in Roman architecture; but I am aware of no ancient building having its various floors marked by uniform ranges of windows as decorated features, such as we find especially characterising the architecture of the Renaissance.

Another source of beauty, wholly unknown to Classic art—namely, the balustrade, is also due to the originality and inventive genius of the quatrocentists; and it is curious to note the avidity with which artists learnt to avail themselves of this novel and ingenious mode of turning so prosaic and utilitarian an object as a parapet into an ornament of great æsthetic value.

The systematic superposition of several regular orders was another practice particularly affected in renascent architecture. It had, indeed, been suggested by the magnificent amphitheatres of the Romans, as well as by a rare instance or two of still earlier date, but was certainly not practised by that people generally, either in temples or in their domestic buildings. I have enumerated some of the more prominent characteristics of Italian art, which stamped it with originality, and gave birth to a school as widely differing from the primitive, strictly classical, school, as from the Mediæval school which it supplanted.

Such was architecture at the beginning of the sixteenth century in Italy, then the instructress of Europe in the fine arts, as well as in most other branches of intellectual culture.

I have on a former occasion dwelt at sufficient length on the phases of our art down to this period—a period which, again adopting the language of a kindred science, may be regarded as an anticlinal axis. A downward course here commences. It is an ungrateful task to record the weaknesses of men and the errors of genius; but perhaps it is a useful one. Perhaps there may be as much advantage derived from inquiring how and why art decayed, as in marking and admiring its growth and elevation. Such, at all events, is the task which I have this evening imposed on myself.

To inquire why art decayed after it had arrived at a point of great excellence is, perhaps, equivalent to inquiring why genius is erratic, why we are unstable in our judgment, and why human fancy is like the fabled bird of paradise, that exists only when on the wing.

Had the men who followed the bright period to which I have adverted been plodders on the highway of art, without soul or invention, and content to follow with painful exactness the footsteps of their predecessors; we might, perhaps, have seen an age of good imitators, and of a level platitude; a race of tame transmittors of the excellence of others, productive of a perpetual repetition of approved forms and established models.

But very far otherwise was the case. Art, in all its branches, throughout the sixteenth and even the seventeenth centuries, was in a state of excitement and activity. Vasari, writing in the middle of the sixteenth century, vaunted that such was the fecundity of art and facility of execution in his time, that six pictures could then be painted within the time occupied by the previous generation of painters on a single picture. The simple-minded historian of art seems to have been hardly aware that his vaunt implied rather reproach than praise; although it is true he has elsewhere amused his readers by the anecdote of an eminent painter who, at his easel, when called to his meal, replied that he would come directly, "for he had but one saint more to paint."

The growth of public wealth and the progress of civilisation brought into existence hosts of artists and of patrons of art. Popes and potentates vied with each other in the patronage of it, and even kings would condescend to bid against each other for the corporal possesion and exclusive monopoly of some favourite practitioner.

The consequences of such excessive stimulus were obvious and inevitable. Prosperity begot reckless and careless extravagance, and extravagance led to a rapid deterioration.

The real laborious artists of the fifteenth century wrought, no doubt, slowly and painfully—urged onwards not so much by a thought of lucre or applause, as by a deeply-felt love of their art; whilst the flattering crowd of artists who filled the scene in later times were the spoilt children of fortune; painting and carving and building with wonderful dexterity and readiness of execution it is true, and with a wonderful facility of invention in devising new shapes and fashions and fantastical combinations; but without that earnest, ardent, painstaking, and simple severity of study which had conducted their forefathers to real excellence.

By way of illustrating the vast change that had taken place during the sixteenth century, let us compare the works of Bramante, who flourished at the beginning of that century, with those of Borromini, who was born at the end of it. I have on a former occasion dwelt on the peculiar merits of Bramante. His was a pure, honest architecture, perfectly free from affectation and conceits of any kind whatever. His style appears to me to be all the more captivating from the very absence of all *ad captandum* contrivances, and all the more effective from its manifest freedom from all seeking after effect.

If we turn from him to Borromini, we shall be shocked to see what devastation and corruption of taste had taken place during the one hundred intervening years.

The one sought to charm by his purely architectural feeling; aiming, for the most part, at those high qualities—order, symmetry, and rythmical arrangement—which the great father of architecture, Vitruvius, had long before pointed to as the distinguishing character of good architecture; whilst the other set at defiance all order and moderation. The one never feared to draw a straight line, unless the requirements of his work seemed to render a curved or a broken line preferable for some special purpose—and surely a straight line seems to be, of all others, the line of architectural fitness, and therefore of beauty; whereas, Borromini must evidently have abhorred such a line above all things. He it was who, of all men, contributed most to the introduction of that system of architectural design (if it can worthily lay claim to the dignity of a system) by which masonry lost its special character and its most appropriate forms. His façades curved inwards or bulged outwards on their plan, as if made not of hard stone, but of some yielding and plastic substance; and his pediments, totally forgetful of their primitive form, offered every variety of intricate convolution and distortion.

Bramante called in the aid of sculpture with that chariness and caution which plainly indicated how highly he appreciated its noble attributes and fitting application; and as if he feared to vulgarise it by too frequent a use of it, or by excess of any kind. Yet, highly as he appreciated sculpture, he never permitted it to encroach upon the proper limits of his own special art. Sculpture was used by him as an honoured accessory, well calculated to stamp a moral value on his work, and to give it a grace beyond the reach of mere architecture.

Borromini, on the other hand, permitted sculpture to dominate over the main object of his art without restraint: his whole building was literally sculpturesque, and his masonry was left to the humbler duty of forming a mere vehicle for the consolidation of some fantastic piece of clay modelling. Such had been the downward progress of architecture during the period to which I have been adverting.

It must not, however, be supposed that the transition was sudden, or even rapid. The activity and energy of the sixteenth century were wonderful, and led to perpetual changes, and were constantly giving birth to novelties. New schools were founded, and eminent masters appeared in rapid succession, and of most opposite characters;—Sansovino, with his superabundant wealth of sculptural resources; Palladio, with a moderation and purity of feeling far beyond his fellows; Michael Angelo, whose length of life enabled him to see out most of the brightest lights of Italy, although he was himself a fellow-labourer with some of the earliest and ablest masters of the great Italian Renaissance. Still, though the course of architecture was an onward course, yet it was also a descending course. The art lost its dignity, and became frivolous and trifling. Every part of a building seemed to be, as it were, in restless movement; curved lines were broken and inverted; straight lines were perpetually interrupted or diverted; and all breadth was frittered away by a multitude of lights and shadows.

It is worthy of note how great a sympathy has always seemed to exist between our art and that of the sculptor. Whether dignified and severe, noble or mean, national or conventional, grand or grotesque, those two sister arts seem ever to have proceeded hand in hand; for ever sharing the same fate; rising together into greatness and sublimity, and together sinking into painful imbecility. Without going too far back into the history of art (although in remotest times the sympathy between the two arts was eminently conspicuous), we shall find the observation hold good in Mediæval art. The culminating period of ecclesiastical architecture was precisely that which has been eulogised by our Flaxman as distinguished by high sculptural excellence. The quatrocentist introducers of modern art in both these branches shared like feelings, and were remarkable for like excellences. The sculpture of Donatello, like the architecture of Alberti, was alike vigorous and original, and full of delicacy of feeling; these high qualities being in both arts somewhat qualified, it is true, by a certain degree of hardness and rigidity. In Michael Angelo we find the same colossal and masculine breadth, whether we regard the examples he has left us of his sculpture or of his architecture.

Then, coming down to the epoch that more particularly engages our attention this evening, we shall find the same debasement pervading the two arts. I have already said that one of the marked characteristics of the architecture of the seventeenth century was that of restless movement; so also the sculpture of the seventeenth century exhibits, in an especial manner, the absence of that tranquil dignity which is particularly becoming in sculpture, especially when applied as an accessory to architecture. A want of repose is almost equally offensive in both the arts. The eye is fatigued and the attention distracted by an excessive flutter in the details, whether we contemplate a building or a group of sculpture. Bernini set the example, but Borromini went far beyond him in this vicious treatment of the sculptural accessories of their respective buildings. Indeed, one of the most repulsive faults of sculpture at this degenerate period was its utter want of repose, and the inordinate love of representing agitated drapery.

It is said of Bernini, by Milizia, that, although he was himself far from a pattern of sobriety in this respect, he yet knew enough of his art to condemn the fault in others. Remarking on one occasion the extreme agitation of St. Veronica's clothing, under the dome of St. Peter's, he sarcastically inquired of the sculptor from whence the wind came that so seriously disturbed the virgin saint's drapery, seeing that she stood protected within the walls of the edifice. The sculptor, fortunately for him, had an answer that effectually disconcerted the critic:—"The wind," he replied, "obviously came through the serious fissures in the masonry of the dome, occasioned by the critic's (Bernini's) want of skill, in destroying the stability of the piers of that dome;" Bernini having shortly before somewhat rashly interfered with Michael Angelo's piers, by the insertion of colossal niches excavated out of the substance of those piers. Such were the mutual recriminations of these two most eminent artists, who contributed so largely to the degradation of their art. I am confident that I am using no extravagant or inordinate expressions when I designate the architectural sculpture of the seventeenth century, in its treatment and mode of introduction, as ridiculous and absurd. Their sculpture may probably have been designed with boldness and vigour, and executed often with a masterly dexterity; certainly we cannot justly charge it with tameness or insipidity. Its faults were, indeed, exactly the reverse. There is a grotesque energy, a violence of gesticulation, which is perhaps very true to nature, if we seek nature in the wine-shops of the Campagna, or among the Lazzaroni of the Chiaja; but the united voices of all cultivated artists will concur in condemning that style of nature as unfit for the study and imitation of sculptors.

A painter may, with perfect propriety, impart whatever degree of violent action his subject may demand: his pencil undertakes to realise to the eye actual scenes; and, if intense action is to be represented, he is most successful who best realises on the canvas that intensity. The case is, as it appears to me, far otherwise with the sculptor's art; at least when it is applied as the accessorial embellishment of architecture. Statues in niches, or on balustrades, or otherwise fringing the sky-line of a building, must, I should think, be subdued both in attitude and in treatment.

(To be continued.)

TO DETERMINE BY INSPECTION THE AMOUNT OF HEART-WOOD IN SLEEPER BLOCKS, BEAMS, &c.

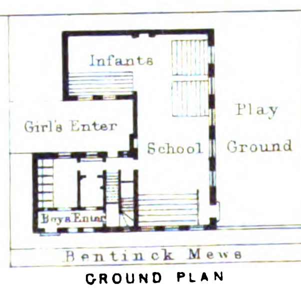
By Thomas Cargill, C.E.

In every specification attached to a contract for the delivery of sleeper-blocks, beams, or other timber intended for engineering or architectural purposes, one of the most important clauses is that which specifies the amount of heart-wood which the block or beam must possess in order to insure its being passed by the engineer or other person deputed to examine it; for it is calculated that a certain quantity of perfectly sound and well-seasoned wood ought to be obtained out of every block, and it is evident this would not be the case should the timber contain more than the allowable proportion of sap-wood.

It is a matter then of some importance, and of considerable convenience to the person in whose hands rests the responsibility of passing or rejecting timber, to be able to ascertain speedily and accurately whether the blocks under his examination possess a sufficient amount of heart-wood to furnish good and sound material for the purposes for which they are intended; and I propose giving a short rule, by which anyone may calculate a table which will enable him to discover by simple inspection whether a piece of timber will give the quantity of heart-wood required by the specification. In any block of timber the heart wood is found disposed in a pretty uniformly circular figure around an imaginary line passing through the centre of the block, and which may be regarded as its longitudinal axis. This is shown in the diagram, which represents, to a scale of one-sixth, a section of a block of timber 13 inches by 14; the inscribed circle is intended to show the heart-wood, while the rest of the figure exterior to the circle represents the amount of sap-wood which the block contains. Although my object at present is not to define, yet it may be well to mention that the sapwood is that portion which is of the newest or most recent growth, and which, owing to the premature felling of the tree, not having had time (to use a common phrase) to acquire the consistency and close-grained structure of the interior parts, is totally unfit for purposes of construction, but which would become heart-wood in the event of the tree remaining unfelled—in fact, were the tree permitted to attain to maturity there would be scarcely any sap-wood at all.

In the diagram let a, b, be the breadth and depth respectively of the block; d the diameter of the circular portion of heart-wood; and let n represent the proportion of sap-wood allowed in the specification. Now the total amount of heart-wood will evidently

J.R. Jobbins

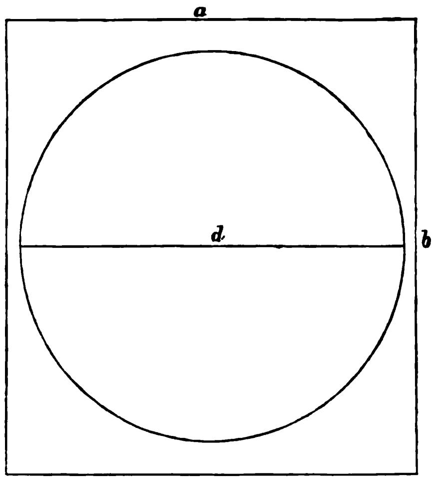


GROUND PLAN

S. WEST VIEW OF ST JAMES' SCHOOLS BENTINCK MEWS, MARYLEBONE LANE.

WILLSON & NICHOLL, ARCHTS

equal the difference between the contents of the whole block and the proportion of sap-wood, $=ab-nab=ab(1-n)$. Again, as the heart-wood lies wholly within the circular portion of the figure,



the area of this circle must $=ab(1-n)$, which gives us the following equation:—

$$\frac{\pi d^2}{4} = ab(1-n),$$

π of course being ratio of circle to diameter. Reducing the equation, and solving for d, we obtain

$$d = 2\sqrt{ab} \times \sqrt{\frac{1-n}{\pi}} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

As the length of the piece of timber would be common to both sides of the equation, it would be superfluous to introduce it into the calculation, more especially as it does not affect the use of the rule.

In cases where $a=b$ the equation becomes

$$d = 2a\sqrt{\frac{1-n}{\pi}} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

As a, b, and n are always known, it is clear that a table could be easily constructed for the corresponding values of d; and all that remains for the inspector of the timber to do is to lay his rule across the centre of the block, and ascertain whether the actual and calculated lengths of d coincide. Since n in the same contract is generally constant, the calculations in the equations become very much simplified, particularly in the equation (2) for square blocks, which are the most usual; for the value of $\sqrt{\frac{1-n}{\pi}}$ once determined, suffices for all the different values of a and b.

Dublin, Jan. 17, 1862.

ST. JAMES' CATHOLIC SCHOOLS, MARYLEBONE LANE, LONDON.

(With an Engraving.)

These schools occupy a central position amid a large number of families of the working classes, for whose use the establishment is intended. Simple as are the main requirements of day schools, there is on examination opportunity for much thought and labour in designing the general arrangement and various details to make up the necessary sum of space, light, ventilation, warming, easy access, due separation, convenience for washing, depositing caps and cloaks, &c., that constitute a serviceable building. In this instance, in order to leave an open playground to serve as well for light and fresh air, the three schools for infants, girls, and boys, are disposed on three floors; the height thus necessitated is undesirable, but readily excused from the great scarcity of land. The staircases and offices, and two separate entrances, form one wing, all of fireproof construction. A considerable economy of space is gained by the compact arrangement of the two staircases winding over each other in the same space. The teachers' rooms, cloak and cap rooms, lavatories and latrines, all communicate with the different stairs; in the latter a careful construction of glazed stoneware, with a flushing apparatus, has been adopted to insure cleanliness.

The style, in accordance with the every day material used, is simple and structural, as our illustration shows: in this instance, it has been an object that on entering the building no feeling of disappointment should be the consequence of a forced contrast with too ambitious features in the exterior.

The foundation stone of this building was laid on the first of November last, by the clergy of the church in Spanish-place. Canon Hunt officiated, assisted by the Rev. Chaplains J. Rhing, Dr. Banns, and Edward Taylor, the manager of the schools.

The accommodation is for six to seven hundred children. Mr. J. Ross is fitting the rooms with improved desks, &c. of American birch. The contractor, Mr. G. P. White, of Pimlico, has energetically carried on the works during the winter months, and with evident security. The architects are Messrs. Willson and Nicholl, of Marylebone-road, London.

ON PHOTOGRAPHIC DISTORTION.

By Robert H. Bow, C.E.

"CHART DISTORTION."

Plans and charts become worse than valueless when copied so as to have distorted scales; it is therefore a most important matter to free the copying as much as possible from this defect.

Believing that this distortion exists to a much greater degree than is generally thought, and that the usual combinations for copying are not so perfect as they get credit for, I trust the society will excuse me for treating of the subject at considerable length, although not so fully and completely as I could have desired; but the subject is new to me, the calculations somewhat tedious, and the aid to be obtained from the ordinary treatises on optics very doubtful indeed. The chief information and the higher researches on the action of lenses are confined to the production of the most perfect image of an object seen under a very small angle of view, of which we may take the moon, or about half a degree, as the greatest; whereas what the photographer desires is an angle of 50 or 60 degrees, or more if he can get it. The questions are so different that one of the first proceedings of the photographic optician is to turn the lens exactly the reverse way of that directed by the astronomical mathematician, sacrificing fine definition at the centre of the picture for a more generally distributed though far inferior excellence.

The Origin of the Distortion.—If we were to take a copy of our chart by means of the rays passing through a pinhole, or by means of a very small lens of considerable focus, that copy would be free from the defect we are now considering: the various lines would be more or less hazy and indistinct, but their positions and distances would be everywhere correct, according to the scale of the centre. The want of sharpness, however, in the best of such copies thus obtained, except when the size is very small compared with the length of focus of the lens, is so great, that we are driven from this simple to more complex arrangements in search of "flatness of field," or of such a condensing of the oblique and straight pencils of light as to bring them all to their foci in the same plane.

The diagram, Fig. 1, exhibits the different foci for some pencils of light all at the same very oblique angle, but passing through different parts of the lens, and at once points out the use of a stop at SS, to cut or stop off all the rays which come to the shorter foci; and this device of a stop is the principal step in all arrangements for obtaining flatness of field.

Unfortunately the employment in this manner of a stop brings with it the evils of chart distortion; thus in Fig. 2, let AI = ID.

The rays OA and OI, coming from an object beyond the stop, would give a correct projection on the plane of AD; and therefore, in order that the image formed at PF may be correct, PR should bear the same proportion to RF which AI bears to ID, and it would do this approximately if the tangents of the angles of refraction were proportioned to the tangents of the angles of incidence, *i.e.*, if PP′ to RR′ were as AD to ID; but it is the sines of the angles and not the tangents which are proportionate, the consequence is that PF compared with RF is too small, or the ray OAP is too much refracted to give an undistorted image.

In calculating the distortions produced by the different lenses, and in comparing the effects producible by combining two lenses one on either side of the same stop, it will greatly facilitate the

* Continued from page 26.

operations if we assume certain rays passing the stop at definite angles; and perhaps the rays shown in Fig. 2 are the most convenient for our purpose. The extreme ray is taken at thirty degrees with the axis of the lens, and the tangent to it, AD, is divided into four equal parts, so that the angles of the other rays are as

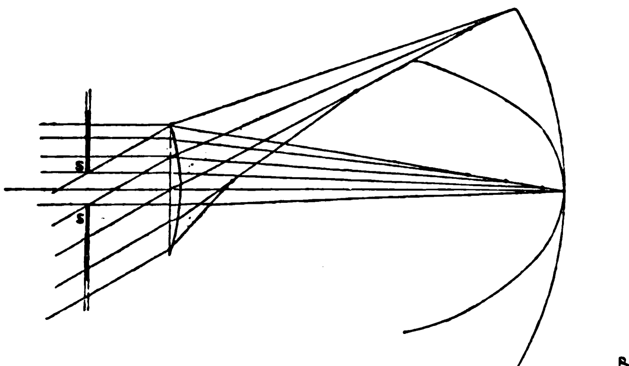


FIG. 1.

NOTE.—The more curved "field" is given by using the central part of the lens alone: the flatter "field" is obtained by placing a stop at SS.

marked in the figure. Taking AD as the unit of our dimensions, KD will be $=0{\cdot}75$, ID $=0{\cdot}5$, and GD $=0{\cdot}25$, also the distance of the stop or OD will be $=1{\cdot}732$. All the other dimensions, such as the radius of curvature, distance of object or image, &c., are to be referred to this same unit AD. All the lenses here considered are plano-convex.

The Unit of Non-Distortion.—The amount of the distortion will diminish towards the centre of the picture, the tangents and sines becoming there more and more nearly equal, and at the centre the distortion will be zero.

If we imagine a ray O*m* (Fig. 2) to be exceedingly near to the axis, then the ratio which *w*F bears to *m*D gives us a standard by which to calculate the amount of distortion produced upon any of the radii, such as DG, DI, DK, or DA; and if we make the value which DA *should* possess in the picture at PF (if it were undistorted like the centre) equal to unity, the actual values of PF, TF, RF, and QF, when compared with 1, 0·75, 0·5, and 0·25 times this undistorted value, respectively, will indicate the amount of contraction which each has undergone. The ratio which *m*D bears to *w*D when the ray O*m* is infinitely near the axis is

$$=1:1-\frac{D+\frac{1}{u}T}{2R}$$

where u = index of refraction, D = OD, T = DE, and R = radius

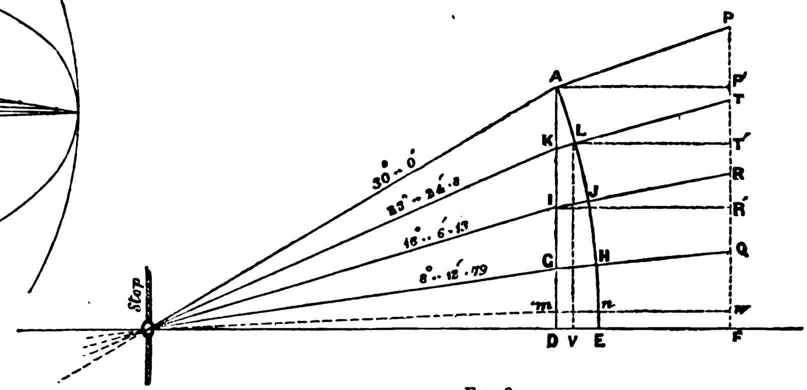


FIG. 2.

of curvature of AE, and taking $u=1{\cdot}5$, and since AD = 1, the value of our *unit* of non-distortion is $=1-\frac{D+\frac{2}{3}T}{2R}$

The courses of the four rays have been calculated for the various examples with considerable care, the effect of the thickness of the glass, &c. being taken into account. The index of refraction employed has been taken as usual $=1{\cdot}5$ for the sake of convenience, although a higher value would have been better.

The results are given in Table 1. It will be observed, from the second and third lines, that the absolute contractions of the radii vary nearly as the cubes of their lengths, and that the percentages of contraction are therefore nearly as the squares of the lengths.

TABLE I.—*Of Results of Calculations.*

Radius of Curvature of Lens and its Distance OD from Stop.	No. of Line	PF = 1	TF = 0·75	RF = 0·5	UF = 0·25
Rad. = 3.					
OD = 1.732.	1	0·8846	0·6994	0·4850	0·2480
	2	0·1154	0·0506	0·0150	0·0020
	3	11·54	6·74	3·00	0·78
	4	2·94—	2·96+	2·937	say 2·94
	5	33·90	19·97	8·80	2·30
Rad. = 3.					
OD = 0·866.	1	·9259	·7172	·4903	·2486
	2	·0741	·0328	·0097	·0014
	3	7·41	4·38—	1·94—	0·57
	4	2·85—	2·83	2·76	say 2·8
	5	21·12	12·39	5·35	1·60
Rad. = 4.					
OD = 1·732.	1	·9045	·7081	·4878	·2484
	2	·0955	·0419	·0122	·0016
	3	9·55	5·59	2·43	0·64+
	4	2·95	2·97	2·92	say 2·94
	5	28·17	16·60	7·10	1·88
Rad. = 6.					
OD = 1·732.	1	·9275	·7187	·4906	·2488
	2	·0725	·0313	·0094	·0012+
	3	7·25	4·17	1·89	0·49+
	4	2·94—	2·94+	2·93	say 2·93
	5	21·32	12·26	5·55	1·44

Explanation of the Table.

The first line gives the values to which the various radii are reduced by distortive contraction when the distance DF is assumed to be infinite (and are then proportional to the tangents of the angles of emission.)

The 2nd line of results gives the absolute amount of distortive contraction.

The 3rd line gives the per-centage values of the distortions of the radii.

The 3rd line also expresses the per-centage of lateral distortion of a body situated at the extremity of a radius.

The 4th line gives the values of the index n calculated with reference to the ray nearest the axis, so that r^n varies as the absolute distortion.

The 5th line gives the per-centage values of the radial contractions taken at the extremities of the radii. These are shown, by detailed calculations in the original paper, to amount to n times the value given in the 3rd line for the total radial, or for the extreme lateral contractions.

(*To be continued.*)

REVIEWS.

Specimens of Early French Architecture, selected chiefly from the Churches of the Ile de France, and Illustrated in Geometrical Drawings and Perspective Views. By ROBERT J. JOHNSON, M.R.I.B.A., Architect. Parts I., II., and III.

In giving a passing glance in our notice of Foreign Publications at the 'Monuments of Mediæval Art in Austria,' of Helder and Eitelberger, we remarked that the work would be perhaps more esteemed by the antiquarian than by the students of practical architecture such as we find them in this country at the present day. The very reverse of this observation applies to the work now under notice. It is neither more nor less than a selection of the sketches made by an architectural student during a continental tour, elaborated into good but not highly-finished drawings, and published. Much the same thing has been done in the recent and well-known works of Mr. Norman Shaw and Mr. Nesfield, and in some earlier instances: the present work, however, differs from the two just named in being confined to one country, and as a rule to one province of that country; and differs also in the style of lithography adopted, being executed entirely in line lithography.

About one-third of the proposed series is now published, and from that we can judge of the selection of subjects and of the execution of the plates. The subjects are of the twelfth and thirteenth centuries, and may be appropriately described by quoting a few lines from a letter from Mr. Gilbert Scott, recommending the work, which is incorporated in the prospectus. "The buildings which you have selected for illustration," remarks Mr. Scott, "belong to that part of France which was the very cradle of Pointed architecture, and where it assumed its purest and most perfect forms; and the subjects themselves, while they are of the highest excellence, are mostly on a scale which renders them more suggestive to the student of our own day than those of a more magnificent class." Abbey and parish churches, of dimensions and elaboration not exceeding those now built in this country, have accordingly been chiefly selected, and are illustrated by external perspective sketches, measured sections and plans of portions to a small scale, occasional internal perspective views, and frequent details of mouldings to a scale sufficiently large for all practical purposes, with some few examples of carving. These are clearly drawn in line lithography, and the author shows very considerable skill in draughtsmanship, which here and there, as for example in the exterior view of St. Framboise at Senlis, and the interior of St. Martin at Etampes, rises to high artistic power.

In one respect, however, the work is deficient; the representations of sculptural decoration are inferior to those of purely architectural forms, a point the more to be regretted, because the sculpture of these early French works, at once characteristic, simple, and effective, forms one of their strong claims on our attention. Compared with the woodcuts of Viollet le Duc, or the lithographs of Mr. Nesfield, Mr. Johnson's drawings of sculpture leave much to be desired, may we hope to be amended in future portions of the issue. This excepted however, the work is a most acceptable addition to our scanty and incomplete stock of architectural literature. It is prepared by an architect, and for architects, and will be found to convey very much the information which every student of French churches would like to collect for himself; and, with perhaps here and there a little additional finish, in very nearly the same form in which a well-kept sketch book would preserve it.

The views of towers and steeples, which, by the bye, the author refers to in his prospectus as a distinct feature of his project, will be found peculiarly valuable and suggestive, and the distinctness with which they are drawn renders them very useful for study.

This work, we may add, is now in course of publication in monthly parts, and is intended when complete to contain about 100 half-imperial plates, which at the price charged per part will cost under 9*d.* a plate. We hope to take another opportunity of noticing it, either during its publication or upon its completion; and in recommending it heartily to our readers, we are induced to add one or two words as to the value of all such works.

Addressed mainly to students and to practitioners actually engaged in architectural work, these books of sketches offer a mass of valuable but miscellaneous information, in a form in which it is of far greater use to the collector than to any other person. No one could make for himself the series of sketches and measurements which this or any similar book contains without acquiring in the process a mass of the most valuable information, which almost insensibly will arrange itself in the mind, and be of great value. It is, however, possible not only to possess, but even to examine such a work as this without sensible benefit; nay, more, it is a matter of some difficulty to extract from it all the information which it can afford; and to those who possessing this volume desire to master the subject of it, we recommend an attempt at classification of its contents by means of rough sketches made from the drawings themselves, as more likely to aid them in the study of French architecture than repeated inspections, or even the occasional extraction of a feature or a detail, or a general outline.

Far different is it with such a book as Sharpe's Parallels, a work probably at the head of its class in England. Here, not only has the information been collected, it has also been digested, systematised, and arranged, and it is presented to the student in such a form that he can hardly turn over the plates without gaining lasting instruction. It is, however, idle to expect that every student who undertakes the labour of preparing an illustrated book on architecture, whatever he may in part do for his own benefit, or in his own mind, should be able to devote the time and trouble requisite for the production of highly studied works of this class. Such a miscellaneous collection as that before us, although not much more than a mass of materials, is of great value to students, and will prove to those about to proceed to France a very good example of what to study and how to study it, so far as "study" refers to actual investigation, sketching, noting, and measuring on the spot, exclusive of future classification and generalisation of the materials so gathered. To architects this book will no doubt often furnish a suggestion, and sometimes a precedent; and to some future writer it may furnish some of the materials for part of a great work which has yet to be written, if written it ever will be, now that the most celebrated of English art critics is understood to have abandoned the attempt in despair, disheartened, and disgusted by the ruthless and wholesale destruction of the genuineness of mediæval monuments in France which recent "restorations" have occasioned. A work that should fully unfold the rise and growth of pointed architecture in France, the country of its greatest excellence if not of its birth, and which should systematize and comprehend much ascertained information that many labourers have collected, either for their own use or for publication; and giving a connected view of the whole, should also trace, step by step, alike the contemporaneous progress and the various devergencies which Gothic architecture in France exhibits in so marked a manner.

The Mechanics of Construction. By STEPHEN FENWICK, F.R.A.S., of the Royal Military Academy, Woolwich. London: Bell and Daldy, 1861.

This work treats of the theories of the strength of materials, roofs, arches, suspension bridges, &c., and of the application of the results of theory to particular cases. What the author appears to have proposed to himself seems to have been to enable the student not only to become familiar with the general scientific principles of construction, but to learn how to apply them readily. This object is very satisfactorily sought by means of careful explanation and numerous well selected examples. There are also given several tables of the strength, weight, &c., of materials. The author has brought to his task a thorough acquaintance with the mathematics of the subject, and some study of various English and foreign works on constructive mechanics and kindred topics, which are enumerated in the preface. We may as well give Mr. Fenwick's account of the scope and design of his book in his own words:—

"I have divided my subject into two parts:—

The first part includes the theory and some of the applications of the strength and resistance of materials. The second part contains the theory and the construction of roofs and arches. The straining forces which act upon a structure having been determined by simple statical considerations, formulæ of solution are thence deduced by the theory established in Part I., with the ultimate view of estimating the strength of each particular construction. These formulæ are the result of exact mathematical reasoning. The various experimental data which have been adopted are placed in convenient juxtaposition with each corresponding theoretical section.

Throughout the whole work the method of determining the *dimensions* of the different parts of a structure, in order to fulfil certain conditions, has been attentively kept in view. This important feature constitutes a distinguishing characteristic of the present publication. In no other English work is this method adopted with respect to torsion, solids of equal resistance, roofs and arches.*

With the desire of rendering my labours more easily available, I have divided the work into small chapters, and in some cases each chapter is subdivided into sections. Chapter I., Part I., contains some necessary introductory remarks, and the first principles of the resistance of materials. This part of the subject is developed at considerable length. In the preliminary observations the practical man is cautioned against trusting implicitly to the formulæ established in Part I., when the straining forces which act upon a body pass certain limits. It is a remarkable fact, noticed by all experimentalists on the strength of materials, that after a certain point has been reached, any addition of strain increases the dilatation of a body in a much higher proportion than before this limit is passed. This, it is conjectured, arises from the disunions of the particle of the body whose joint action contributed to the whole effect. Hence I have taken the utmost care to cite from the best authorities the necessary constants for those limits, which are usually denominated *coefficients of safety*.

* "In the new edition of the 'Encyclopædia Britannica' just completed, in the article on the Strength of Materials, we are told that the writer has not been able to deduce the formula for the resistance to torsion of a cylindrical body when the length of the cylinder is taken into account. This formula is given in the present Treatise, and according to Morin, the truth of the formula has been verified by the experiments of MM. Duleau and Savart."

The want of a small and compendious volume for the use of students of military and civil engineering has been of late greatly felt, especially since the highest educational authorities have introduced these branches of study into the programme of the examinations for engineer and artillery officers. To supply this want is the main motive that has impelled the author to draw up the present treatise."

The first part, which treats of the resistances to Extension, Compression, Flexure, and Torsion; Moments of Load; Sectional Form of Beams; Estimation of Deflection, &c., is very clear and accurate. There is one clause indeed (the 25th, on page 34) in which we fail to find our author's usual transparency, although the course of proof is geometrically exact. In this clause the sum of the moments of inertia of a surface about two perpendicular axes in its plane is equated with the moment of inertia about an axis passing through the point of intersection, and perpendicular to the plane of the surface. Now the former are moments of inertia opposed to *transverse flexure*, while the latter is the polar moment of inertia measuring the resistance to torsion. The equation would therefore be apt to puzzle a learner, since torsion is not treated of until further on in the book. We think, however, that Mr. Fenwick's line of argument might be readily so modified as to prove the following general theorem:—"The sum of the moments of inertia of a surface about two axes in its plane and perpendicular to each other is constant, when the point of intersection of the axes is fixed, but their directions variable." It is easily deduced fron this theorem that the moment of inertia of a square bar is the same *whatever* the direction of flexure; *i.e.*, whether the bending be parallel to a side, in the direction of a diagonal, or in any intermediate direction. A square bar therefore resembles a cylindrical bar in being equally *stiff* all ways; though it differs from the cylindrical bar in not being equally *strong* all ways.

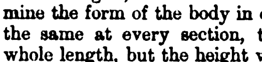
The proposition to which we have demurred is however merely a subordinate one, and the subsequent proposition (to which it is in a certain sense a lemma) is capable of independent demonstration.

As a specimen of the manner in which our author handles the analytical part of his subject, we make the following extract from his chapter on Solids of Equal Resistance, under which title he treats of beams whose sectional strength is everywhere proportional to the strain. We may as well first explain that S denotes the extreme strain of compression or extension at the top or bottom of the section under consideration:—

"PROBLEM 4. A body of length l rests in a horizontal position on two supports at its extremities, and is uniformly loaded along its whole length with p lbs. on every unit of length. The cross sections of the body are rectangles, the middle one of which is of breadth b and height h; determine the form of the body in order that its resistance to fracture may be the same at every section, the breadth being constant throughout its whole length, but the height variable from the middle to each extremity.

For the cross section of the body in the middle we have by Arts. 35, 40,

FIG. 28.



$$p\frac{l^2}{8} = \tfrac{1}{6}Sbh^2,$$

$$\text{or } S = \tfrac{3}{4}\frac{pl^2}{bh^2} \quad \dots \quad \dots \quad \dots \quad (1)$$

and for a section of the body of breadth b and height y at a distance z from one end we have, by Art. 35,

$$\frac{p}{2}z(l-z) = \tfrac{1}{6}Sby^2, \text{ or } S = \frac{3pz(l-z)}{by^2} \quad \dots \quad \dots \quad (2)$$

Wherefore, as the resistance is to be the same for every section, the tension S per unit of surface must be the same for all the sections of the body. Hence, by (1) and (2), we get for the section of the solid, the equation,

$$\tfrac{3}{4}\frac{pl^2}{bh^2} = \frac{3pz(l-z)}{by^2}, \text{ or } y^2 = \frac{4h^2}{l^2}(lz-z^2).$$

This is the equation of an ellipse, and hence the form of the body is determined.

PROBLEM 5. Find the form of the body in the last problem when the height is constant and the breadth variable.

Let the body have at every section an equal height h, and at a distance z from one end let the breadth of the section be x. Then by the reasoning of the preceding problem, we get between x and z the relation.

$$\frac{3pz(l-z)}{xh^2} = \tfrac{3}{4}p.\frac{l^2}{bh^2}, \text{ or } x = \frac{4b}{l^2}(lz-z^2) \quad \dots \quad (1)$$

In order to determine the nature of this curve let us remove the origin of co-ordinates from one support to the middle point of the line which connects the two supports. This will be effected by writing in (1), $\frac{l}{2} - z$ for z.

Hence the equation of the curve becomes, in reference to the new axes,

$$\frac{4b}{l^2}\left(\frac{l^2}{4} - z^2\right) = x \dots \quad \dots \quad \dots \quad (2)$$

In order still further to simplify the equation of the section of the solid let us remove the new origin of co-ordinates to the extremity of the breadth b of the middle cross section, by writing in (2), $b - x$ for x. The equation (2) then becomes

$$z^2 = \frac{l^2}{4b}x \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

Hence it is obvious that the extremities of the variable breadth lie on a *parabola* which has its vertex at the extreme point of the middle breadth b.

The *ground sketch* of the body is therefore a figure similar to a rhombus whose sides, however, are formed by four similar parabolas, every two of which coincide with their vertices at the extremities of the middle breadth b."

The Deflection of Beams is treated in a very satisfactory manner. There are however two slips, which are so obviously such that we should not care to mention them but for the possibility of their perplexing beginners, and the ease with which the corrections might be made. One occurs on page 84, where it is stated that "the deflection produced by a weight uniformly distributed along the length of a beam resting on two supports at its extremities is equivalent to the deflection produced by $\frac{8}{5}$ of this weight condensed at the centre of the beam." It should read "$\frac{5}{8}$"; for the deflection caused by a distributed load of (say) 8 cwt. is equal to that caused by 5 cwt. collected at the centre. As the whole of the context is correct, this error simply lies in reversing the fraction. The other occurs on page 86, and is exactly similar, where we read—"When a beam is fixed at one extremity, the deflection produced by a weight attached to its free extremity is equal to that which would be produced by $\frac{3}{8}$ of this weight distributed along the whole length of the beam." Instead of "$\frac{3}{8}$" it should be "$\frac{8}{3}$." 3 cwt. at the extremity would cause the same deflection as 8 cwt. distributed.

The subject of torsion is discussed in a remarkably lucid way. As particular attention is challenged in the preface to this portion of the work, we extract it. We hardly think any of our readers will need to be reminded that the "angle of torsion" denoted by a in the formulæ is measured, not in degrees or minutes, but in terms of the arc divided by the radius.

"A prism experiences a *simple torsion* when a cross section of the prism turns, relatively to a section indefinitely near to it, round the axis of the prism. The prism is consequently subjected to exterior forces which tend to twist it about its axis.

The *angle of torsion* is that which two lines originally parallel and passing respectively through the centres of the two cross sections of the prism indefinitely near to each other make between them after the distortion of the prism.

To find the resistance to torsion of a homogeneous prism.

Let us consider two cross sections of the prism near to each other, and the elementary fibres included between these sections. The exterior twisting forces will cause one of these sections to rotate, relatively to the other. about the axis of the prism. Wherefore one of these sections being regarded as fixed, a point in the other section will undergo an angular displacement by torsion, equal to the arc $r'\beta$ r' being the distance of this point from the axis of the prism, and β the circular measure of the angle of torsion. If we take the ratio of this displacement to the distance l between the two sections, or the length of the fibre of which the point under consideration may be considered as one extremity, we shall have for the displacement of this fibre referred to the distance between the two sections, the expression

$$\frac{r'\beta}{l} \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

Now it is found by experiment (see Morin's 'Résistance des Matériaux,' p. 455, edition of 1857), that the resistance t of a fibre to torsion is proportional to the expression (1) and the area of the fibre. Calling a then the area of a fibre at a distance r' from the axis of the prism, and E′ a constant to be determined by experiment, we have as in Art. 29,

$$t = E'\frac{\beta}{l}.\ ar' \quad \dots \quad \dots \quad \dots \quad (2)$$

The distance l between the two sections of the prism being the same for all the fibres of the section in which a is the area of one, the greatest displacement, and consequently the greatest resistance, is the value of (2) for the fibre the most removed from the axis of the prism, or for the greatest value of r', which we shall denote by r.

The moment of the resistance (2) about the axis of the prism is,

$$E'\frac{\beta}{l}.\ ar'^2,$$

and the sum of all the similar moments for the whole section is

$$E'\frac{\beta}{l}\Sigma(ar^2),$$

The expression $\Sigma(ar'^2)$, which has been called the moment of polar inertia, is evidently the moment of inertia of a cross section of the prism about an axis through its centre of gravity and perpendicular to its plane. Denoting it by I_1, the sum of all the moments of the molecular resistances to torsion for the cross section of the solid is

$$E' \cdot \frac{\beta}{l} \cdot I_1 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \ (3)$$

Now in order that equilibrium may exist between the exterior forces which tend to produce torsion and the molecular resistances to torsion, the sum M of the moments of the exterior forces must be equal to the sum of the moments (3) of the molecular resistances to torsion, so that we shall have the equation

$$M = E' \cdot \frac{\beta}{l} \cdot I_1 \quad \ldots \quad \ldots \quad \ldots \ (4)$$

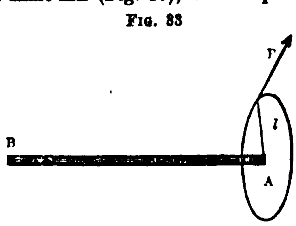
Such is the general relation which expresses the condition of equilibrium between the molecular resistances to torsion and the exterior forces, for each section of a homogeneous prism.

The corresponding expression for a cylindrical prism or shaft of length L is deduced in the following manner.

Torsion of a cylindrical beam or shaft.

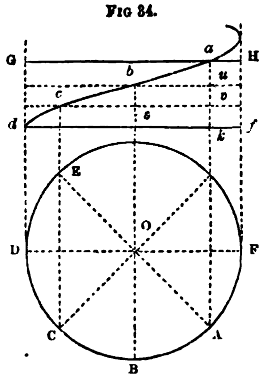
Let us consider a cylindrical beam or shaft AB (Fig. 33), acted upon by a force P which tends to twist the beam about its axis.

Fig. 33



Then if all the cross sections of the beam between A and B be supposed to be equally fixed, the effects of torsion will be transmitted progressively to the cylindrical beam from the extremity A to the extremity B, so that any one section of the beam will experience the effects of torsion only when the immediately preceding section to this begins to rotate. Consequently the extreme section B will begin to move only when all the sections which precede the section at B have been put in a state of torsion.

Fig 34.



Let a cylinder in a state of torsion be projected on two planes perpendicular to one another, the circle ABCDEF (Fig. 34) being the projection on one of these planes, and the figure GdfH the projection on the other plane.

Then a particle A at one extremity of the cylinder has been transmitted by the torsion of the cylinder to a certain point at D, at the instant the corresponding point a at the other extremity of the cylinder begins to move. Hence the generating line Aa of the cylinder has been curved into the thread of a screw, of which the projections on the respectives planes are ABCD and $abcd$.

Likewise the point (A, v) of this generating line has been removed to (C, c), the point (A, u) to (B, b); and so on.

Hence it follows that the section df has turned through the angle of torsion AOD: the section cv through the angle AOC, &c.

Let L be the length of the cylinder; then by the property of the screw,

$$\frac{arc\ BC}{bs} = \frac{arc\ AD}{ak} = \frac{arc\ AD}{L}, \ s \text{ being in } df.$$

Applying this result to (4) of last article, we get

$$M = E' \cdot \frac{a}{L} \cdot I_1 \quad \ldots \quad \ldots \quad \ldots \ (1),$$

$$\text{or } a = \frac{M \cdot L}{E' \cdot I_1} \ldots \quad \ldots \quad \ldots \quad \ldots \ (2);$$

a being the angle of torsion for the whole cylinder, and M the sum of the moments of the exterior forces. The quantities E' and I_1, are the same as in (4), Art. 66.

Cor. It appears from (2) that the angle of torsion is directly proportional to the sum M of the moments of the exterior forces, and to the distance L between the extreme ends of the cylinder.

Obs. According to General Morin, these results have been verified by the experiments of MM. Duleau and Savart. (Morin's Résistance des Matériaux, p. 455.)

The equation (1), Art. 67, may be put in a more convenient form for use in the following manner:—

Since I_1 is the moment of inertia of a circular section of the cylinder about an axis perpendicular to its plane and passing through its centre of gravity; if r be the radius of the cylinder, we have by Art. 45,

$$I_1 = \tfrac{1}{2}\pi r^4.$$

Wherefore (1) of Art. 67 becomes

$$M = \frac{E' a \pi r^4}{2L} \ldots \quad \ldots \quad \ldots \quad \ldots \ (1)$$

For hollow axles or cylinders $I_1 = \frac{1}{2}\pi(h_1^4 - h_2^4)$, h_1, h_2, being respectively the exterior and interior radii; and therefore for hollow cylinders

$$M = \frac{E' a \pi}{2L}(h_1^4 - h_2^4) \quad \ldots \quad \ldots \quad \ldots \ (2)$$

Values E' in the formula (1), Art. 67, for different materials in pounds avoirdupois per square inch, from Morin's work on Résistance des Martériaux,

	lb.
Wrought-iron	E' = 8,533,700
Iron in bars...	E' = 9,481,000
German steel	E' = 8,534,000
Cast-steel, very fine	E' = 14,223,000
Cast-iron	E' = 2,845,000
Copper	E' = 6,210,000
Bronze	E' = 1,516,100
Oak	E' = 569,000
Fir	E' = 616,000

The Second Part of the work deals with Constructions.

On the subject of roofs we find much that is sound. We especially notice the investigation of the action of the collar or cross-beam in relieving rafters from transverse strain, but at the same time *increasing the thrust.* This is a fact well known to those who are familiar with the theory of roofs, but we are not certain how far it is more generally recognised. We are, however, not quite able to follow Mr. Fenwick when he adds, that if the cross-beam were left out the rafters would bend so as to reduce the angle of inclination of their lower extremities, "and consequently the thrust would become greater;" if it be meant that this reduced inclination would increase the thrust in any appreciable degree.

The Theory of Arches is investigated geometrically, at considerable length and with much laboriousness: attention being principally given to semicircular and segmental arches, which are trigonometrically treated. There is one point in this section of the subject in which a little more explicitness might be desired. We find it stated (page 143) that "the greatest horizontal thrust in a circular arch is at the *reins of the arch*, the corresponding joint being inclined to the vertical at an angle of about 60°." (It is the circular arch without surcharge or loading that is spoken of here.) Again (page 150), "the thrust at the *reins* is considerably more than at the springing line."

Nine readers out of ten would derive the notion from these and similar passages which occur elsewhere, that the amount of horizontal thrust in an arch was actually different at different points. Yet the equality of the horizontal thrust throughout the arch lies at the basis of all true theory. We do not imagine that Mr. Fenwick has any intention of abandoning this principle. It is therefore to be supposed that the statement that the thrust at the reins (or haunches) is greater than that at the springing line is to be understood as a short way of saying that a Line of Pressure touching intrados at the haunches would involve a greater thrust than one touching intrados at the springing. But this matter should not be left to inference.

An investigation (with the aid of the calculus) of the ordinary and other catenaries, concludes the Second Part of the work. The reasoning is generally sound, and the conclusions such as are universally accepted. We however think some explanation should be given where the "thickness" of a chain is spoken of, while what is meant is the *sectional area.* The curve of the Catenary of Equal Strength is determined, and some other equally elegant problems are solved. A desirable addition would have been the general determination of the law of these curves by a formula in which the *horizontal rate of loading* replaces the *tangential rate* (or area of section of chain.) Such a formula exhibits more distinctly the close connection between the chain and the arch, and is directly applicable to the suspension-bridge. We observe that Mr. Fenwick investigates the case of a suspension-bridge carrying a loaded platform on the tacit assumption that the chains preserve the form of the common catenary; whereas when the load is heavy in proportion to the chains the curve is much nearer to the parabola. It is fair to state that elsewhere the author distinctly recognises the parabola as practically the curve for bridges of this description. This consideration enables the problem to be solved with much ease and without tables, and at the same time with a greater approximation to the truth. An appendix is added.

The work as a whole possesses much merit, and will well reward the study of the careful and intelligent reader.

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Elementary Treatise on Physics, by Professor A. Ganot. Translated and edited from the Ninth Edition, by E. Atkinson, Ph. D., F.C.S. Parts I., II., and III. London: Baillière, 1861.

This work, which treats of physics, experimental and applied, is being brought out in monthly shilling parts, and is expected, when complete, to form a volume of some 800 pages 12mo. The fact of the original volume having reached its ninth edition abroad speaks much for its scientific merit, as well as for its popular character; and the first three parts, now before us, impress us very favourably. The information is condensed, but most explicit, and there is a remarkable lucidity and transparency in the general treatment of the subject. This is doubtless mainly due to the ability of the author; but it also reflects credit on the translator and editor. The illustrations are admirably executed on wood, and numerous; and the arrangement and style of letterpress clear and suitable. We feel confident that the volume, when completed, will prove a valuable text-book.

The Engineer's, Architect's, and Contractor's Pocket Book for 1862. London: Lockwood and Co.

The edition for 1862 of this very useful work contains the usual ample complement of data, together with some original articles and sundry additions. In turning over the pages we observe an interesting paper on sewers, with a plate showing a plan of the metropolitan main sewerage system. There are also tables of natural sines, cosines, &c., for every ten minutes in the quadrant, which, with the explanatory notes that accompany them, are likely to prove extremely serviceable to many who do not possess tables of logarithms, or who do not care to use them. An obituary of eminent engineers and architects, and of some other prominent or useful men, closes the work.

FOREIGN PUBLICATIONS.

In another part of the present number will be found the first portion of a translation of the official programme to which we recently referred in noticing the *Révue Générale.*

The recent numbers of *Nouvelles Annales de la Construction* contain much interesting matter and some useful illustrations. From these we may select for notice an elevation and details of the lattice girder railway bridge over the river Meuse near Mæstricht. The descriptive account of this bridge, though condensed, is very complete. The bridge is one of six bays—the two widest having an opening of 30 mètres (98 ft. 6 in.), and the four others being 27·50 mètres (90 feet) each. The bridge is arranged for a single line of rails, and consists of two deep lattice girders carrying the roadway between them. The principal scantlings and dimensions are given, also the weights and cost of various portions and of the whole, together with the actual results of proof both by a rolling and a stationary load. The notice of the bridge concludes in a manner too rarely attempted in this country, for the writer, pointing out that the weight of iron employed as compared with the duty to be performed is considerably in excess of the proportions to be found in recent French works, proceeds to give a theoretical explanation of how, in his opinion, that excess might have been diminished. Without transferring the whole investigation and the illustrations to our columns, for which we have not space, it would not be fair to attempt any opinion of our own as to the extent to which this view is tenable, further than perhaps to remark that an engineer having a proper desire for the stability of his work will in some cases resort to scantlings much in excess of what have at times been used, and will not be to blame for so doing; but we mention the circumstance as showing an admirable spirit of close and critical examination, such as cannot always be attempted in this country without provoking expressions of surprise, and even of resentment.

Contrary to general expectation, a further portion of two works published under the auspices of the French Government has recently appeared; one is the magnificent *Monographie de la Cathédrale de Chartres*, which has already been noticed in our pages, and the other is the *Archives des Monuments Publiques*, which we have also mentioned. In both instances, the plates fully equal those already given, and contain subjects of beauty and interest. Among the churches chosen for illustration in the recently published part of the Archives, one of especial value, St. Saturnin at Toulouse, must be especially indicated. This exceptional church, peculiar in its style, its material, and its grandeur, not to say in its reputed sanctity, is very well illustrated in five plates, the execution of which is magnificent.

In a recent number we noticed a German work on the Architectural Antiquities of Dalmatia and the adjacent provinces, by Professor von Eitelberger, and published in 1861. We propose now to say a few words as to an earlier, but connected work, published in identically the same form and style, and size, both as to letterpress and illustrations. This work, entitled *Mittelalterliche Kunstdenkmale des Oesterreichischen Kaiserstaates* ('The Monuments of Mediæval Art of the Austrian Empire,') was commenced in 1856, and completed October 1859. It is by Dr. G. Helder, the before-named Professor R. von Eitelberger, and Herr Hiesner, architect, and is published at Stuttgardt. It is not, of course, to be expected that in two moderately thick volumes of small folio size, with some eighty or hundred engravings on steel, an account should be given, or attempted, of all the mediæval monuments in an empire which at that time included, along with a large portion of Germany and Hungary, the whole north of Italy, nor has this been attempted. The authors express that their desire has been that their work "should present a picture of that activity in the arts which displayed itself at the period selected throughout the entire compass of the Imperial States, and should bring more within the reach of the friends of art, both within Austria and beyond her limits, those monuments of which they possessed either absolutely no representations, or very insufficient ones," and that in carrying it out they have in almost all instances contented themselves with selecting one work only as the representative of a large group of other works allied to it by local position, by chronological proximity, or by similarity of treatment. Milan, Venice, and Cremona afford examples of Italian Gothic, that style which by the labours of Street and other English architects has not only been rendered familiar to us, but to a certain extent has been introduced among us. The German examples, which are drawn from various parts of Austria Proper, include every variety of period, although the most valuable and the most carefully illustrated examples are those of the greatest antiquity. It is hardly possible to praise too highly the patience and care displayed in this work from beginning to end; the large illustrations, the smaller ones on wood profusely introduced into the letterpress, and the careful explanations both of architectural peculiarities and of archæological points, all contribute to give very complete information as to the different buildings selected. This work is perhaps more directly of value to the archæological student than to one desiring, amid the hurry of modern modes of transacting business, to familiarise himself with examples of such a character as could advantageously influence his practice in actual architectural works; but it has a practical value also, and will well repay perusal by all who read German, and follow the arts, and especially by all students of mediæval antiquities.

THE HARTLEY COLLIERY ACCIDENT.

The terrible catastrophe which has carried desolation into so many collier's houses differs in some essential respects from the generality of mining accidents. Lamentable as these casualties are whenever they occur (and they have been unhappily but too frequent), they at least seldom startle by the discovery of such unsuspected perils, or rivet the attention by so prolonged a suspense of hope and fear.

The ordinary dangers of fire and choke-damp, irruptions of water, or falls of earth, we have long learnt to associate with mining; and fatalities from these causes, however they may shock the public, hardly excite surprise. Inquiry may be made in such cases whether the proper precautions were observed; but it is felt after all that the best precautions can only in a measure abate the risk, and that safety must still remain a mere question of degree. But the destruction of two hundred and fifteen lives in the New Hartley Colliery creates a sensation unusually painful, as having resulted from a disaster totally unexpected, preceded by no warning, and coming from a quarter where absolute security was reckoned on.

We have no wish to prejudge a matter which will doubtless be made the subject of searching investigation, assisted by the judgment of scientific and practical men specially qualified to deliver opinion upon it. But we think that a calamity so deplorable ought not to be without its lesson; and there are one or two *primâ facie* conclusions which we feel justified in presenting to our readers, whatever further light may be looked for from official inquiry.

The origin of the whole mischief was the snapping in two of the cast-iron beam of the steam engine, and the fall of the half of this beam, weighing 20 tons, down the shaft of the coal pit. The uncertainty of cast-iron when exposed to a transverse strain is too well known; and it is a strain of this nature that engine beams have to sustain. The failure of the Dee Bridge in 1847, and the investigation to which that event gave rise, effectually checked the employment of cast-iron for longitudinal bridge girders; which are now almost universally made of wrought-iron. Had the engine beam been formed of rivetted boiler-plate instead of cast-iron, the failure might never have taken place, and would certainly not have occurred without warning. A boiler-plate beam would also have been much lighter. The strength which had been supposed to exist in the 40 tons beam of cast-iron would probably have been effectually secured in a plate beam of one-third the weight. The risk of injury ensuing from the shock and jar of the weight of the beam itself, or the accidental dropping in the attempt to renew the brasses, would have been incalculably less than in the massive and brittle casting.

But if the cause of the original disaster is traceable to putting too much trust in a treacherous material, the great loss of life which resulted demands some further explanation. It seems that the operations of working, pumping, and ventilation were all carried on in one shaft, so that upon this single channel of access the existence of every soul in the mine depended. Thus it came to pass that at a single blow, escape, food, and air were simultaneously cut off. This surely is a risk that might have been avoided. We trust there are not many mines where there is so fearful a stake upon a single chance. It is impossible to disguise the fact that had there been a separate air shaft those men might have been living now, ventilation could then have been maintained, and the miners extricated more or less speedily. As it was, the wooden brattice, intended to secure an upcast and a downcast in the same shaft, filled the bottom with its wreck, ventilation ceased at once, and the rising water in the lower workings was but a secondary peril. Had there but been an "air staple" between the yard seam and the high main, most if not all of the men might probably have been rescued.

It is to be hoped that points of such vital concern will not be left to the advocacy of colliery strikes and "double shaft movements." We trust that the investigation of this melancholy case may be carried to a practical issue, and that there may be some better security for the future against calamities so fatal and apparently so avoidable.

NOTES OF THE MONTH.

Bombay, Baroda, and Central India Railway.—At the recent meeting of the proprietors of this Railway, the chairman remarked that, owing to the excellence of their gradients, they had conveyed large numbers of passengers over the portion of line completed, in trains of seventy-four carriages, forty-nine carriages, and forty carriages respectively, each drawn by one engine. The construction of the iron bridges on their line had been looked upon as experimental to some extent, but it now appeared that they were a perfect success. The great work of the line—the Nerbudda Bridge—had been completed and opened in May last. It consisted of sixty spans of 60 feet each, and was 70 feet above the bed of the river. During the monsoon the floods in the river rose 55 feet, and had a velocity of ten miles an hour. Owing to the alluvial nature of the soil it would have been scarcely possible to have built piers of masonry in such a position, but the screw-pile system of forming them, adopted by their consulting engineer, Colonel Kennedy, had answered admirably. They had conveyed 4000 persons in a train weighing 720 tons, drawn by only one engine, on the occasion of the Hindoo holidays. Colonel Kennedy said, when he first proposed his plan for overcoming the difficulties of crossing the great rivers it was considered in the light of a hazardous experiment, but the plan was founded on the most careful analysis he could make. It was thought absolutely impossible to construct a railway in that direction, and he believed it would have been impossible by the ordinary means. The other ob-object he had in view was to reduce the dead weight of their trains, by getting the most favourable gradients. The steeper the gradients on a line the shorter would be the train to ascend them, and the less effective would be their engine power. He pointed to a diagram in the room showing that a passenger train six times the average length of passenger trains on English lines had been drawn at twenty miles an hour over their line by one engine, which showed the advantage of their level line. He could have easily found gradients of 1 in 100 on their line, and had some difficulty in avoiding them. The steep gradients on English lines not only limited the load, but materially added to the working expenses. With regard to the train that had passed over their line, they would perceive that instead of having six engines and tenders to convey it in separate trains, they on their line only required one engine and tender to propel it, weighing probably 45 tons, and thus saving the dead weight of the other five engines and tenders, making together 225 tons. This was a most important matter in the cost of engines and in working the traffic on the railway. They had to provide chiefly for third-class passengers in India. They had some third-class carriages constructed in two stories, so that every one of those double carriages would hold 100 third-class passengers instead of 50. They would thus get rid of a considerable amount of dead weight, and reduce the proportion of working expenses to receipts. Their line was the most difficult to construct of any railway in India, and he believed its cost would not exceed £10,000 per mile, or £3,130,000; but if it had been constructed in the usual way they must have added £3,000,000 to its cost, and, with the usual gradients, 150 more locomotive engines and tenders would have to be provided, at a cost of £450,000.

Art Design at the International Exhibition of 1862.—The following is a minute of the Art Designs Committee of the International Exhibition of 1862. "Her Majesty's Commissioners for the Exhibition, being desirous of exhibiting the progress of ar-designs for manufactures, would be glad to receive contributionst from possessors of drawings and models by British artists executed within the century 1762-1862. Artists, designers, and manufacturers in general are hereby invited to send works, suitably framed and glazed, or if of large size on strainers, properly prepared for hanging. Designs in all departments of art industry capable of reproduction are admissible in this class. Designs for glass and ceramic wares, precious and other metals, furniture and carving, plastic decorations, and other objects in relief; also designs for textile fabrics, paper-hangings, mural decorations, tiles, mosaics, inlays, stained, painted, and decorated glass, &c. Assistance from the possessors of drawings and models by such artists as Chambers, Adams, Soane, Stothard, Flaxman, Pitts, Pugin, Wyon, and others is especially desired. All works must be delivered for the inspection of the committee, on or before the 31st of March, at the South Kensington Museum.

Floating Dock Gate for Alloa, Scotland.—Mr. George Macfarlane, of Dundee, has nearly completed a floating dock gate for the new wet dock at Alloa. This gate is of a novel construction, the usual description allowing only of the crossing of foot passengers, while this is to serve for the passing of horses, carts, and carriages. It is wholly composed of iron, and is 42 feet long and 10 feet wide; is divided into five compartments in the height, the lower two divisions to be filled with masonry for ballast, while the others are to be water-tight, and are to act as air chambers to float the mass when the tide rises to a depth of about 15 feet; or it can be sunk to any depth required, by opening the chambers and allowing the water to flow into them. This gate was designed by Mr. Charles Ower, harbour engineer Dundee.

Competition Designs for the Houses of Parliament, Sydney.—Out of the twenty sets of designs submitted, it will be remembered that six were selected, bearing the following mottoes:—"I bide," "Hora e Sempre," "Palladio," "Fide et Virtute," "Sic fortis Etruria crevit," and "Follower of Wren." First premium (£600), design marked "I bide." Second premium (£300), design marked "Hora e Sempre." The design marked "I bide," was by Mr. William Henry Lynn, of 64, Upper Sackville-street, Dublin. It is in the Gothic style, the cost of executing as estimated by the Colonial architect, would be £642,205. The architects of the design marked "Hora e Sempre," are Messrs. Stent and Laver, of 127, Great Portland-street, Portland-place, London, and Ottawa, Canada West. There were two designs under the above motto,—the one Grecian, and the other Gothic. Both of the designs were considered by the commissioners, but they have given their award upon the Gothic design. The classic design of "Hora e Sempre" would cost to execute £656,641, and the Gothic design £505,113. Of the twenty designs sent in for competition, eleven came from Europe, and of the remaining nine only five are attributed to Sydney architects.

The Stephenson Memorial.—Great progress has been made with the Stephenson memorial about to be erected in Newcastle. Four of the statues are already cast in bronze, and in the hands of the chaser; the fifth will shortly be out of the mould. The stones for the pedestal have been for some time past in course of selection, but their large dimensions preclude their being collected other than gradually.

CLASSIFIED LIST OF PATENTS SEALED IN JAN. 1862.

During the year 1862 *a classified analysis will be given in this Journal of the Patents provisionally specified and sealed under the authority of H. M. Commissioners of Patents.**

1975 Bovill, G. H.—Ships of war and other vessels, and manufacture of armour and other plates of wrought iron—August 8
1814 Rogers, J. W.—Ships and floating batteries—July 18
2076 Muntz, G. F.—Sheathing iron ships or vessels—August 20
1828 Brooman, R. A.—Propelling vessels by superheated steam (com.)—July 19
1882 Harfield, W. H.—Propelling ships and vessels—July 27

1758 Adams, J.—Revolving firearms and cartridges—July 12
1858 Sidebottom, J.—Firearms and ordnance—July 24
1887 Sturrock, G.—Breechloading fire-arms–July 29
1964 Mennons, M. A. F.—Breechloading fire-arms (com.)—August 7
1824 Brooman, R. A.—Breechloading ordnance (com.)—July 19
1871 Robertson, C.—Sights for firearms—July 25
2093 Richardson, W.—Improvement in rifles and projectiles—August 21
1988 Vavasseur, J.—Transportable machine for rifling cannon—August 8

1979 Kinsey, H.—Steam engines and boilers—August 8
1932 O'Harlow, P.—Improvements in marine steam boilers—August 3
1851 Hughes, T.—Improved steam generator—July 24

1727 Handcock, E. R.—Applying motive power—July 6
2953 Macintosh, J.—Obtaining and applying motive, steam, and liquid power–Nov. 25
1750 Farron, J.—Apparatus and fittings for steam engines and boilers—July 11
1754 Messenger, T. G.—Improvements in valves—July 11
2878 Newton, W. E.—Steam engine governers (com.)—November 15
1818 Shaw, P.—Hot-air engine—July 19
1919 Benton, R.—Obtaining rotary motion by the use of the gravitating power of solid or fluid matter—August 2
1669 Maillard, N. D. P.—Self-acting and inexhaustible hydraulic and atmospheric motive-power engines—August 8

1843 Griffin, G. F.—Permanent way—July 23
Blinkhorn, J.—Railway signals—July 16
1890 Riley, R.—Improvement in fog signals—July 29
1830 Thatcher, R.—Improvements in lubricators—July 20
1891 Melrose, W.—Construction of railway wheels—July 29
2002 Gedge, W. E.—Breaking apparatus for railway and other vehicles (com.)—August 12
1845 Dumesnil, N. E.—Lubricating machinery—July 23
1907 Rylands, J. R. T. G. and Rylands, P.—Joining wire for telegraphic conductors—July 31
2081 Bethell, J.—Manufacture of journal axle boxes, &c. from steatite—August 15
2843 Johnson, J. H. Improvements in making steam-tight joints—November 12
2535 Downs, J.—Improvement in hydraulic presses—October 10

2001 Garzend, A.—Apparatus for cutting up and reducing dye and other wood.—August 12
1846 Thompson, R.—Woodcutting machinery—July 23
1829 Price, W.—Tools for cutting shirves or other conical blocks—July 20
2243 White, R. O.—Manufacture of bricks—September 7

1767 Smith, T., Taylor, G.—Horse rakes and cultivators—July 13
2555 Newton, A. V.—Machines for cleansing and dressing grain (com.)—October 12
1821 Savory, W, and Savory, P. H.—Winding machinery for ploughing, quarrying, &c.—July 19
2314 Samuelson, B.—Harvesting machines—October 17
2360 Bousfield, G. T.—Manufacture of shoes for horses (com.)–September 20
1899 Cressey, T. S.—Manufacture of casks–July 30
1963 Hughes, E. T.—Improved wheel-barrow–August 7
1937 Richmore, F. and Chandler, H.—Improved sack holder—August 5
2025 Sylvester, T.—Weighing machines—August 14
1897 Bradford, T.—Washing machine–July 30
1914 Muggridge, E. J.—Washing machine—August 1

1779 Johnson, J. H.—Apparatus for cleaning rice (com.)—July 15

1912 Shaw, H.—Improvements in wet gas meters—August 1
1739 Parkinson, W. C.—Frictionless bearing for gas meters—July 9
1834 Henry, M.—Obtaining increased effect from lights—July 20
2618 Evans, F. J.—Carburetting gases for the purpose of illumination (com.)—Oct. 19

2635 Frost H.—Apparatus for measuring liquids—October 22
1795 Butterworth, J. H.—Hot water apparatus (com.)—July 17
1939 Meyer, H. C.—Slide valves to regulate or stop the flow of water, steam, or other fluid—August 5

2662 Heaton, J. C., Dean, J.—Improvements in taps or cocks—October 24
1863 Longmaid, W.—Manufacture of iron—July 24

2664 Chesterman, J.—Hardening and tempering steel—October 24
1817 Mushet, R.—Manufacture of cast steel—July 19
1774 Taylor, R. and Price, T.—Manufacture of tin and terne plates—July 15

* Arrangements are in progress by which increased facilities, in connection with the management of this Journal, will be afforded to Inventors for securing valid Patents.

1869 Haeffely, E.—Extracting copper from its ores—July 25
1983 Hemingway, J.—Machinery for working coal, ironstone, or other minerals—August 9

1839 Wood, W.—Manufacture of beams and girders—July 22
1865 Brown, B.—Spinning machines—July 25
1859 Threlgall, R.—Spinning machines—July 24
1882 Platt, J.—Spinning machinery—July 20
1981 Henderson, J.—Weaving machines—August 8

1720 Schutt, H.—Spinning frames (com.)—July 6
1766 Tolhausen, F.—Improvement in ribbon looms (com.)—July 13
2528 Bennett, T. P.—Self-acting mules—October 10
1810 Williams, P.—Carding-engine for cotton, &c.—July 18
2758 Brown. B.—Improvement in scutching and carding engines—November 2
1838 Wood, J. B.—Shuttle pickers—July 22
1827 Hughes, E. T.—Woven seamless gloves (com.)—July 19
2823 Turner, A.—Knitting machinery—November 9
2482 Tongue, W.—Improvement in manufacture of printed yarns—November 12
2039 Combe, J.—Machinery for hackling flax and other fibrous substances—August 15
1777 Browne, B.—Cleaning and smoothing spun thread or yarns—July 15
2358 Bousfield, G. T.—Improvement in combing cotton, &c. (com.)—September 20
2826 Tongue, W.—Preparing and combing fibrous materials—Nov. 11
1862 Cook, H.—Improvements in pattern cards for weaving, &c.—July 24
2756 Wright, J.—Utilising the droppings of carding machines–Nov. 2
1844 Gray, T.—Preparing old material for re-spinning—July 23
1988 Lee, C., and Mace, T. K.—Backing cut pile fabrics—August 9
2116 Clissold, W.—Oiling wool—August 24
1967 Viollier, L. W.—Twisting yarns and wire rope—August 7
1992 Birkbeck, G. H.—Construction of tents (com.)—August 10

1796 Butterworth, J. H.—Improved mode of desiccating wet or moist substances (com.)—July 17
1893 Scott, W. L.—Manufacture of red, purple, and other dyes–July 29
3046 Hartog, C. S. H.—Improvement in preparing fibrous materials for dyeing—Dec. 4

1755 Ashwell, H.—Dyeing and cleaning apparatus—July 11
1783 Fernier, E.—Fibre from broom for the manufacture of paper and recovery of dyeing products—July 15

1732 Cobley, T.—Manufacture of silicates of lead and baryta–July 8
1784 Cobley, T.—Recovery of bases from slag, scoria, &c.—July 9
1772 Cobley, T.—Manufacture of alkaline silicates, acetates and caustic alkalies—July 15
1773 Cobley, T.—Preserving and rendering uninflammable wood, timber, and other vegetable matter—July 15
1775 Coombe, J. C.—Manufacture of glass, porcelain, and plastic ware—July 15
1776 Cobley, T.—Fluo-silicates of tin, zinc, and baryta, and enamelling colouring glass, &c.—July 15
1819 Laing, R., Cossins, G. H.—Improvement in manufacture of sulphuric acid—July 19
1836 Kottula, C. N.—Improved manufacture of soap–July 22
2831 Wilson, G. F., and Payn, G.—Improvement in treating fatty and oily matters—November 11
1956 Clark, W.—Bleaching saccharine matter (com.)—August 6
1892 Guffroy, C. C. J.—Manufacture of cod liver and other fish oils—July 29
1991 Falgas, A. F. B.—Improvement in trusses and bandages—August 9
1885 Robertson, J.—Steam and hot air for the treatment of bodily pain—July 27
2335 Coombe, J. C., Wright, J.—Induration of building materials—September 19
1962 Lesueur, N. A.—A new system of covering for houses and other buildings and coverings—August 7
1973 Hogg, W. S.—Construction of doors, gates, and shutters, principally applicable for fire-proof buildings—August 8
1921 Dronot, J. E.—Improved method of kneading bread—August 2
1858 Wood, A.—Brewing and storing beer—July 24
1733 McNeill, T. T.—Barometers—July 8
1941 Johnson, E. D.—Construction of centre seconds watches—August 5
2078 Sutton, T.—Photographic cameras—August 20

1807 Johnson, B.—Pianofortes–July 18
1751 Cotter, J. R.—Pianofortes—July 11

1815 Walker, B.—Packing and stopping bottles–July 19
1723 Ridsdale, J.—Inkstand and stoppers of bottles—July 6
1728 Tutill, G.—Banners and flags–July 6
1740 Keats, J. and G.—Sewing machinery—July 9
1784 Clark, W.—Stage scenery, &c. (com.)—July 15
1936 Lewis, J.—Producing printing, and transferring surfaces on lithographs—August 3
2768 Horton, G.—Skates—November 4
1927 Jones, G. F.—Prevention of injury to pipes by frost—August 3
1866 Klotz, M.—Ornamenting tissue paper and like material—July 25
1875 Thurel, F. N.—Fastenings for shoes, stays, and gloves—July 26
1926 Cross, J.—Fastenings for wearing apparel—August 3
2180 Fox, W.—Parasols and umbrellas (com.)—August 31
1906 Flanders, J. T.—Splitting skins and other materials—July 31
2724 Winfield, R. W.—Ornamentation of metallic bedsteads and furniture–October 30
1877 Wigall, M.—Manufacture of brushes and brooms—July 26
1902 Hart, J. M.—Locks and fastenings–July 30
1881 Herbert, J. B.— Improvement in fire-guards—July 27
1789 Jones, R.—Safety lamps–July 16
1793 Palmer, W.—Improvement in lamps—July 16
1816 Gallasent, D.—Refrigerating machines—July 19
1820 Newbury, R. C.—Manufacture of enamelled cards—July 19
2840 Newton, W. E.—Self-feeding ink-stands—November 11
1826 Newton, W. E.—Copying letters or writings (com.)–October 19
2379 Wiley, W. E.—Pens and penholders—September 24
2941 Sansum, S.—Penholders—November 23
1843 Griffin, G. F.—Apparatus for ventilation and extinguishing fires—July 22
1929 Viscount de Ponton d'Amécourt, G. L. M.—Apparatus connected with aërostation—August 3
1880 Garrood, R. E.—Mitre boxes and shooting boards—July 27
1913 Pratt, M.—Manufacture of candle moulds—August 1

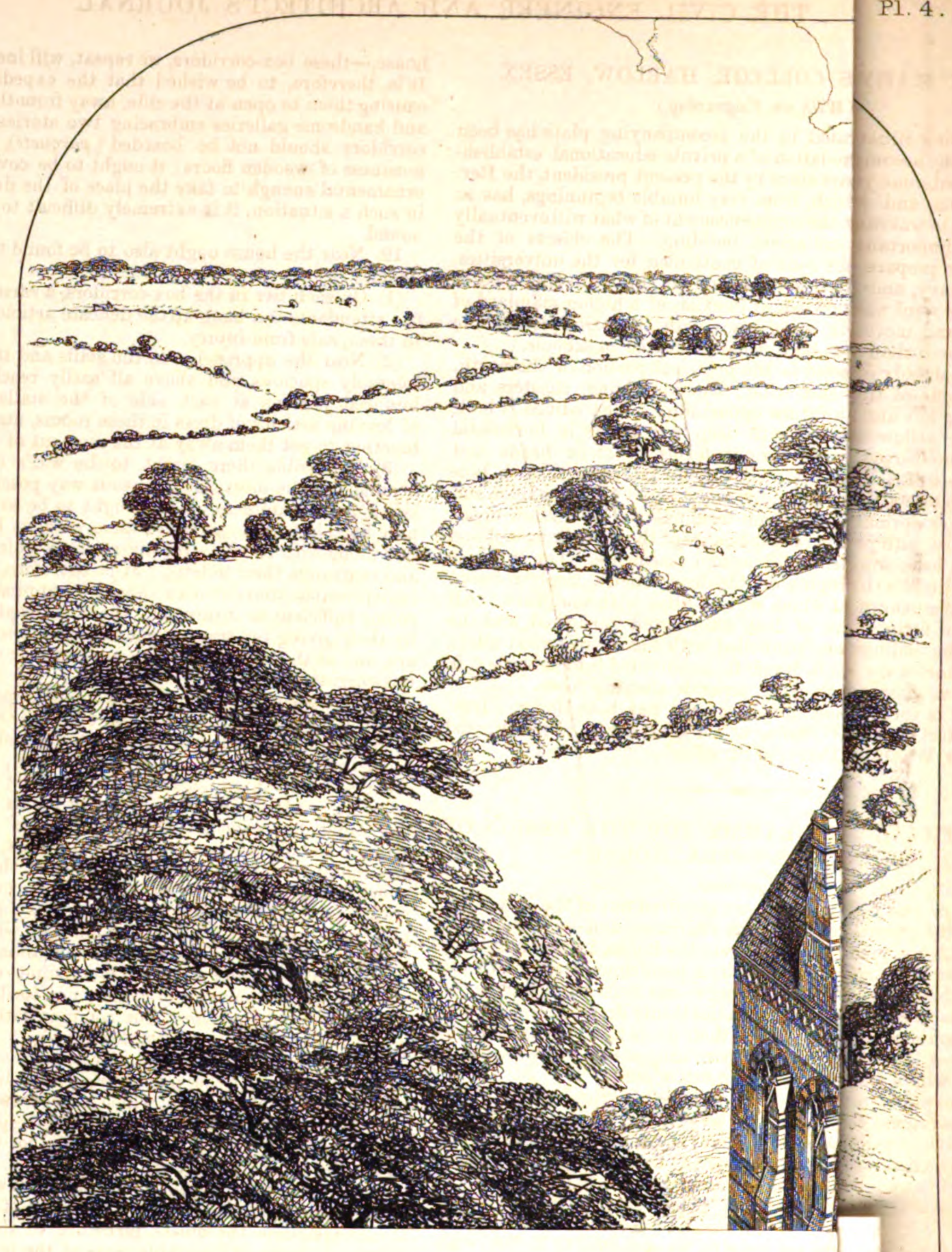
ERRATA.

The following typographical errors occurred in our last number:—

Page 3, art 10, in the two formulæ the radical signs should not extend over $-q_1$, or $-p_1$.

,, 5, in the formula in the first column, for sign $\div$ read $\doteqdot$ or $\times$.

Pl. 4.



extend over

management of this Journal, will be afforded to inventors for ...

SAINT MARY'S COLLEGE, HARLOW, ESSEX

(With an Engraving.)

The building illustrated in the accompanying plate has been erected for the accommodation of a private educational establishment, founded some years since by the present president, the Rev. J. C. Goulden, and which, from very humble beginnings, has so increased as to warrant the commencement of what will eventually become an important collegiate building. ' ne objects of the school are to prepare the sons of gentlem for the universities, army and navy, and civil service, and' supply to this class of students the want acknowledged to e' ,c, of a higher standard of education, and more in accordan' with the principles of the English church than has been r' .ally adopted in schools.

The part already erected i ,e principal portion of the north, and the whole of the ea' .ing; the west wing, cloisters and chapel being left until ,are opportunity. The edifice is built of common yellow ' ,ks, with deep red bands in horizontal courses, interspers with various forms of stone heads and parti-coloured brick arches. The roofs are covered with blue Countess slate, with red tile ridge and crest. All the gables and the numerous dormers have iron terminals. The window openings are filled with ordinary sashes, except those of the school and hall, which have wooden mullions and casements. The entrance to the buildings is through a double door under a deeply-recessed arch, the tympanum of which will be filled with sculpture. All the internal fittings are of deal, stained and varnished, and the whole of the ceilings are pannelled with chamfered wood fillets. The dormitories are 40 ft. by 20 ft., subdivided into cubicals 5 ft. by 8 ft., thus giving each boy a separate sleeping room.

The cost of the portion already erected has been under £4000. The architect is Mr. Withers, of Doughty-street, London; and the builder Mr. John Perry, of Stratford.

THE OFFICIAL PROGRAMME FOR THE DESIGN OF THE PARIS OPERA HOUSE.*

Staircases.

13. One or two public rooms are required out of the immediate course of the crowd, adjoining the staircases, and communicating readily with the principal exits from the house, in which visitors can wait for their carriages, safe from pernicious drafts and from injury to their dress. These waiting rooms must serve, during the cold winter evenings, to shelter ladies thinly dressed, and leaving a very warm room; consequently their doors must not open direct to the street, it will be better for them to open into warm sheltered corridors, where footmen can be in attendance.

These corridors must, as far as practicable, run parallel to the rank of carriages, so that it will be possible for persons to leave through several exits at once. This is necessary for reasons similar to those which have caused the waiting rooms of a well-arranged (*French*) railway terminus to be placed parallel to the rails.

14. These waiting rooms, which will be occupied for only a very short time by some three or four hundred persons at the moment of leaving the house, do not require, we consider, to be lofty; we would take the vestibule of the Theâtre Français as an example. This being so, the vacant space under the amphitheatre and the first tier of boxes might be made use of for this purpose.

Public Saloon.

15. The public does not crowd into the saloon as into a waiting room, but promenades there. The saloons ought, therefore, to include—(1) One or two galleries, as extensive as possible in their length; (2) an open gallery or box; (3) and, near the extremities of the principal gallery, small rooms communicating with it by folding doors, where frequenters of the place, who do not care to promenade, can chat quietly.

16. Contiguous to the saloon ought also to be found—(4) the refreshment room, and a suitable room for the preparation of refreshments, and to which they can be brought without passing any part of the saloon or the house; (5) also, a suitable place for the stand of the dealer in bouquets, and for a book-stall.

17. An arrangement which would provide, level with the third tier of boxes, a gallery or balcony for the use of the spectators in the upper part of the house, could not fail to be approved.

18. The corridors, the height of which is fixed by that of the boxes, and which ought to be far wider than those of the present house,—these box-corridors, we repeat, will inevitably be too low. It is, therefore, to be wished that the expedient be adopted of causing them to open at the side, away from the boxes, upon wide and handsome galleries embracing two stories. The floor of the corridors should not be boarded (*parqueté*), on account of the noisiness of wooden floors: it ought to be covered with mosaics, ornamental enough to take the place of the dusty carpets which, in such a situation, it is extremely difficult to preserve clean and sound.

19. Near the house ought also to be found the following dependencies:—

(1) On each tier in the box-corridors, a variety of closets, where the attendants can hang up the delicate articles of dress intrusted to them, safe from injury.

(2) Near the approaches to the stalls and the pit, cloak rooms, tolerably spacious, and above all easily reached. More than a hundred persons at each side of the stalls are in the habit of leaving articles of dress in these rooms, and crowd all of them together to get them away at the moment of leaving.

(3) If possible there ought to be w.c.'s on each story, and arranged in the most advantageous way possible to secure ventilation and cleanliness. They ought to be so placed that females may be able to have access to them without hesitation, and may find along with them a dressing-room, in which they can examine and rearrange their toilette. It is, therefore, requisite that these indispensable conveniences should be approached through anterooms sufficient to insure that their use shall not be prohibited by their giving too transparent an indication of what they really are, and at the same time they must not be too remote from the box-corridors.

(4) The medical arrangements must, if possible, be provided for on the first floor, and not too far from the boxes. Besides a room for the medical man in attendance, and separate w.c.'s, two rooms of moderate size must be provided, in which would be collected every thing necessary for the relief of persons who may be taken suddenly ill. One of these rooms is intended for men, the other for women. These apartments need only be large enough to hold one or two other persons besides the invalid and the physician; but must be reached through an ante-room which isolates them. The physician's room, even, is not absolutely indispensable; this useful functionary has a stall appropriated to him, and could keep all the appliances which he requires to make use of in one of the rooms for invalids.

(5) On the ground floor, or mezzanine, will be situated the office of the commissary of police, not itself intended for more than five or six persons, but communicating easily with the police stations and the constables outside.

(6) The accountant's offices may be more out of the way. They will comprise—(A) the inspector's room, lighted by day-light; (B) the cashier's office, in which ten or twelve persons will be employed daily, verifying tickets and receipts; (C) office for wo or three inspectors of the house, closets for tickets, for the wardrobe of the managers, &c.

20. The house upholsterer (*tapissier de la salle*) ought to have a store placed on the most central tier, and of sufficient dimensions to accommodate the entire furniture of the house—namely, a thousand chairs, the portable seats of the pit and stalls; or, what would perhaps be better, one *depot* on each tier and a central store in the roof; where also the store of the gas-fitter (*lustrier*) must be placed, with a workshop for two or three men.

The Boxes.

21. The frequenters of the opera have an invincible repugnance to the boxes in the upper tiers. The number of boxes in the first tier is not equal to the demand for them, and yet it is often difficult to fill those on the second and third tiers, even with gratuitous orders.

22. This arises from two causes—First, the excessive height of the stories, due to the fact that the floor of the house is more than four metres above the level of the road, and that sixty steps must be mounted to reach the first tier of boxes (there are seventy-one between the level of the road and the floor of the Emperor's box), seventy-six to reach the second tier, and ninety-two to reach the third; and then that the taste for luxury that has followed the growth of public wealth caused persons to disdain inferior positions, making every person wish to be placed in the first rank. Further, the difference of price between boxes on the first and second circles cannot be large enough to cause even the most economical to hesitate. It is but one item of their total expendi-

* Continued from page 33.

ture, an unimportant one for the majority of the frequenters of the opera, and not of consequence for those among the visitors who go but rarely to the opera, and who, on that very account, only choose to go to the best places. Consequently, at the opera there need only to be two classes of seats—the highest and the lowest; and as the larger part of the receipts flow from the first-class seats, it is essential to provide as many of them as possible. To secure this result, the second tier of boxes must be so arranged that it shall be possible to rate them at the same prices as the first. This aim can be attained by a disposition of which the theatre at Bordeaux affords an example.

The grand staircase communicates with two tiers of boxes: the first tier, not much raised above the house corresponds to the first landing at the half flight; the second tier, which can be reached by ascending another half flight, is on a level with the saloon, and on the principal floor of the building.

In this way, advantages are so evenly balanced that it is almost a matter of indifference whether to go to the first or the second tier, and thus two tiers of select boxes are obtained. A third tier can be obtained, as has been done in the theatre at St. Petersburgh by forming a tier of uncovered boxes in front of the first tier of closed boxes on a substructure rising from the floor, and not on corbels.

These uncovered boxes would naturally be without ante-rooms, but on the other hand they would have the advantage of showing the *toilettes* of the ladies in full brilliancy, and of being divisible into compartments of four places each, which would certainly cause them to be very much sought after. The tier of uncovered boxes which we are proposing is not incompatible with the amphitheatre which supplies a public want, and must be retained; it may be connected with the latter at the two sides, or be blended with the upper ranks of it.

23. To secure that the access to the boxes shall be by only a small number of steps, the orchestra must be on the same level as the lobbies, and the floor of the theatre very slightly raised above the ground floor level. The result of this will be that the spaces under the theatre must be all formed by excavation; a structural difficulty far from insurmountable. It has not, however, been proved that the vaults require to be so deep as is ordinarily thought necessary. We on the contrary believe that with a rational system of machinery the motion of large scenes would be almost always horizontal, which would diminish considerably that importance of the spaces below the stage.

24. The internal arrangement of the house in the Rue Lepelletier is considered the finest known disposition. We may add that it will perfectly admit that arrangement of places which we consider, for pecuniary reasons, it is indispensable should be adopted.

25. The number of seats we would limit to 2000; there are now 1750, and were they better distributed that number would suffice. The opera is not and cannot be appropriated to great popular gatherings. It is the theatre of good society, its public has habits of comfort and elegance which must always render it difficult to satisfy; and its subscribers, coming for pleasure, ought not to find themselves worse off than if they had stopped at home. All the seats should therefore be roomy and comfortably appointed. At the same time an injuriously liberal distribution of space must be guarded against. The boxes must be wide and high. The stalls must be wide also, with space for easy moving to and fro between their rows; but at the same time, without being crowded, the spectators must be in contact. In a theatre sensations run through the audience almost like an electric spark, and by isolating the spectators, as for example would be done by doubling the present allowance of space to each one, the result would simply be to make the performances chilling in their effect. Moderation must therefore be observed, and the following dimensions are the most appropriate in our opinion.

	Width in metres.	Depth in metres.	Ft.	in.	Ft.	in.	Ft.	in.
Boxes for six persons	1·50	2·50 =	5	0 ×	8	3		
,, ,, four ,,	1·50	1·70 =	5	0 ×	5	7		
Amphitheatre stalls	0·70	1·00 =	2	3 ×	3	3		
Orchestra ,,	·65	0·90 to 1·00 =	2	0 ×	3	2¼ to	3	3
Pit ,, ,,	·55	0·75 to 0·80 =	1	9 ×	2	5 to	2	7½

26. These dimensions admit of the boxes being furnished with chairs of the most comfortable shapes, and allow great comfort in the stalls. Each box would also be attended by a little ante-room, necessarily narrow, because its width must be regulated by that of the box it belongs to, but which must be roomy enough to afford a pleasant place for social intercourse between the acts A depth of 3 metres (10 feet) would appear to us ample.

27. To recapitulate—it appears to us necessary to limit the number of seats in the new house to 2000, and to apportion them as follows:—On the floor of the house, the lowest part being on the same level with the lobbies—(1) A tier of *baignoires* with ante-rooms; (2) The amphitheatre (130 to 150 seats); (3) The pit; (4) The orchestra stalls (200 to 250 seats). Raised—(5) Two tiers of boxes approached by the principal staircase: the first tier including (A) a series of closed boxes with ante-rooms; and in front of these last (B) a tier of open boxes with four seats in each. (6) Lastly, one or two upper tiers—the highest being divided into seats rather than boxes.

28. The acoustic conditions which the future house must fulfil, and the systems of lighting and warming which ought to be preferred, are subjects for special investigation, the examination of these questions would not be appropriately included in this programme. We will simply say, that *calorifères* which circulate hot air ought to be proscribed: they are extremely injurious to singers, whose breathing they oppress, and are a most active source of currents of air, for as they do not afford a possibility of equalising the temperature of the various portions of the house, they continually occasion rapid movements in the mass of air which fills it. For lighting we believe the chandeliers and the *rampe** to be indispensable, but the direction of the opera is far from thinking that these apparata cannot be improved, and at the present time is applying a system of *rampe*, the principle of which, without doubt, is capable of being worked out, and is calculated to obviate all the disadvantages hitherto connected with this mode of illumination.

Arrangement for the use of the Emperor.

29. The imperial box will be placed as now at the proscenium of the first tier of boxes; the staircase giving access to it must be easy and with few steps. Its dependencies will consist in—(1) an ante-room or guard room; (2) a room for aides-de-camp; (3) a large saloon; (4) the small private room of H. M. the Empress; (5) dressing room, wardrobe, closets, &c.

30. This suite of rooms must be entirely disconnected from all other departments; means of at any time opening a communication with the house, and another with a small box overlooking the stage (*sur le théâtre*) must however be provided.

31. The vestibule giving access to the staircase must be wide and easily approached, and ought to open upon a closed porch large enough to contain at one time the imperial carriage, two carriages of the suite, and the escort.

32. In an inner court near this porch there should be—(1) a standing for three carriages, with their horses put to them, and a stable for two or three outriders' horses; (2) a guard-house and stable for the escorting picket (fifteen to twenty horsemen and an officer); (3) a guard-house for an infantry picket (twenty-five to thirty men and an officer); (4) a station for the "cent guardes" (ten horsemen); (5) a stable for their horses; (6) a room for livery servants (fifteen to twenty persons).

33. On state occasions the imperial box occupies the centre of the first tier of boxes opposite the stage. As no permanent arrangement and solid box exists (as is the case in the great houses of Germany, Russia, and Italy, an arrangement the nobleness of which cannot be denied), this box is improvised by means of temporary scaffoldings and hangings, which always recal too closely the arrangements for public fêtes. It is certainly not suitable to run up an imperial box in the same way that the ordinary decorations of the theatre are done, and above all on state occasions, when imperial pomp is displayed in all its grandeur, the imperial box ought to present the most elevated and magnificent appearance, and every ornament of a trifling nature ought to be excluded. The state box ought to be an integral part of the architecture of the house, and ought to be its leading feature.

34. The chilling effect of this large box, commonly standing empty, is however dreaded, and it is calculated that it would seriously injure the receipts, by destroying several of the best boxes: these are serious objections.

35. The following arrangement appears to reconcile all difficulties. According to it the state imperial box would be constructed with all suitable magnificence, and of costly materials, bronze, and marble, but in detached pieces easily movable, which would only be fixed when wanted; nothing is more easy than to accom-

* Side lights behind the scenes.

plish this by suitable adjustments properly incorporated with the structure of the house.

36. The arrangement of this box would doubtless be analagous to that of the imperial tribune in the theatres of Versailles and Fontainbleau; but as it would be put up on rare occasions—not forming part of the ordinary subscription nights—there is no reason why it should not be carried out on a most magnificent scale.

37. As regards the box, then, what is proposed would cause no alteration in the customary practice, which consists in replacing a few of the ordinary arrangements of the house by a temporary structure; only this would be done in a monumental fashion, and one worthy of its destination, instead of putting it up by the help of unsatisfactory uphosterers' decorations.

38. We should desire, however, that the imperial saloon—to which purpose the public saloon is at present converted on these occasions—should be distinct. This saloon ought to be one of the most brilliant appendages of the new house. Placed between the boxes and the public saloon, and entirely distinct from the waiting rooms attached to the emperor's private box, it might on ordinary occasions, be thrown open to some of the audience, for example, to the subscribers to the boxes, and would thus furnish to ladies something which the public saloon does not afford them, a delightful spot for promenading and social intercourse.

THE ECONOMIC ANGLES IN PARALLEL OPENWORK GIRDERS.

Under the term openwork-girders we include all properly braced girders, whether the bracing be of the triangular character made use of in warren and lattice bridges, or of the diagonal description common in structures of older date, and in which the frame is subdivided into quadrilateral openings which have their diagonals supplied with ties or struts.

We purpose first to point out what influence (if any) the upper and lower members of the structure, sometimes called the booms, have upon the question, when the whole material required for these, together with that for the braces, is to be rendered a minimum.

In estimating the quantity of material necessary for the different parts, we require for our present object their proportional values only. And where no great precision is demanded we may treat of the strength of struts like ties, as independent of their lengths within moderate limits. In this preparatory discussion we shall not draw any distinction between the amounts of material required for struts and ties subjected to equal stresses, but represent the quantity or cost or weight of any strut or tie as proportional to its length multiplied by the stress acting through it: the most convenient units of length, and of stress or weight, being chosen.

In Figs. 1 to 12, let the depth D be the same in each, and let it be taken as the unit for length; let also the span S in each=12 times the depth. Further, let the loading be spread uniformly over the top at the rate of $\frac{1}{2}w$ per unit of length; or $6w=W$, over the whole span of twelve units in length; w represents the unit of weight or stress=loading spread over a length of the span measuring 2D. Let N be taken generally to represent the number of bays or parts into which the span is divided by the points at which the roadway or top-boom is supported by the bracings; when

Fig. 1.

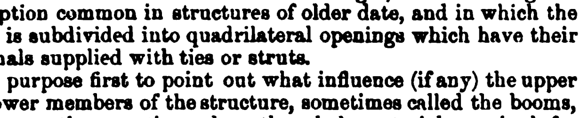
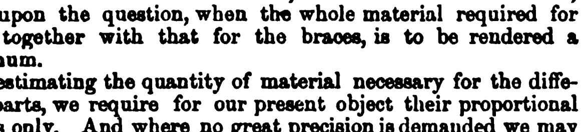


Fig 2.



there is but one series of braces N will be the number of triangles making up the span. Let θ represent the angle which a brace makes with the vertical, and a the angle which it makes with the horizontal direction. In Figs. 1 and 2, in which N is respectively equal to 6 and 2, let us first adopt the very usual supposition that each of the apices of the triangles receives the same share of the loading$=6w\div N$. By the principles on which the stresses on such structures are calculated, we can readily affix to each brace, as is done in these figures, a number to denote in units the vertical component of the stress acting upon it, when all the loading is on the structure (the stresses on the booms being then the greatest). Knowing the vertical component of the stress on a brace we obtain the horizontal stress which it induces in the booms, by multiplying the former by the tangent of θ. And since the depth of the structure is taken equal to unity, the tangent of θ is simply the horizontal stretch of the brace. Proceeding on these principles we obtain the stresses on the booms marked against the various parts in the figures;* and to obtain the proportional quantities of the materials for the booms we have merely to multiply these stresses by the respective lengths thus:

$$\begin{matrix}\text{Fig. 1.}\\ N=6\end{matrix}\left\{\begin{matrix}\text{Top} &=(5\times2+8\times2+9\times1)2=70\\ \text{Bottom}&=(3\times2+7\times2+9\times2)2=76\end{matrix}\right\}=146$$

$$\begin{matrix}\text{Fig. 2.}\\ N=2\end{matrix}\left\{\begin{matrix}\text{Top boom} &=(9\times3)2 &=54\\ \text{Bottom do.}&=(9\times6)2 &=108\end{matrix}\right\}=162$$

Now we have here an increase in the material required for the booms accompanying the diminution in the value of N, and this deduction is borne out by other similarly treated examples, and might very readily mislead us, as it has already misled one writer, into thinking that there is an advantage to be gained by an increase in the number of the triangles above what would be the most economical were the material of the braces alone to be reduced to a minimum, *i.e.*, that θ should be diminished or a increased above 45°, the well-known economic angle for the

Fig. 3.

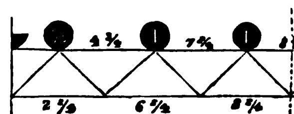
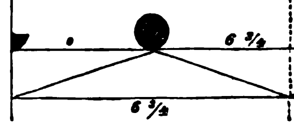


Fig. 4.



braces when these are arranged in isosceles triangles. This erroneous view springs from the figures 1 and 2 not truly representing the conditions under which a uniform loading would be borne. The assumption that every one of the apices of the triangles receives an amount equal to $W\div N$ is incorrect. A little consideration of the mode in which the loading is brought upon the points will convince us that the points immediately adjoining the piers receive each only three quarters of the amount of the loading given up to each of the others, the other quarters being supported in a direct manner by the piers. The true conditions are therefore those shown by Figs. 3 and 4; and calculating the proportional quantities for the booms, as before, we have for

$$\begin{matrix}\text{Fig. 3.}\\ N=6\end{matrix}\left\{\begin{matrix}\text{Top} &=(4\tfrac{3}{4}\times2+7\tfrac{3}{4}\times2+8\tfrac{3}{4}\times1)2=67\cdot5\\ \text{Bottom}&=(2\tfrac{3}{4}\times2+6\tfrac{3}{4}\times2+8\tfrac{3}{4}\times2)2=73\cdot0\end{matrix}\right\}=140\cdot5$$

$$\begin{matrix}\text{Fig. 4.}\\ N=2\end{matrix}\left\{\begin{matrix}\text{Top boom} &(6\tfrac{3}{4}\times3)2 &=40\cdot5\\ \text{Bottom do.}&=(6\tfrac{3}{4}\times6)2 &=81\cdot0\end{matrix}\right\}=121\cdot5$$

Here then we are led to an opposite deduction, and all similarly and correctly treated examples confirm it, viz., that a diminution in the material required for the booms to resist the longitudinal stresses accompanies a diminution in N; and consequently, if the consideration of the booms be admitted into the question, and the value of N be optional, the economic value of θ will be greater, or that of a less than 45°.

When, as in the succeeding figures, the structure is suspended at the extremities of the upper member, and the loading spread uniformly over the top, then every apex will be loadeu exactly to the extent of $W\div N$; so that with this arrangement of the structure, the error we have discussed above could never have been fallen into. The results for the figures 5 to 8 are as follow:

$$\begin{matrix}\text{Fig. 5.}\\ N=6\end{matrix}\left\{\begin{matrix}\text{Top} &=(2\tfrac{1}{2}\times2+6\tfrac{1}{2}\times2+8\tfrac{1}{2}\times2)2=70\\ \text{Bottom}&=(5\times2+8\times2+9\times1)2 \quad =70\end{matrix}\right\}=140$$

$$\begin{matrix}\text{Fig. 6.}\\ N=4\end{matrix}\left\{\begin{matrix}\text{Top} &=(3\tfrac{3}{8}\times3+7\tfrac{7}{8}\times3)2 &=67\cdot5\\ \text{Bottom}&=(6\tfrac{3}{4}\times3+9\times1\tfrac{1}{2})2 &=67\cdot5\end{matrix}\right\}=135$$

* These numbers have been omitted in some of the figures, but are all given in the detailed calculations of the booms.

Fig. 7. N=3, θ=63° 26′
$$\left\{\begin{array}{ll}\text{Top} = (4\times4+8\times2)2 & =64\\ \text{Bottom} = (8\times4)2 & =64\end{array}\right\} = 128$$

Fig. 8. N=2
$$\left\{\begin{array}{ll}\text{Top} = (4\tfrac{1}{2}\times6)2 & =54\\ \text{Bottom} = (9\times3)2 & =54\end{array}\right\} = 108$$

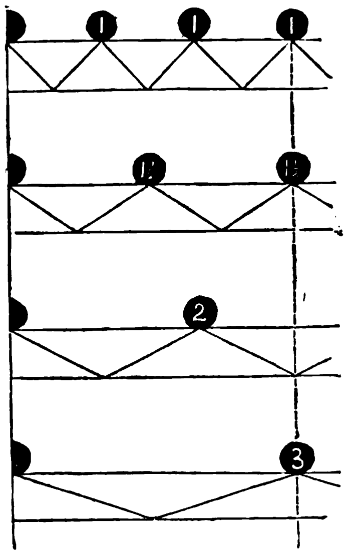
So that we have here the same result as when the former figures 3 and 4 were correctly dealt with—a diminution of the material in the booms accompanying a diminished value of N. It would, however, be proceeding too hastily to conclude that the degree of slope of the braces directly affected the amount of material

Fig. 5.

Fig. 6.

Fig. 7.

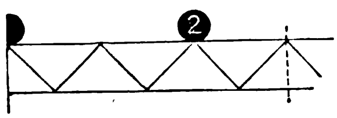
Fig. 8.



required for the booms. The fact is, we have not yet carried the analysis far enough: in the conversion of Fig. 5 into Fig. 7 two changes have been made: we have changed the value of the angle θ, but we have also changed the arrangement of the concentrated points of the loading, as well as the portion of the loading (=W÷N) which is in a direct manner imposed upon the piers. It remains then to discover what effect these changes will produce on the requisite material for the booms when each is constrained to act independently of the other.

First then let us make such a change on the loading of Fig. 5 as is exhibited in Fig 7, but without being complicated with a

Fig. 9.



change in the angle θ; this we are enabled to do by adopting the arrangement shown in Fig. 9, for the booms of which we have:

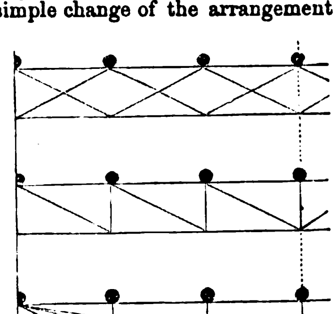
Fig. 9. N=6, θ=45°
$$\left\{\begin{array}{ll}\text{Top} = (2\times2+6\times2+8\times2)2 & =64\\ \text{Bottom} = (4\times2+8\times3)2 & =64\end{array}\right\} = 128$$

Which when compared with the calculations for Figs. 5 and 7 shows that the simple change of the arrangement of the loading

Fig. 10.

Fig. 11.

Fig. 12.



is sufficient to account for all the difference in the results. But to make it still more clear that it is the change in the loading alone that causes the difference in the results, we add Figs. 10, 11, and 12, in which the arrangement of the loading is retained exactly as in Fig. 5, but the angle θ is very materially altered. The results for these are:

Fig. 10. N=6, θ=63° 26′
$$\left\{\begin{array}{l}\text{Top} = (2\times2+6\times2+8\times2)2 = 64\\ \text{Bottom} = (3\times2+7\times2+9\times2)2 = 76\end{array}\right\} = 140$$

Fig. 11. N=6, θ=63° 26′ & 0
$$\left\{\begin{array}{ll}\text{Top} = (5\times2+8\times2+9\times2)2 & = 88\\ \text{Bottom} = (5\times2+8\times2)2 & = 52\end{array}\right\} = 140$$

Fig. 12. N=6, θ=63° 26′, 75° 58′, & 80° 32′
$$\left\{\begin{array}{ll}\text{Top} = (9\times6)2 & =108\\ \text{Bottom} = (2\times2+6\times2)2 & = 32\end{array}\right\} = 140$$

All of which results agree with that for Fig. 5, so that we must come to the conclusion that the value of θ has no direct influence on the quantity of material required for the booms.

The saving in the booms from a reduction in the value of N must be chiefly caused by a larger portion of the load being deposited at once upon the piers. And this reduction of the load actually imposed upon the framing of the structure must also, *cæteris paribus*, have an influence in reducing the material required for the braces. So that the economic angle for the braces considered alone would, if we might choose any value for N, come out somewhat greater than 45°. In structures such as Figs. 1—4 the loading actually thrown upon the bracing is =W—(W÷2N), and in those like Figs. 5—12, it is only=W—(W÷N). In lattice bridges with many series, N (=the number of bays into which S is divided by the points of concentration of the loading) is very high, and then nearly the whole of W is supported by the framing.

When there is but one series of braces under the conditions of Figs. 5—8, then D the depth being taken as the unit of length, and therefore S÷D=S; and the unit of load or stress being taken equal to the loading lying on a length of the span=2D, W=(S÷2) units of weight. For such figures, *when N is an even whole number*, we have no difficulty in arriving at the following general formulæ for the proportional quantities of material required for the booms and braces, these quantities being represented all along by the stress multiplied by the length of each part. Let the proportional quantity for the booms be represented by B, that for the bracing by R, and that for the whole girder by G=B+R.

N odd or even
$$B = \frac{WS^2}{6D} - \frac{WS^2}{6DN^2} = \frac{S^3}{12} - \frac{S^3}{12N^2} \quad \dots \quad (1)$$

N even
$$R = \frac{W}{2} ND \sec^2\theta, \text{ but } \sec^2\theta = \frac{S^2}{4N^2} + 1$$
$$\therefore = \frac{WS^2}{8N} + \frac{WN}{2} = \frac{S^3}{16N} + \frac{NS}{4} \quad \dots \quad (2)$$
$$G = \frac{S^3}{12}\left(1 + \tfrac{3}{4}N - \frac{1}{N^2} + \frac{3N}{S^2}\right) \quad \dots \quad \dots \quad (3)$$

Differentiating the value of G with N as the variable, we have, after clearing the coefficient, the following equation for G a minimum

$$\tfrac{2}{3}S^2 = \tfrac{1}{4}S^2N - N^3 \quad \dots \quad \dots \quad \dots (4)$$

Now to satisfy the premises, N must be an even whole number, let us therefore assign to it successively the values 4, 6, 8, 10, &c., the resulting values of S will show the proportions of span to depth which require *exactly* these values of N to produce the minima. The results, with the corresponding values of θ, are given in Table I.

TABLE I.

N=	4	6	8	10	12	14	16	100
S=	13·86	16·10	19·60	23·35	27·21	31·12	35·05	202·7
θ=	60°0′	53°18′	50°46′	49°25′	48°35′	48°1′	47°37′	45°23′

We may now take a particular value of S, say = 16·10 times the depth, and calculate the values of G by formula 3 to show what amount of extra material is incurred by departing from the most economical value of N (here =6); and it will be observed from the results as given in Table II. that the variations in the values of G are surprisingly small, and would be still less so were R of its full value, as explained further on.

TABLE II.

$$S=16{\cdot}10,\quad B=347{\cdot}77-\frac{347{\cdot}77}{N^2},\quad \text{and } R=\frac{260{\cdot}83}{N}+4{\cdot}025N.$$

N =	2	4	6	8	10	12	16
B =	260·83	326·04	338·11	342·34	344·30	345·36	346·41
R =	138·46	81·31	67·62	64·80	66·33	70·04	80·70
G =	399·29	407·35	405·73	407·14	410·63	415·40	427·11
θ =	76° 3′	63°35′	53° 18′	45° 10′	38° 50′	33° 51′	26° 35′

The case of $N=2$ is exceptional, it does not satisfy, after the same manner as do the other values, the equation (4) by which Table I. is calculated, and in Table II. it produces a secondary minimum, the proper minimum being at $N=6$.

It should be borne in mind that the variations in the values of B are produced solely by the variation of N, the number of points at which the loading is caused to concentrate or is supported, and that the value of θ has no direct influence on the value of B. Now if N be previously determined upon to suit the requirements of the roadway, suppose it to be $=16$, then the corresponding value of B, $=346{\cdot}41$, is fixed, and unaltered by any value that may be assigned to θ; and therefore in such a case the economic value of θ for the whole girder will be that which under the particular conditions gives the minimum for the bracing taken alone. When the bracing is of the isosceles character the minimum of the bracing will accompany the nearest practicable approach to the case of $\theta=45°$. So that for $N=16$ and $S=16{\cdot}10$, Table II., instead of using $\theta=26°35'$, with $R=80{\cdot}7$, when one series of braces only is admitted, we may adopt a form in which there would be two series having a prevailing angle $\theta=45°1'$, except at the ends, where it may be necessary to combine the two series into one to satisfy the conditions.

In the above calculations R as compared with B is undervalued, in the first place, because the material of the bracing as there estimated is such as would be required for a uniformly distributed *constant* loading. But when the loading is wholly or partially a moveable one the amount of material for the braces becomes increased, without however affecting the value of B in the least. Again, the allowance of material in proportion to stress would in practice be greater for the braces than for the booms. But this part of the question is not of that importance that we need dwell at greater length upon it here.

The conclusions that we have arrived at are:

1. When the loading and the bearings on the piers are on one level (or, in other words, when there is a full-lengthed bay adjoining each pier), and only one isosceles system of braces as in Figs. 5 to 8, and when the number of points in the span to be supported by the bracing may be of any number,—the lightest structure will be produced by a certain low value of N dependent upon the value of $S \div D$, as shown in Table I. But on the other hand, as shown by Table II., the variation produced in the total weight of the girder by varying the value of N is very slight, and therefore that value would be chosen which gave a sufficiently liberal number of supports to the roadway.

2. When N is fixed or previously determined upon, but the points of support on the piers, the number of series, and the arrangement of the braces are all left optional (as in Figs. 5, 10, 11, and 12), the greatest economy will be secured by causing θ to approximate to a certain economic value to be determined for the particular kind of bracing and materials to be employed. The minimum for the bracing taken alone having in this case to be considered.

In our next we shall discuss the economic values of θ for various forms of bracing, and draw comparisons to show their relative costs.

Edinburgh. R. H. B.

VENTILATION OF DWELLINGS AND HOSPITALS.

(Continued from page 35.)

ON leaving the comparatively simple question of the ventilation of ordinary dwelling rooms for that of hospitals, we at once encounter a vast complication of conflicting opinions and practice, and a really perplexing amount of contradiction in the views of those who are considered authorities. The causes of this complication are twofold. First, the problem itself is a less simple one than that of how to ventilate an ordinary dwelling room, because in hospitals other causes of vitiation are at work besides respiration; and the air which is rendered insalubrious by these agencies is less elevated in temperature, and consequently less readily discharged than that vitiated by respiration. Secondly, the very fact of having a large building in which vacant spaces can be found, in which a system of pipes and flues can be constructed, and in which attendance, fuel, and even steam-power can be procured if wanted, tempts those having the care of arranging the ventilation to venture upon some elaborate "system," for carrying out which the building will offer facilities impossible in a private house. Accordingly in hospitals, and we may add in other great institutions, above all in prisons, we find what is called "artificial" ventilation adopted in a majority of cases, and frequently we see an amount of scientific skill brought to bear upon it which merits the highest tribute.

An artificial method or system of ventilation may be defined as a method or system where the motive power for removing the vitiated air and introducing fresh is something other than the natural rise of temperature due to the warming of the air of respiration while in the lungs. Writers on ventilation have sometimes recognised two classes of artificial systems, calling those systems where artificial power is employed to force air into a room furnished with suitable outlets, so that it may pass through the room and out again, systems of *plenum* ventilation; while those systems where the power is employed to draw vitiated air *out* of a room, without applying power to the inlet, are termed *vacuum* systems. This distinction of systems, designated however by the more scientific appellations of ventilation by propulsion, and ventilation by extraction, is found recognised in extract from Report of the Barracks and Hospital Commission which we have already given.*

The artificial ventilation of hospitals has been already treated of in our columns, and almost all that can be said in its favour will be found in the two articles on the subject which we printed in 1858.† Arguments for at least a partial use of artificial means will be there found of a cogency almost unanswerable, and the experience of certain foreign hospitals has been again and again appealed to by the supporters of this plan, yet we find the barrack and hospital commission deciding against its adoption; and it will not be difficult to show that in coming to that decision their views coincide with the published opinions of many of those who in this country are now considered competent authorities on the subject of hospital ventilation and construction.

The desirability of perfect ventilation in hospital wards would be partially recognised without our insisting on it at great length —but few who have not paid special attention to the subject are quite aware of its paramount importance. In one ward of an hospital the sick will linger, wounds will refuse to heal, gangrene will be frequent, and fever will from time to time occur, while in another ward of the same building, under the same regimen, nursing, and medical attendance, the sick will habitually recover, and hospital gangrene and fever will be unknown. This is a matter familiar to physicians, and the explanation is always to be found in the construction of the ward itself with regard to ventilation, the thoroughly airy wards being invariably those where the process of recovery goes on as the medical attendants would desire and expect, the close and badly ventilated ones being those where it is checked and prevented by an unseen but not imperceptible enemy.

Upon this point we may refer once more to the Barrack and Hospital Report.

"The atmosphere of a sick ward, besides being deteriorated by the ordinary process of respiration, is filled with miasms generated by the sick. These, if not sufficiently diluted and rapidly carried away, give rise to what are called hospital "contagions" and "infections," which, as all experience has proved, are far more prejudicial to the sick than is the breath of healthy men to the healthy. Sick men in hospital are much more exposed to danger from such causes than are healthy men in barracks, because not only are sick more susceptible to the influence of such miasms, but the emanations themselves have often a special poisonous quality, and generate disease even among healthy attendants."

We may also quote, from a pamphlet of great value on hospital arrangement by Mr. John Roberton, of Manchester, a few words very much to the point.

"So wide is the difference between the wants of a ward filled with the sick and wounded with respect to ventilation, and the wants of every other kind of apartment in which people in health congregate or lodge,

* *Ante* vol. xxiv., pages 219 and 220. † *Ante* vol. xxi., pages 333 and 356.

that the means which are found sufficient to maintain the purity of the one fail in maintaining the purity of the other; and an architect who has not submitted to make himself familiar with the state of the atmosphere in, for example, the crowded wards of a badly constructed hospital, at those hours of the day and night when the admission or the exclusion of air is left to the nurse and patients, is ill qualified to form an opinion on ward ventilation. Until the architect will consent to give his organ of smell a few minutes' practical training, about six or seven o'clock in the morning, in a crowded surgical ward, he can never realise the importance of a truth which can hardly be enunciated with too great emphasis—that not merely must a ward, if it is to be kept sweet, be ventilated in the ordinary sense of the term, but it must be so ventilated as to secure for it *the constant renewal of the contained air*—the displacement of the fœtid effluvia ever being emitted from the bodies of the sick and wounded, and the substitution instead, of air, not drawn from cellars, corridors, and passages, but admitted direct from the store of the unpolluted heavens."

Having thus pointed out the peculiar necessity of perfect ventilation for hospitals, we propose to proceed very briefly to describe first, the views and plans of those who prefer ventilation on the natural method, and lastly to give some account of one or two of the most successful systems of artificial ventilation of hospital wards.

(To be continued.)

THE STATICS OF BRIDGES.

*The Suspension Chain.**

HAVING ascertained the mechanical conditions of equilibrium in a chain, and shown how to determine its curve by construction, we may now venture to generalise a little further. This will be best accomplished by the aid of algebra; an instrument we have hitherto employed as little as possible.—our object having been to obtain practical results by a plain and tangible method, before proceeding to more abstract reasoning.

The simplest case is that in which, the horizontal distribution of the load, and the rise or versed sine of the chains being given, it is required to determine their curve and find the amount of tension. This is generally speaking the problem to be solved in any ordinary suspension bridge. The curve of the chains is calculated with reference to the load on the platform, of which the distribution is known. The tension is reckoned from the combined action of the weight of the chain and the weight of the load. In this computation the weight of the chain may commonly be averaged as if its horizontal distribution were equal, without introducing any large error into the conclusion. The curve of the chains thus found will be an approximation sufficiently near the truth for all practical purposes, so long as the proportion of the weight of the chains to the total load is not large.

When the towers are equal and the loading is symmetrical, the point of greatest moment will of course come at the half span, and it is there that the lowest point of the chain will accordingly be found.

When the disposition of the load is no longer symmetrical, the ollowing rule gives the position of the point of greatest moment, or lowest point of the chain, the towers being equal:—Find the centre of gravity. Divide the total amount of load between the two towers in the inverse ratio of the distances of its centre of gravity from either. The point where the load is thus divided is that of greatest moment.

Where the towers are of unequal heights (h_1 on the left and h_2 on the right), the point where the load divides, or the lowest point of the chain, will be so placed that $h_1 : h_2$: : moment of left section of load : moment of right section of load.

If the horizontal rate of loading is uniform, the application of the preceding rule is very simple, the distance of the lowest point of the chain from the half span being at once reducible to the following expression:

$$\frac{h_2+h_1-2\sqrt{h_2.h_1}}{2\,(h_2-h_1)}\times\text{Span}.$$

Or thus:—Take the arithmetical mean of the heights less the geometrical mean; divide by the difference of the heights; and multiply by the span. The result will be the distance from the half span at which the load divides. When the heights of the towers are not only unequal, but the loading also irregular, the manner of distribution of the load has to be considered before the position of the lowest point of the chain can be predicted. To this end the readiest and surest means will be to plot the Curve of Loading. In Fig. 35 the horizontal line AB represents the span, and the line AmL the Curve of Loading; of which the ordinate at any point is equal to the aggregate load measured from A,—the last ordinate BL being equal to the total load on the platform between the piers. This curve, if divided at the proper point by a horizontal line, will give areas equal to the respective moments of the loads* depending from the two towers respectively. Thus, supposing *m*M to be the line at which the load divides, draw the horizontal line *amb* cutting the Curve of

FIG. 35.

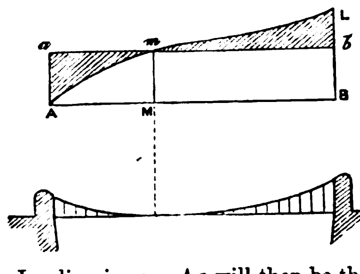
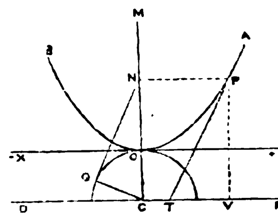


FIG. 36.



Loading in *m*. A*a* will then be the load on the tower at A, and the area A*ma* will be the corresponding moment. L*b* will be the load on the tower at B, and the area L*mb* the corresponding moment. But by the rule already given, the respective moments are to each other in the ratio of $h_1 : h_2$. Therefore $h_1 : h_2$: : area A*ma* : area L*mb*. The position of *m* which gives areas satisfying this equation is soon found by trial. The ordinate *m* M wlll then give the true division of the load, or the position of the lowest point of the chain. When the towers are equal,

Area A*ma*=Area L*mb*.

Having found the position of M, the curve of the chain can be determined by means of the moments, in the way already shown (*ante* page 49.) The Horizontal Tension will be obtained by dividing the total moment on either side of M by the height of the tower on the same side. The heights of the towers have been taken throughout the foregoing investigation as measured from the lowest level of the chain.

The proportion between the ordinates of the Curve of the Chain and those of the Curve of Moments being constant and measured by the amount of Horizontal Tension (*ante* page 48), the following equations will hold good.

Let R be the rise of either segment of the chain taken from the lowest point; M the moment of the corresponding load; *l* the aggregate load up to a certain point, measured from the lowest point of the chain; *m* the moment of the same; T the horizontal tension.

Then $R\times T=M$, and $T=\frac{M}{R}$

$$\text{or, horizontal tension} = \frac{\text{moment of segment of chain}}{\text{rise of same}}$$

$$y\times T=m, \text{ and } y=\frac{m}{T} \quad \ldots \quad \ldots \quad (A)$$

$$\frac{dy}{dx}=\frac{l}{T} \quad \ldots \quad \ldots \quad \ldots \quad (B)$$

$$\frac{d^2y}{dx^2}=\frac{\frac{dl}{dx}}{T}=\frac{\text{horizontal rate of loading}}{\text{horizontal tension}} \quad \ldots \quad (C)$$

Radius of curvature at lowest point of chain (when there is no concentrated load at that point) $= \frac{\text{tension}}{\text{rate of loading}}$ ... (D)

The equations (A), (B), and (C) are identical with those given (vol. xxiv., p. 348) in treating of the line of pressure of the arch.

In considering the curve in which a chain would hang of itself, we have to set out without the knowledge of the *horizontal* rate of loading. What we know is merely the sectional weight of the chain, or what may be called the *tangential* rate of loading.

Now, (tangential rate of loading) $\times\, ds$ = ((horizontal rate of loading) $\times\, dx$, and consequently, from equation (C),

$$\frac{d^2y}{dx^2}=\frac{ds}{dx}\times\frac{\text{tangential rate of loading}}{\text{horizontal tension}}$$

Or if we put w = sectional weight of chain (or tangential rate of loading)

* Continued from page 50.

* Because $m=\int l.dx$, or Moment=Integral of Load with respect to Horizontal Distance. See Vol. xxiv, p. 65

$$\frac{d^2y}{dx^2}=\frac{ds}{dx}\times\frac{w}{T}=\sqrt{\left(1+\left|\frac{dy}{dx}\right|^2\right)}\times\frac{w}{T}\quad\ldots\ (E)$$

The equation (E) gives the general conditions of catenary curves, viz.:—the relations between the form of a curve, the horizontal strain, and the sectional weight, whether constant or variable.

The equations (A), (B), (C), and (D) of course hold good for all catenary curves. When the sectional weight of the chain is uniform (or w a constant) the curve of equilibrium will be that known as the Common Catenary.

In this case, the load l and the arc s being alike measured from the lowest point of the curve, $l = w\times s$ $\therefore$ (from equation (B),

$$\frac{dy}{dx}=\left(\frac{l}{T}=\right)\frac{ws}{T}\quad\ldots\quad\ldots\quad\ldots\ (1.)$$

$$\text{But } \frac{ds}{dx}=\sqrt{\left(1+\left|\frac{dy}{dx}\right|^2\right)}$$

$$\therefore\ \frac{ds}{dx}=\sqrt{\left(1+\frac{w^2}{T^2}s^2\right)}\quad\ldots\quad\ldots\ (2.),$$

Let $\frac{T}{w}=a$ (which of course is a constant); then (2) gives, after substitution of $\frac{1}{a^2}$ for $\frac{w^2}{T^2}$,

$$\frac{ds}{dx}=\sqrt{1+\frac{s^2}{a^2}}\ldots\quad\ldots\quad\ldots\ (3.)$$

The definite solution of this differential equation (when the origin of x is taken at the lowest point of the curve) will be

$$s=\frac{a}{2}\left(E^{\frac{x}{a}}-E^{-\frac{x}{a}}\right)^*\quad\ldots\quad\ldots\ (4.)$$

$$\text{But, from (1), }\frac{dy}{dx}=\frac{s}{a},\ \left(=\frac{1}{2}E^{\frac{x}{a}}-E^{-\frac{x}{a}}\right)$$

$$\therefore\ y=\frac{a}{2}\left(E^{\frac{x}{a}}+E^{-\frac{x}{a}}-2\right)\quad\ldots\quad\ldots\ (5.)$$

(y being=0 when x=0.)

Let t = the amount of tension at the point (x, y) in the direction of the tangent of the curve. Then, by resolving t into the horizontal tension T and the load l, we find that

$$t^2=T^2+l^2=w^2(a^2+s^2)\quad\ldots\quad\ldots\ (6.)$$

whence it is readily deduced that

$$t=w\times\frac{a}{2}\left(E^{\frac{x}{a}}+E^{-\frac{x}{a}}\right)\quad\ldots\quad\ldots\ (7.)$$

$$\text{Or, } t=w\times(y+a)\ \ldots\quad\ldots\quad\ldots\quad\ldots\ (8.)$$

The simple relations between the Tension, the Arc, and the Ordinate, expressed in equations (6) and (8) can be visibly displayed in a diagram. In Fig. 36, AOB is the Common Catenary. COM is the axis of y, and O is at once the lowest point of the curve and the origin.

The horizontal line DR is drawn at the distance CO=a below the axis of x, and is termed the Directrix. To find the tension (=t) at any point P, let fall PV perpendicular to the Directrix. Then, (from Equation (8)) $t=w\times$PV. From the centre C describe the circle of the radius CO=a. This might perhaps deserve the name of the Directing Circle, on account of properties to be now explained.

From P draw the horizontal line PN to meet the axis of y in N. From N draw the line NQ touching the circle in Q, and join the radius CQ. Then NQC is a right-angled triangle, of which we know the hypothenuse NC to be $=\frac{t}{w}$, and the side CQ to be $=a$. $\therefore$ (from Equation (6), the other side NQ $= s$, =Arc OP.

It follows from this property of the *Directing Circle* that the line NQ is parallel to the tangent PT. For PT : TV : : Tangential Tension : Horizontal Tension. : : NC : CQ. And since NCQ and PTV are both right-angled triangles, and have the sides enclosing the angles at N and P respectively proportional, these angles must be equal, and consequently NQ and PT are parallel to one another.

For a known amount of Horizontal Tension (in terms of the sectional weight of chain) we can therefore very readily find the *direction* of the tangent at any given *elevation*. From these data it is possible to construct the curve without reference to tables of logarithms.

* E being the base of hyperbolic logarithms.

THE ELEVATION OF THE EXTERIOR RAIL ON RAILROAD CURVES, &c.

By Oliver Byrne, C.E.

Let w be the weight of the moving body or train, V its velocity in feet a second, R the radius of the curve, and g=the force of gravity at the surface of the earth; and let f represent the centrifugal force: then by a well-known dynamical expression

$$f=\frac{wV^2}{gR}$$

If R=one quarter of a mile=1320 feet, V=velocity=38·6 feet a second, and $g=32\frac{1}{6}$ feet,

$$\text{Then } f=\frac{w\times(38{\cdot}6)^2}{32\frac{1}{6}\times1320}=\frac{193}{5500}w.$$

In this example the centrifugal force is about $\frac{1}{28}$ part of the weight.

If R=a mile=5280 feet, g as before=$32\frac{1}{6}$ feet, and V=60 miles an hour=88 feet a second, then

$$f=\frac{w\times88^2}{32\frac{1}{6}\times5280}=\frac{1}{22}w\text{ nearly.}$$

In this last case the centrifugal force, that urges the moving body to leave the curve, is equal $\frac{1}{22}$ part of the weight of the moving body. This force is in a great measure counteracted by the conical tread of the wheels, each pair of which is firmly fixed to an axle AB, Fig. 1. The rails C and D may be level, yet if the points of contact be at I and E, coned wheels will run round a circle whose centre is at Q. If the points of contact of the rails be I and F, then the centre will be at O; but if the wheels assume the position that the equal circles G and H come in contact with the rails C and D, the axle AB and KL would be parallel, and hence do not meet. The conical tread, the lateral play of the flanges, about half an inch on each side, and the centrifugal force of the weight moved on the curve, enlarge the diameter of the exterior wheel B, and diminish that of the interior A; hence there is a centripetal force directed towards the centres of the cones Q, O, &c., as the rails change their points of contact on the coned tires. Let d be the diameter of the wheels at the circles G and H, when they stand level, or rather when the line KL joining the points of contact is parallel to the axis AB. Let the outer diameter be increased by a variable small quantity z, as the rail touches nearer the flange; or let the outer diameter become $d+z$, it is evident that the inner diameter will become $z-z$. The value of z, generally varies from 0 to $\frac{3}{5}$ of an inch; so that the diameter of the wheels may be made to vary according to the circumstances of the motion from about 36 to 36·6 inches, sometimes more and sometimes less. Let r be the variable radius OT, answering to the increase z, and b= the gauge or breadth of the road CD; then $r+\frac{1}{2}b$ and $r-\frac{1}{2}b$ are the distances of the circles of contact from the centre O. By similar triangles

$$d+z : d-z :: r+\frac{b}{2} : r-\frac{b}{2}$$

$$r=\frac{bd}{2z}$$

If the breadth of the road=4·7 feet, the diameter of the wheel

$$\therefore\ d : z :: 2r : b$$

=3 feet, and z=one-tenth of an inch,

$$OT=r=\frac{12\times4{\cdot}7\times3\times12}{{\cdot}2}=10152\text{ inches}=846\text{ feet.}$$

Again, for the sake of example, let z equal $\frac{1}{40}$ of an inch, the breadth of the road=7 feet=84 inches, the diameter of the wheel at the level tread=30 inches. Required OT=r.

$$r=\frac{30\times84}{{\cdot}05}=50400\text{ inches}=4200\text{ feet.}$$

But the centripetal force corresponding to radius r is $p=\frac{wV^2}{gr}$ which acts in a contrary direction to the centrifugal force: they will hold each other in equilibrium when they become equal, and the train will have no inducement to fly off the track;

$$\therefore\ \frac{wV^2}{gr}=\frac{wV^2}{gR}\text{ or } r=R.$$

Consequently the vertex O of the imaginary cone must coincide with the centre of the curve of the railroad, to avoid slipping or dragging. But it was before shown that

$$r=\frac{bd}{2z}\ \therefore\ R=\frac{bd}{2z}\ \therefore\ z=\frac{bd}{2R}$$

which is the increment and decrement that the exterior and interior wheels respectively receive to produce equilibrium between the centripetal and centrifugal forces of the train.

Let the gauge of the road $= b = 64$ inches, the diameter of the wheels at the points where they rest level on the rails=36 inches; R, the radius = 600 feet, $2\,R \times 12 = 14{,}400$ inches; hence in this case

$$x = \frac{64 \times 36}{14400} = \cdot 16 \text{ of an inch.}$$

The coning of the wheels will not compensate for much more than this, as there is only a play of about half an inch on each side between the flanges and the rails.

Let Fig. 2 represent part of the tire of a railway car wheel; the rise from A to C half an inch in $3\frac{1}{2}$ inches, that is,

$$AB : BC :: 7 : 1.$$

But in order that the statement may be general and applicable to all cases let $AB : BC :: n : 1.$

When the wheels stand level on level rails, let E be one of the points of contact, DB the space given for the play of the wheel between the flange and the rail; this for the sake of example I put $= \frac{1}{2}$ an inch $= v$. The rail and wheel may touch at any other point between C and A, yet the space DB is unaltered, and the elevation will be as n to 1. The diameter through E is put equal d.

$$n : 1 :: v : \frac{v}{n} \quad \therefore \frac{2v}{n} = x;$$

giving to v what I have just supposed to be its greatest value, half an inch, $x = \frac{1}{7}$, and

$$r = \frac{ndb}{4v} = \frac{bd}{2x}$$

It is clear that, as x increases, r decreases. Let $d = 3$ feet, b=4·7 feet, $x = \frac{1}{7}$ of an inch=$\frac{1}{84}$ part of a foot;

$$\therefore\ r = 3 \times 4 \cdot 7 \times \frac{84}{2} = 592 \cdot 2 \text{ feet}$$

the least possible radius of curvature on the suppositions made, in which the two forces balance each other, supposing the two rails to be exactly level. I will assume another case.

Let $v = \frac{1}{4}$ of an inch, and $\frac{1}{n} = \frac{1}{7}$;

$$x = \frac{2v}{n} = \frac{1}{14} \text{ of an inch}$$

$$r = \frac{bd}{2x} = 3 \times 4 \cdot 7 \times \frac{14}{2} \times 12 = 1184 \cdot 4 \text{ feet.}$$

Again, let $v = \frac{1}{8}$ of an inch, $z = \frac{2v}{n} = \frac{1}{28}$

$$\therefore\ 2x = \tfrac{1}{168} \text{ of a foot}$$
$$\therefore\ r = 3 \times 4 \cdot 7 \times \tfrac{168}{1} = 2368 \cdot 8 \text{ feet.}$$

Hence it may be inferred that the coning of the wheels, without a rise in the outer rail, cannot be depended upon in curves of less than 2000 feet radius.

What I have said on this subject up to this is mere preliminary matter. I will now find the elevation of the exterior rail for any radius R of a railroad curve. Let x=the required elevation; b, as before, the gauge of the road; $\frac{wx}{b}$ will be the force drawing the train to the interior rail on account of the elevation x. This force must hold the centrifugal force in equilibrium, hence

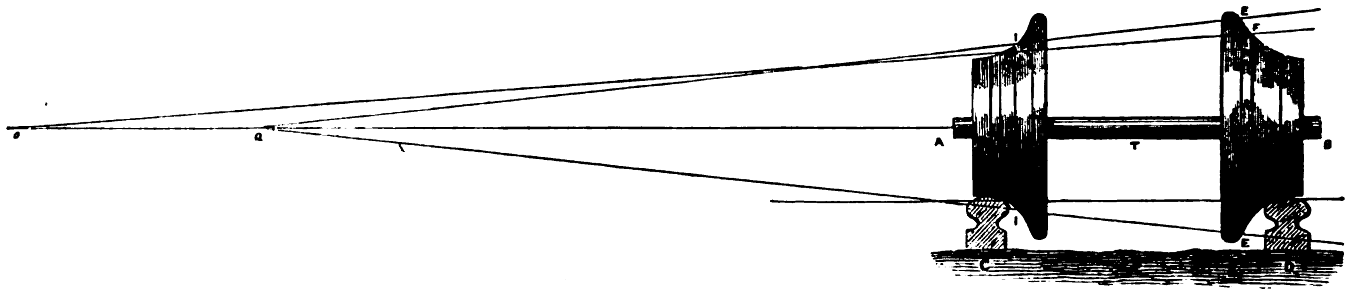
$$\frac{wx}{b} = \frac{wV^2}{gR}\ ;\ \text{V being the velocity.} \quad \therefore\ x = \frac{bV^2}{gR}$$

Example.—Let R=1910 feet, g=32·2, b=4·7 feet, V=44 feet a second=30 miles an hour;

$$\therefore\ x = \frac{4 \cdot 7 \times 44^2}{32 \cdot 2 \times 1910} = \cdot 224.$$

This value of x involves the elevation given by *coning* the wheels; the proper coning for a radius of 1910 feet=R, as before established, is

Fig. 1.



$$z = \frac{bd}{2R} = \frac{36 \times 56\frac{1}{2}}{2 \times 12 \times 1910} = \cdot 044$$

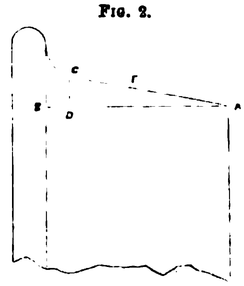
on the supposition that b=36, and d=4 ft. $8\frac{1}{2}$ in.

·224
·044

·180 inches rise of outer rail.

When the coning of the wheels is so defective that the proper circles on the wheels cannot be employed, then the outer rail is pressed and broken by the flanges. It is in this particular that engineers have erred. Wheel-makers have no system of coning, so that the wheels they make may run on a curve with a given velocity without injuring the flange and outer rail. In my Pocket-Book for Railroad and Civil Engineers, for the first time I laid down the means of effecting this object; it is simple, when the rise (x) of the outer rail is formed for any radius (R) and velocity (V); if the coning (z) cannot be established more or less without constraint, the wheels will not run on the curve with freedom. In fact, at all the speeds on every curve, the apices O, Q, &c. (Fig. 1) must coincide with the centre of the railroad curve, or damage will be done to the running gear. Want of skill in this particular is, in America, made up by a range given to the kingbolt, a lateral-motion beam, and other contrivances.

Fig. 2.



Example.—Let the diameter of the wheels $= d = 33\frac{1}{2}$ inches, at the points where they touch on the level rails; say the coning allows the diameter of the outer wheel to be increased, while the diameter of the inner wheels are diminished ·13 inch; what is the least radius with this play, that these wheels will accommodate themselves to? and what is the elevation of the outer rail for a velocity of 50 miles an hour on a track of 819 feet radius, the gauge = 4 feet $8\frac{1}{2}$ inches?

$$R = \frac{33 \cdot 5 \times 56 \cdot 5}{2 \times \cdot 13} = \frac{b'd}{2z} = 7280 \text{ inches} = 606 \text{ ft. 8 in.}$$

the least radius that these wheels will accurately accommodate.

50 miles = 264,000 feet; velocity $V = 73\frac{1}{3}$ feet a second.

$$x = \frac{bV^2}{gR} = \frac{4 \cdot 7 \times (73\frac{1}{3})^2}{32 \cdot 2 \times 819} = \cdot 958,$$

for a radius of 819 feet,

$$z = \frac{bd}{2R} = \frac{2 \cdot 8 \times 4 \cdot 7}{2 \times 819} = \cdot 008$$

$$\therefore\ \cdot 958 - \cdot 008 = \cdot 95, \text{ elevation of the outer rail.}$$

ON THE PRESENT ASPECT OF THE FINE ARTS IN ITALY, WITH ESPECIAL REFERENCE TO THE RECENT EXHIBITION IN FLORENCE.*

By M. Digby Wyatt, Architect.

To proceed with some little method, it will be well to take first of all the three generally received fine arts—Architecture, Painting, and Sculpture; and then the leading art-industries in succession, noting briefly the apparent condition of each in Italy at the present date.

With regard to Architecture it may be observed that the pernicious influence exercised by Bernini and Borromini, whose trivialities obtained excessive vogue during the greater part of the 17th century, tended to the production of that *rococo* style which caused a great deterioration in the florid ornament of the Roman, Venetian, and Northern Italian schools. But extravagant as Bernini was, it would be unjust to deny that he frequently redeemed his excesses, as in the colonnade of St. Peter's, and in the Church of St. Agnese, in the Piazza Navona, at Rome, by great facility of design and a certain not unnoble bravura of style. Borromini's great follower, Guarini, out-Heroded Herod, and demonstrated by an *argumentum ad absurdum*, the ridiculous consequences of adopting the whimsicalities of Borromini.

The brilliant talents of Vanvitelli, and the majestic scale upon which he worked out the immense Palace at Caserta, tended to maintain the dignity of his art during the greater part of the 18th century; and showed that magnificence and grand conceptions of pictorial effect had not yet deserted Italian architecture. From his death in 1773, architecture and ornament also greatly declined; and although monuments upon a large scale have been frequently erected since that period in Italy, but few of them are worthy, in any quality excepting that of scale, to rank with the purer taste of earlier times.

The feeble classicisms of the style of the Empire were generally slavishly reproduced in Italy during the early part of the present century; and until comparatively recent days little of considerable merit has been executed.

The works of Piranesi, Albertolli, Cicognara, and Canina, and the illustration principally by foreigners (such as Percier and Fontaine, Mazois, Grandjean, Famin and Montigny, Gauthier, Letarouilly, Zahn, Gütensohn and Thürmer, Grüner, Taylor and Cresy, Willis, and Hessemer,) of their great monuments of art, have led to a return toa purer class of architectural ornament than had been previously in vogue; while the earnest writings of the Count Selvatico, and the translation of Rio's Poësie Chrétienne, have introduced to the Italian architects those rational principles of design, including the treatment of constructive form and of ornament, originated amongst us by the younger Pugin.

The great scale of the existing edifices, and the reparations which it has been necessary to make from time to time to save them from destruction, have constantly maintained Italian artizans in the practice of rivalling the ancient work; so that in every department of building, hands at least abound perfectly capable of carrying out the most difficult designs.

No better illustration of this abundant material power could probably be given than the rapidity and dexterity with which the buildings for the Exhibition were adapted to their present purpose, in a few weeks only, under the skilful directions of the architects Signori Presenti of Cortona, and Martelli of Florence.

The feeble academic system which has until recently prevailed, and under which the professorial chairs were not unfrequently occupied by political parasites, rather than by duly qualified professors of real abilities—coupled with the lack of occupation—has certainly enfeebled the powers of the last generation of architects in Italy, although there are, of course, some honourable exceptions to such a reproach.

Among them I would place conspicuously the Cavaliere Nicolo Matas, of Florence, who is now on the eve of completing a work which must for ever do honour to his country. I allude to the restoration of the façade of the Church of Santa Croce, which is being conducted upon a scale of nobleness worthy in every respect of the building in which are deposited "ashes" which, as Byron says, are in themselves "an immortality of dust." The whole of this work, which is of enormous extent, is carried out in different coloured marbles, wrought with an exactitude worthy of the celebrated masonry of the shrine of Orcagna in the Or San Michele, so highly praised by Varsari. The sculpture is being executed by the most distinguished sculptors of Florence, and the result of their combined abilities is such as could scarcely, I believe, be rivalled at the present time, by designers, artists, and workmen in any of the capitals of Europe.

Scarcely less praise should be awarded to the authors of the noble restoration now making of the Bargello at Florence—the old palace of the Podestas.

Very recently a programme has been put forth, inviting designs from Italian and other artists, for completing the façade of the cathedral at Florence. The greatest praise is due to the Italians for their earnest desire to remedy so great a blot as the incomplete state of this façade has always been to that noble building, Santa Maria del Fiore, the master-piece of Arnolfo di Lapo and Bruneleschi.

In the Exhibition, under the head of "Building Materials and Contrivances" but little was worthy of remark, with the exception of the terra-cotta, which was, generally speaking, very good, more especially in the article of stoves, and vases for garden decoration. There are some successful imitations of the works of Luca della Robbia, as well as of the glazed and coloured tiles attributed to Girolamo della Robbia. To these we shall however return, under the head of ceramics. There are some interesting collections of marbles and building stones, and some very excellent scagliola. No less than four exhibitors received prizes for the production of hydraulic cements—an article until recently, despite their pozzolana, scarcely manufactured in Italy. An imitation of marble, made with cements of this description, and admirably coloured, has been perfected by the Marchese Campana, of Naples, and several specimens of his skill have been purchased for the South Kensington Museum. A manufactory of parquetry on the Swiss system has been lately established at Florence, and very fair specimens of flooring are exhibited.

Of decorative painting as applied to architecture I observed no specimens in the Exhibition, but in the streets and houses quite enough to assure me that very great dexterity was common among men little raised above the class of ordinary house painters.

For more elaborate decorations we know, from the skill of Signor Abbate, the decorator of the Pompeian house in the Crystal Palace, in this country, how readily competent decorators may be found; and it would, I think, require very acute observation on the part of anyone inspecting the old arabesques by Pierino del Vaga, in the Villa Doria at Genoa, and the grotesques executed in the same building by Annibale Angiolino, of Perugia, now living, to distinguish between the old and modern work.

Of the architectural designs in the Exhibition I am sorry to be unable to speak in laudatory terns. The most industrious amongst the artists appear to be Niccole Bregalia and Panfilo Rosarti, of Naples, who produce many drawings of architectural fragments and restorations from Pompeii, executed in the French academic style. In the remainder there is but little merit, although in water colour drawings there is evidence of considerable command over the delineation of architectural form.

The modern paintings of the Exhibition have been so fully and ably commented on, in the pages of the *Times* by Galenga's brilliant pen, of the *Athenæum* by Mr. Trollope, and of other journals, that I do not propose to dwell at any length upon them; but would simply remark that the old school of David and the classicists, as represented in Italy by Camuccini, and to a certain extent by his rival, Benvenuti, appears rapidly dying out; and in place of the well-drawn, but artificially grouped and badly coloured gallery pictures, such as many of those of the late Professor Bezzuoli, of Florence (one of which figures in the place of honour in the great gallery of the Exhibition), *genre* and landscape paintings, less carefully drawn, but embracing more romantic incident, livelier action, more natural effect, and far better colour, appear to predominate.

There are, however, two large gallery pictures which merit the highest possible commendation. One is "The Expulsion from Florence of the Duke of Athens," by Professor Stefano Ussi, which is a noble historical picture; and the other a picture of great power, by Domenico Morelli, of Naples, called "The Iconoclasts"—the subjects of both, it will be seen, rendering tribute to the importance, the one of political, the other of spiritual, liberty.

Among the best of the pictures of less pretension than these two may be noted, "The Procession of the Burial of Buondelmonte," by Altamura, of Naples; two other pictures by Morelli;

* Continued from page 38.

"The Council of Ten in the Courtyard of the Palazzo Ducale, on their way to the Hall of Council," by Celintano, of Naples; "Some Incidents of the War," painted by Carlo Ademmolo, of Florence; and "The Battle of Magenta," by Induno, of Milan, a smart *souvenir* of Vernet. Of the Neapolitan school one has to remark the specially improved character of the colouring and mode of painting.

For the same reason that I have so summarily disposed of the paintings in the Florentine Exhibition, I would refrain from entering into detail upon the subject of Sculpture; but as, proportionately, the monuments in the latter art are of a superior quality to the evidences of ability presented by those of the former, I think it but just to indicate a larger number of those works which appear to me to possess distinguished merit.

To say that the spirit of Canova is yet dead in Italy would be incorrect: but one is happy to recognise that, while much of his effeminacy and artificial composition is disappearing, much of his beauty of form and delicate finish in marble working is satisfactorily preserved. The care he bestowed in modelling the articulations of limbs, and the extremities generally, is rivalled in most of the best works now exhibited, although some few, otherwise excellent, fail in those important details.

The work which has attracted most attention, and with good reason, is the well imagined and gracefully carried-out figure of "A Girl reading," by Pietro Magni, of Milan. That sculptor, with Strazza (the author of the "Ishmael," in the Exhibition of 1851), and Vela, of Milan, an artist of great talent, may be looked upon as leading representatives of the Romantic school of sculpture in Italy, as opposed to the more Academic style, which finds its ablest representatives in Cambi, Santarelli, Costoli, and Fantacchiotti.

Dupré, of Florence, a sculptor of very great power, partakes of the merits of both classes, but falls slightly, in some of his works, into that leading defect of inattention to pure beauty of form, with which the Romanticists, in aiming at expression rather than the "beau ideal," may be occasionally reproached.

The most absolutely Canovesque of sculptors is, apparently, De Fabris (lately deceased), whose "Love and Psyche" is one of the honied but feeble reminiscences of the subject so dearly loved by his master, the father of modern Italian sculpture.

It is to be regretted that Tenerani, of Rome, Canova's favourite Italian pupil, has not contributed to this Exhibition, since his great powers would have gone far to vindicate the school of that really fine artist, under whose influence Tenerani's best works have been produced.

The principles upon which I believe the popularity of Magni's statue of the "Girl reading" is founded, appear to me so important, and indeed so novel, in their application to modern sculpture, that I think it my duty to dwell for a few minutes upon them. A maiden, of no great pretensions to beauty, either of form or feature, and in the simplest dress, is represented seated on a common rustic chair, reading. There is no very great study evidenced in the arrangement of the lines either of the figure or of the draperies, and indeed, in one important particular, the modelling of a portion of the bosom, a manifest defect is to be observed. The head is very truthfully modelled, and the expression is one of quiet concentration on the theme of the volume, in the study of which the reader's whole attention seems to be absorbed; that theme being, as may naturally be imagined at the present juncture, the development of Italian liberty under the sovereignty of Victor Emmanuel. Such elements may not in description, perhaps, appear likely to result in the production of a striking work of art; and yet the power of this small statue is such as to arrest and enchain the attention of everyone coming within sight of it. The potency of the spell I believe to mainly consist in the concentration of purpose manifested in the whole composition. There is no straining for effect—to borrow a theatrical phrase, "no playing to the foot-lights"—and none of that coquetry, half conscious of nudity, and evident flirting of the damsel with the spectator, which disfigure so many ordinary representations of female form. Other charms are unquestionably the ease, nature, and simplicity of the whole arrangement. Nothing is allowed to interfere with the tranquility of the action, and such is the effect of this appearance of quiet, that almost instinctively the spectator treads, as he passes, with lighter foot, and speaks in "bated breath," lest he may startle the marble maiden, who sits wrapt in her brooding fancies, as it were, unconsciously before him. A second of Magni's works, "An Indian Mother," seated in a shawl swung over the branches of some trees, in such a manner as to make the figure appear entirely unsupported, is a *tour de force* in marble working the slight tendency to extravagance in which is to be overlooked in the elegance of the action and the careful modelling of every portion.

A third work by the same sculptor is of considerably less merit. It represents a statue of Socrates, and, whether intentionally or not on the part of the artist, conveys an almost instinctive reminiscence of what one cannot but fancy the sovereign of United Italy himself might be with little else upon him than a rather scanty shirt. The compliment, if it be meant for one, is indeed somewhat dubious.

Vela, another Milanese, contributes one figure only, and that of an almost too voluptuous cast of beauty and attitude—"Spring," a nymph bounding upwards, but, as it were, caught and entangled in the vernal flowers from which she seems to be rising. In delicacy of modelling, and that truthful rendering of flesh in marble which the Italians term *morbidezza*, there is nothing, I think, in the whole Exhibition to equal it. It is to be regrettted that other works of Vela's are not to be found at Florence.

The most ambitious figure is certainly the "Daughter of Zion in her desolation," by Morelli, of Leghorn; but in aiming at grandeur the sculptor has neglected beauty, and thus fails to engage the sympathies of the spectator.

Fantacchiotti, of Florence, who enjoys a great and deserved local reputation, exhibits several works of very considerable merit, the best being the monument to the late wife of Mr. Spence, an English artist, long resident at Florence. The figure, which is that of a very beautiful matron, is represented as extended, after the manner of some of the finest of the cinquecento monuments, on a bier, recalling, in many particulars, the general form of the ancient sarcophagus. In front are amorine, and beneath are square tablets, inserted, as it were, in a plain and well-designed pedestal. The special merit of this work is two-fold. In the first place, all that may be called pure sculpture—that is the representation of the human form, and the draperies and ornaments connected with it—is thoroughly good; and in the second, these elements are combined with such conventional lines, masses, and ornaments, as adapt the whole composition for alliance with whatever may happen to be the architectural forms of the structure in which this beautiful work may be destined to be placed. What the consequences of the common want of skill in similar combinations may be, it is scarcely necessary to point out to an audience whose remembrances of St. Paul's and Westminster Abbey would, probably, be too poignant for me to do more now than hint at.

Strazza, whose "Ishmael" in the Exhibition of 1851, and whose "Audace" in the Crystal Palace, have made us well acquainted with his capabilities, fails to sustain them at Florence in his statue of the "Sposa Novella," which has however received the compliment of purchase by the king. Neither strikingly beautiful nor very expressive of its title, the modesty of the recent bride seems rather of that affected class, the freedom from which I have already commended in Magni's masterpiece.

Santarelli, of Florence, a well-known artist, exhibits a "Shepherd Boy," which has merit; but his "Magdalen" is too close a reminiscence of that of Canova, and fails to sit up comfortably. The infant's "Prayer of Innocence" is offered up rather by a little man than by a true bambino.

The same reproach as to want of youthfulness in form may be applied to the "Amore Mendicante" of Cambi, the general intention and action of which, however, is clever and expressive. The same sculptor's "Eve" recalls far too much and too many of the leading defects of our English academician, Bailey.

Pierrotti, of Milan, exhibits a very good anatomical study, in the shape of "A Hunter killed by a Snake." The subject is a difficult one, and has been well mastered by the skill and knowledge of the artist.

In the true academic style, Costoli's "Death of Menecæus" is to be highly commended, as being thoroughly well modelled, and well balanced in a difficult *pose*. His "Charity," a large bas-relief, is by no means so good.

Dupré shows a "Mater Dolorosa," the character of which is sublime and devotional in a high degree. He has also a "Sappho," in an attitude not altogether dissimilar to, although in no way plagiarised from, that of the well-known work of Pradier; and a sculptured pedestal, for apparently a large flower basin. The modelling and composition of the figures in alto-relievo which decorate the latter it is no small praise to say are, I consider, fully equal to those we so much admired in Professor Drake's pedestal in the Great Exhibition of 1851, a somewhat similar work. The attitude and expression of the "Sappho" and the draperies are admirable, but some portions of the nude have been modelled from rather too low a type of female beauty to be altogether satisfactory in a work of ideal art.

Admitted into the fellowship, if not the nationality, of Italian sculptors, are the well-wnown American and English artists, Power and Fuller. The "Greek Slave," and "Youth holding a Shell," the Proserpine, and many admirable busts by the former, are too well known in this country to need dwelling upon; but with his "America" we are not so well acquainted. Unlike the life and vivacity of that population, whose every breath it appears must be drawn in an atmosphere of *sensation*, and whose vital energies seem inexhaustible, the embodiment of the sublimated essence of modern republics is tame and dead; but, like at least the major section of that unhappy continent, she stands but feebly and totteringly, and one touch only seems wanting to overthrow the unstable goddess.

By the latter artist (Captain Fuller) there is a remarkably good figure of a "Drowning Boy," admirably modelled, and full of energetic action. The tempest-tossed sailor lad still struggles, though evidently unavailingly, with the elements which overpower him.

This scanty list by no means exhausts the excellencies, or perhaps rightly points to the salient defects, of the really fine collection of works of sculpture, which it is not too much to say formed the leading feature of the Florentine Exhibition; but I feel it necessary to quit the field of pure sculpture for that application of the art which lends its highest graces to industrial production. The two most distinguished workers in this department of industry, worthy maintainers of the fame Brustolone acquired for Italian wood-carving in the last century, are well known in this country—Barbetti and Pietro Cheloni, of Florence. The former exhibits a grand door, carved with no less than twenty alto-relievos of biblical subjects, treated somewhat after the manner of the celebrated gates of Ghiberti. Unlike them, however, the sculptures under notice have been executed in walnut wood, as a commission for Prince Demidoff, for the entrance door to whose Russian chapel at San Donato, near Florence, they are intended. The general design is, it appears to me, monotonous, from its extreme rectangularity, and is ill arranged in the junctions of the vertical and horizontal divisions with the semicircular head of the door. The carving is, however, executed in so masterly a style as to constrain an admiration for the details, which fails to be excited by the general aspect of the whole.

The same artist contributes a large oak bench, the seat of which is hinged, in order that the lower part may answer the purpose of the *cassapanca*, which formed so leading a feature in the Italian interiors of the quatro and cinque-cento periods. In general design this work is better than the door just referred to, and leaves behind a feeling of more entire satisfaction.

The capability for the most important works shown by these productions is destined to be put to an even loftier purpose, since Barbetti and his sons are now engaged in the execution of a magnificent case, 6 ft. 6 in. high, entirely wrought in ivory and ebony, to hold the National Crown of Italy. Of this grand work a full-sized water-colour drawing was exhibited, and I fully believe that the realisation of the design (which is exceedingly good) will be not unworthy of the ancient glories of Italian ornamental carving.

Cheloni works in a manner which very perfectly reproduces the delicate handling of Mino da Fiesole, Civitale da Lucca, and Andrea Ferrucci, and proves that, with judicious encouragement, he may become a formidable rival to the most distinguished amongst the Parisian magnates in the production of luxurious furniture. His bookcase, and above all, a single little panel in wood, fully justify this assertion. It is to be hoped that this fine bookcase, as well as the case for containing the National Crown, by Barbetti, may form ornaments in our Exhibition this year, where they cannot fail, I think, to be greatly admired.

The only rivals, although there are, of course, many approaching the excellence of Barbetti and Cheloni in ornamental carving, are Antonio Superchi, of Parma, and Professor Giusti, of Sienna. The former exhibits only a small panel, carved in soft wood, with arabesque ornament. It is, however, a masterpiece. The latter works in ivory, and appears to be well supported by English patronage, since his miniature reproduction of the celebrated Fountain of Jacopo della Quercia at Sienna, and his exquisite little picture frame, have been produced, the former for the Earl of Northesk, and the latter for the Marquis of Northampton. For the Count Agostino da Gori, Giusti has wrought a little coffer or box to contain autographs of men of science, artists, poets, &c. The shrine is by no means unworthy of the relics.

Time will not permit of my dwelling at greater length upon individual specimens, or even extending my catalogue of ingenious artists. It may suffice to say, briefly, that in marble, stone, ivory, ebony, and plastic compositions, the application of sculpture to industry forms probably the most distinguished feature of the industrial portion of the Florentine Exhibition.

It would be unfair to the Italians to pass from the subject of applied sculpture without noticing one form of it in which, from classical times to the present, they have maintained a decided pre-eminence over other nations. I allude to the art of working in gems and precious stones.

The names of Girometti and Odelli, of Rome, are celebrated, and their productions still command very high prices, in proportion perhaps to the labour, but too great for the art displayed; as for instance, the single cameo of Signor Girometti is valued at no less than 30,000 francs, or £1200, a price possibly, as the Italians say, "da combinarsi." Neither of these artists, in my judgment, sustains his previously acquired reputation; while the intaglios of Berini of Milan, a less known man, are, if not so valuable, far more agreeable, being both designed and wrought in better taste, and rather reproducing Grecian than ancient Roman styles of execution.

The old celebrity of Valerio Vicentini for the execution of intaglios in crystal, resting not only on the warm tribute of admiration paid to his genius by Varsari, but on exquisite relics of his skill still preserved at Naples, Rome, and Florence, has excited the noble emulation of Beltrami of Cremona, a very beautiful specimen of whose handicraft is exhibited by the Brothers Turina. I believe Beltrami to be no longer living.

The medallic art of Italy, so famous of old through the dies cut by Cellini, Bastiano Cennini, and others, is well sustained in the present day, and specimens furnished by the mints of Florence and Rome show that their ancient dexterity has not entirely deserted their descendants.

Before altogether quitting the Fine Arts, there are some forms in which they appear so closely allied to Industrial Art, and in their alliance so little modified, as to demand notice before proceeding to a consideration of those industries, the types and constitution of which are affected comparatively remotely by the three fine arts. I class in the former of these categories engraving, lithography, chromo-lithography, and photography.

From the days of Marc Antonio Raimondi, through those of Volpato and Raphael Morghen, to modern times, rendered illustrious by the names of Perfetti, Jesi, and Toschi, the Italian school of line engraving has maintained an almost unquestioned pre-eminence over its contemporaries of the rest of Europe. That great work, the engraving of the frescoes of Correggio at Parma, upon which all the later years of Toschi's life were employed, contributed to the education of a generation of engravers, many of whose works are fully worthy of their cultivated master.

The basis of all excellence in this art is, of course, the perfection of what is known as the engraver's drawing—in other words, his rendering in chiaroscuro (of the exact size of the plate proposed to be produced) of the picture selected for reproduction on steel or copper. In this art the Italians have greatly excelled, and do so still, since it would be scarcely possible in this way to surpass such a drawing, for instance, as that by Calamatta of Raffaelle's "Madonna di Foligno."

For perfection in soft and fleshy modelling the palm must, I think, unquestionably be given to Toschi, for his print of the Madonna della Scala, by Corregio; and Tommaso Aloysio Juvara, the leader of the Neapolitan school, several of whose minor specimens are of extraordinary excellence, must, I think, be placed next in order of merit.

Of Toschi's old assistants on the Parmesan Corregios, Perfetti of Florence, Scotto of Genoa, and Calamatta of Civita Vecchia, many agreeable specimens are exhibited; and the print of the Madonna della Seggiola, by the first named, is worthy of high commendation.

A work now in progress on the gallery at Florence, and most creditable as a current Italian publication, appears to have given employment to many of the best contemporary engravers, and beautiful plates as well as engravers' drawings for this work are exhibited by Ulisse Forni, Frederico Calendi, and Agostino Tricca. I cannot leave the subject of Italian engraving without noticing the extraordinary pen-and-ink drawings by Professor Vincenzo Gazzoto of Padua. On three large sheets this artist has depicted in a most masterly manner the "Joys of Paradise," the "Sufferings of Purgatory," and the "Despair of Hell." Not only are these compositions highly imaginative—in this respect rivalling the analogous works of our own Martin—but they are drawn with a masterly knowledge of light and shade, foreshortening, and of the human figure. The drawing of Paradise is exceedingly beautiful.

In chalk and ink lithography a fair average is maintained by the houses of Richter, of Naples; Carpentier, of Florence; and Borzino, of Milan; while in chromo-lithography they may safely be put in comparison in quality if not in quantity of production, with the larger establishments of Paris, Vienna, Berlin, and London.

By the first named house two works are exhibited, the execution of which is eminently honourable to Italy at the present time. One of these is a perfect series of illustrations of the painted decorations of Pompeii, published by Niccolini, being for the most part fac-similes of the beautiful drawings of Abbate. The other is an equally fine series of illustrations of the Abbey of Monreale, near Palermo. The latter work has been produced mainly through the energies of the Benedictine Fathers of the Abbey, under the able leadership of the Padre Gravina. For those who would seek to revive the manufacture of pictorial mosaics in this country—and happily they are now many—no more useful work can be recommended than this, in which the glories of the celebrated Norman cathedral are admirably reproduced in all their details. Borzino's imitations of oil pictures are all but deceptive; while Carpentier produces at very reasonable prices excellent coloured souvenirs of the most beautiful pictures of Fra Angelico and other masters.

The illuminator's art is so nearly allied to the art of chromo-lithography, that I may consider this to be the fittest place to notice the evidence given by Napoleone Verga of Perugia, that the traditional skill of the Italians in "quell'arte che alluminare echiamata a Parisi,' from the days of Dante to the end of last century, has not been lost. In his illuminated addresses from the municipality to the Marchese Pepoli, Verga shows himself, if somewhat inferior to Giulio Clovio, Buonfratelli, and Girolamo dai Libri, superior to almost all other ancient magnates in the art of illumination on vellum.

As connected also with chromo-lithography may be noticed the art of colour-printing by means of typography, that is, from type or brass rule. Of this some good specimens were shown by Frederico Lao.

Rafaello Salari, of Florence, contributed fac-similes, executed with the pen, of ancient block and other early printing and woodcut illustrations, fully sufficient to deceive any eyes but those of the most accomplished bibliomaniacs, their perfection equalling, if not exceeding, that of our justly-celebrated Harris, whose works created so much sensation among the learned in rare editions and tall copies in 1851.

In photography the names of Ponte of Venice, Alinari of Florence, and Doviziélli of Rome, are well known in this country as connected with very perfect reproductions of the most striking architectural monuments of those cities. It may be enough to say that they ably sustain their reputation amidst rivals whose excellence brings them within a few paces of the foremost in the race. Duroni of Milan exhibits a full-length life-size figure of the king, in its way a triumph over very great difficulties. A less favourable subject, however, for such an experiment could hardly have been selected. Caldesi's reproductions of the Hampton Court cartoons are too well known to need commendation from me.

My respected colleague, Mr. Le Neve Foster, will no doubt furnish you with such comments on the relative excellence from an economical point of view of the decorative arts, as may justify my noticing now only very briefly those refinements of design or execution which raise certain branches of production from the position of crudely supplying natural wants to that of ministering to that craving for beauty, which becomes more or less largely developed in each branch of manufacture in proportion to the fluctuating conditions of highly-civilised nations.

In metallic art there was not much to notice, since none of the branches of that class of industry were very largely represented' In the precious metals much more design and ingenuity were displayed than—with one or two exceptions, to be presently mentioned—appear in productions in the baser metals. I am unable to praise the silversmiths' work generally, since the Italians as yet do not appear to have fully appreciated the ancient styles of finish of their own forefathers, or even those of the Wagners, Froment-Meurices, Morels, and Vechtes, of the past and present generations in other countries. The best works of this kind, where little was really good, appeared to be the vase designed and executed by Tomaso Rinaldi of Modena, and the sword of honou presented to the King by the citizens of Modena, and executed by Rinzi of Milan. The steel blade of the latter, which was cleverly inlaid with gold and silver, showed that the old art of working *all'azzimina*, or damascening, in which Cellini so greatly excelled, is not lost in Italy.

A still nobler sword than this, as far as material is concerned, was exhibited, the work of Castellani of Rome. The hilt was somewhat too severe in style for one wrought in gold, and did not appear to me equal in workmanship to much that I have seen elsewhere, and indeed in London last season, by the same distinguished jeweller. It is to be regretted that he did not contribute any other specimen of his skill on the present occasion. I must confess that I have seen in shops at Rome, Genoa, Florence, and Naples, far better jewellery than was displayed in this the first great Italian Industrial Exhibition, where so important a branch of industry should have been better represented.

In cast-iron there was little worthy of remark, with the exception of a very clever gas lantern, cast at the foundry at Pignone, near Florence.

In bronze and brass founding and chasing I have never seen in any country better work produced than that for which Clemente Papi, of Florence, is so justly renowned; and I believe that it has puzzled those most learned in the process of metal casting to understand by what means his extraordinary reproductions of groups of natural flowers have been made out of molten metal.

In wrought-iron, for which I need scarcely remind you that Florence and Sienna were formerly most celebrated, Pasquale Franchi, and Benedetto Zalaffi (both of the latter city), exhibit themselves as truly cunning smiths. The former has produced a small pair of gates, in which the vine, the olive, and groups of corn, become admirable ornaments to a well-arranged series of conventional lines and forms; while the latter sends some iron rings and brackets, similar to those formerly attached to the old palaces of Italy. These are all wrought with hammers and punches, with such freedom and spirit as to be likely enough to deceive enthusiastic purchasers, who may be unable to refrain from attempting to carry off trophies of the former glories of those nobles, in whose families the right was alone hereditary to attach such marks of nobility to the head-quarters of their race.

In pierced steel-work the cutlers of Campo Basso, the only place in Italy in which much cutlery is manufactured, exhibit considerable dexterity; and the pierced scissors of Vinditte Terzano are elegant, both in design and execution. One singular pair of desk scissors, highly and pleasingly ornamented, bore the singular inscription, in incised characters, "Scipione Santangelo, al municipio di Firence;" the gift recalling the good old days of Florence, when nothing was deemed too precious to be offered out of the tradesman's abundance to his well-loved home and city.

For embroidery the Italians have long been celebrated, and many specimens were displayed, better both in design and execution than any of those French and Belgian examples which have been so largely manufactured during the last century, for the glorification of the rites and ceremonies of the Romish Church. One of the most splendid specimens of such work, although destined for regal rather than ecclesiastical use, was to be observed in the hangings for the royal throne, embroidered in the public Female School at Florence; the design for which, being by no less clever an artist than Pietro Cheloni, was of a highly satisfactory description, and the work reflected credit more particularly upon the widow Bassi, the teacher of the art of embroidery in that school, under whose special superintendence the whole has been executed.

(To be continued.)

ON SOME RECENTLY EXECUTED DEEP WELLS AND BORINGS.*

By George R. Burnell, CE., F.G.S., F.S.A.

The remarkable success of the operations carried on at Passy, for the supply of the artificial waters of the Bois de Boulogne by means of an artesian boring of unusually large diameter, has lately revived the public interest in that class of operations, both on the continent and in England. It has been proposed, indeed, to apply that system, on even a larger scale than was tried at Paris, to our own metropolis; and the scheme for sinking a series of deep wells in the various parts of London has been revived by some enthusiastic admirers of the results obtained by our neighbours. Experience has already decided the problem of the possible success of such attempts here, and it may, therefore, be desirable at the present day to review briefly the history of artesian wells at home and abroad, in order to prevent the waste of money and the disappointment which may arise from ill-advised imitation of the measures proved to be successful in some cases, but by no means universally applicable.

The term "artesian well" means, strictly speaking, only a well sunk to a considerable depth, through a dry and impermeable upper stratum, to a lower stratum charged with water, under such conditions of pressure as to cause the water to flow over the surface of the ground. The first wells of this description mentioned in modern works on hydraulics were executed in the province of the Artois, in France, where they were sunk in the chalk formation, and were supplied by the streams running between the fissures of that deposit, which were fed by the infiltration from the higher ground of the great north-eastern chalk plateau of France. It is said that some of these wells in the Artois have been used for nearly a thousand years, without any perceptible diminution in their supply; but it must also be added that the ancient Egyptians and the Chinese had, from the remotest antiquity, been acquainted with this method of obtaining water, and that the inhabitants of the plains of Lombardy have long used the waters rising from the deep-seated strata of the valley of the Po for the irrigation of their "marcite," or winter meadows. Be this as it may, and without dwelling upon the locality where this description of well was first made, it seems that about the beginning of the present century great attention was drawn to them by the success of a number of borings through the London clay into the sands of the basement beds of that formation, made in the valleys of the Lea, near Broxbourne, Waltham, and Tottenham, and of the Wandle, near Mitcham, Garratt, Wandsworth, &c. In the low-lying alluvial islands at the mouth of the Thames, some very deep wells were also sunk through the London clay, and a copious supply of fresh soft water was obtained; and, in fact, so many wells have been sunk into the water-bearing strata of the tertiary sands, that they have been nearly exhausted. Whilst these operations were being carried on in England, the French engineers had energetically adopted the system upon which they were founded, and numerous artesian wells had been sunk at Épinay, Stans, and St. Denis, with similar results to those obtained near and in London, that is to say, that in the earlier wells the water, generally speaking, overflowed the surface, whilst in the latter ones it rarely attained the level of the ground; and the water-line sank in the older wells in proportion as new ones were opened.

In 1833 M. Arago induced the Conseil Municipal of Paris to undertake the execution of a deep boring, in the hope of obtaining a supply of water from the lower green sand formations, which he supposed to form a continuous bed under the chalk basin, underlying, in its turn, the tertiary strata of the neighbourhood of Paris. This lower green sand, in fact, outcrops from under the chalk on the whole of an irregular oval, passing from the north-east through the south, nearly to the north-west of Paris, and it approaches that city the most nearly at the point where the Seine forces its way through the overlying recent formations near Troyes, in Champagne. At Lusigny, the precise point of outcrop, the surface of the green sand is about 300 or 350 feet above the level of the plain of Grenelle, where it had been resolved to make the first attempt to traverse the tertiaries and the chalk. From this fact, MM. Arago and Walferdin inferred that the water from the green sand would flow over the surface at Grenelle, and they were encouraged in that opinion by the existence of numerous artesian wells carried through the chalk into that stratum, from which they expected to obtain their supply at Elbœuf and Rouen. The depth it would be necessary to sink the new well constituted the unknown conditions of their undertaking; but not only MM. Arago and Walferdin, but also M. Mulot, calculated from the first that they would find the chalk extend to at least 1300 to 1400 feet from the surface. So little however was known of the probable cost, or of the dangers and risks of these deep borings, at the time the well of Grenelle was commenced, that the municipality of Paris only voted a sum of 18,000 francs (£720) for boring three such wells.

On the 29th of November, 1833, the works of the Grenelle well were commenced by M. Mulot, and after encountering many serious difficulties from the nature of the ground, and from the fracture of the tools made to work at so great a distance from the surface, the able and scientific men who had supported M. Mulot through evil report and bad report, were rewarded by finally obtaining a copious jet of water from the lower green sand on the 26th February, 1841. The depth then reached was 1806 ft. 9 in., of which 1378 feet were in the chalk; the water rose at first at the rate of 800,000 gallons per day, to the height of about 122 feet (the level of the distributing reservoir of Grenelle), and its temperature was about 82° Fahrenheit. When it first rose to the surface, it contained large quantities of sand, clay, and other matters in mechanical suspension, and it was nearly twelve months before the water passages of the subterranean strata were sufficiently cleared to allow the water to rise in a state fit for distribution. On several subsequent occasions also, the sand has accumulated in such quantities, in the pipes lining the bore, as to render it necessary to draw and clean them.

This boring operation had been watched very carefully by English engineers, and even during its progress similar works had been attempted in our own country. As might naturally have been expected, the success of the Grenelle well, under these circumstances, induced our countrymen to continue their work with redoubled ardour, but unfortunately they have displayed less perseverance, and it is to be feared less skill, than our neighbours; for hitherto none of the deep borings undertaken avowedly for the purpose of obtaining a supply of water from the subcretaceous beds in either the London or the Hampshire basins, have completely succeeded. In the case of the Kentish Town well, it is true that some very extraordinary and anomalous conditions of the strata have been found to exist, which have totally deranged all the scientific calculations of the able geologists and well-borers consulted during its execution; but it has too often happened in England, that works of the kind we are now considering have been undertaken solely on the recommendation of amateur geologists, or of "practical men," as it is the fashion to call those who are totally ignorant of recorded science; and the consequence has been that several very costly wells have been undertaken, carried on at great expense, and subsequently abandoned in despair, perhaps just at the moment when success was within grasp.

One of the earliest of the attempts made in England at sinking an artesian well to the lower green sand, was the one made, almost unintentionally, by the town of Southampton. It was commenced by a preliminary boring through the London clay to the chalk, which was reached at a depth of 480 feet from the surface, the upper strata traversed consisting of the sands, clays, and plastic mottled clays of the Hampshire tertiary series. It seems that the well-borer employed carried the boring to a depth of 50 feet beyond the surface of the chalk already mentioned, and he then reported that an ample supply of water was to be obtained from that formation. A shaft was sunk on faith of this report, commencing with a cast-iron lining of 13 feet diameter, which it was proposed to carry to a depth of 160 feet, and then to commence boring with a hole of 30 inches diameter, diminishing gradually to 20 inches in the chalk. The cylinders used were, however, found to be too weak for the purpose they were intended to fulfil; they collapsed in places, and, in driving, they assumed a direction seriously out of the perpendicular. The contractor failed when the cylinders had been thus badly lowered to the depth of about 60 feet, and the works were then taken out of his hands, and placed in those of Mr. Docwra, one of the most able well-sinkers and waterworks contractors of our country and of our day. With great trouble he drove the shaft completely down to the chalk, finishing it with a clear external diameter of 9 ft. 4 in.; part of it was lined with cast-iron plates, and part of it with brickwork in cement. The brickwork lining was carried three feet into the chalk, and below it the shaft was continued to the total depth of 562½ feet from the

* Paper read before the Society of Arts.

surface, in the solid chalk, without any lining, and with a clear diameter of about 7 feet; a boring was then commenced of 7½ inches diameter, and was carried down eventually to a total depth of 1317 feet from the surface. The chalk formation was found here to have a thickness of 851 feet, and the works were suspended when the boring had traversed only 12 feet of the chalk marl. Now at Chichester, where Mr. Gatehouse had also sunk a deep well to the upper green sand about the same period, the thickness of the chalk marl was found to be 61 feet; the upper green sand and gault are of variable thicknesses, but the greatest depth recorded for them was that of the new well at Passy, where they were about 274 feet deep. It is, therefore, very probable, that if the Southampton well had been carried down 330 feet further, or to a total depth of 1650 feet in round numbers, the problem as to the possibility of finding water from the lower green sand, in the Hampshire basin, might have been solved. In the well at Chichester this solution could be even more easily attained, for the boring had actually been carried about 180 feet nearer to the probable surface of the lower green sand, leaving only 200 feet still to be traversed.

It would be impossible to record all the important works undertaken of late years for obtaining water by means of artesian wells, but the circumstances connected with the history of those attempted at Calais, Kentish Town, and Harwich, are so singular, that it behoves us to dwell upon them. At Calais the well was sunk through the chalk, and the whole series of the subcretaceous strata, to a total depth of 1047 feet from the surface, but no water was obtained from it, and the boring passed, at the depth above-named, into the transition rocks, in which it was carried for a further depth of 103 feet. At Kentish Town, the Hampstead Water Works Company endeavoured to secure an artesian supply, in order to comply with the provisions of the Metropolis Water Works Act of 1851. They had very wisely consulted Mr. Prestwich upon the geological questions involved in the preliminary inquiries, and they employed Messrs. Degoussé and Laurent, the best known and most successful well-borers up to that period, on the Continent. Geologists and practical men alike in this instance reasoned that, because the lower green sand outcropped around the edges of the chalk basin containing the Paris tertiaries, therefore, there was every *à priori* reason to believe that the subcretaceous formations would continue under London, and furnish, as had been the case at Paris, the water for a well carried down to them. Acting upon this belief, the company commenced boring in the chalk, at the bottom of a shaft previously sunk to the depth of 539 feet from the surface. The boring was commenced with a diameter of 12 inches, reduced to 10 inches in the intermediate part, and finishing with a diameter of 8 inches. The work began on the 10th of June, 1853, and was carried on with every appearance of success for a considerable time. The strata traversed were found to occur in their regular order, and of the anticipated thicknesses, until the boring had traversed the gault formation at the depth of 1113 ft. 6 in. from the surface; but when, as Mr. Prestwich said, everybody believed that "a very few more turns of the auger would tap the water-bearing sands of the lower green sand formation," it was found that the borings passed at once into a series of beds consisting of alternate layers of red sandstones, red clays, conglomerates, red sands, and rounded pebbles, which geologists are now disposed to class amongst the new red sandstone series. It is very difficult to form any decided opinion as to the real nature of a deposit which has only been explored by the boring tool, especially when the diameter of the bore was only eight inches, as at Kentish Town; and I confess that for my own part, as I said before in this room, and shall have occasion again to repeat, I am disposed to regard the beds of red clays and sandstones rather as being members of the Wealden series than of the new red sandstone. But in either case it was evident that the water-bearing strata were interrupted under London, and that there was no probability of obtaining a supply of any description from them in that district. In fact, the Hampstead Water Works Company, after the failure of this attempt, were compelled to sell their interests to the New River Company, and the well was stopped at the depth above quoted, added to the depth traversed in red sandstones and clays, or at a total depth from the surface of 1302 feet.

About the same time that this unexpected result was obtained at Kentish Town, Mr. P. Bruff, C.E., was employed upon an attempt to obtain water for the town of Harwich, either by a deep well in the chalk, or by traversing, if necessary, the strata below the chalk. Several attempts appear to have been previously made at Harwich to obtain a supply from the chalk, but they had failed, in consequence of the infiltration of salt water into the wells sunk close to the sea shore. Mr. Lankaster Webb, of Stowmarket, a town situated upon the high lands of the valley of the Gipping, the main affluent of the Orwell, had executed a well 895 feet deep, through the drift clays and gravels over the chalk, the cretaceous formations, and the upper green sands and gault. I do not know the level of the ground at Mr. Webb's factory, but as a rough guess I should say that it was about 240 feet above the high tide level at Harwich; and I am not, therefore, surprised that the persons connected with the well at the latter town should have expected, that upon traversing the chalk they would meet with a supply of water under the true artesian conditions. It happened, however, that after the Harwich boring had passed through the drift, the tertiary strata, the chalk, the upper green sand, and the gault, to the depth of 1025½ feet from the surface, it passed, not into the lower green sand, but into a black slaty rock, which Mr. Prestwich pronounced to be a common grey slate of the palæozoic series, whose precise position in the series could, however, hardly be defined, on account of the absence of fossils. Thus at Calais, and I believe also at Ostend, the lower green sand is wanting, and is replaced by a member of the carboniferous series; at Kentish Town the lower green sand is absent, and it is replaced perhaps by the new red sandstone beds, whilst at Harwich the lower green sand is replaced by the very earliest clay slate rocks.

Now there may be drawn, from these unexpected results of the deep borings in the tertiaries of what may be specially named the London basin, some valuable scientific and practical conclusions. These may be briefly stated as follows:—1st. That at present, geology is only so far advanced as to enable us to state, with tolerable certainty, what we shall not find under the surface, but by no means to justify any positive assertion as to what we shall find: thus, knowing that the London clay is on the surface, we may be certain that the crag will not be found beneath it, but it by no means follows that necessarily the chalk, the lower green sands, the oolites, or the usually subordinate strata, should be there. 2nd. That the first attempt to sink an artesian well through a previously untried stratum, is at all times a hazardous experiment, and that it is, therefore, one which should never be tried by those who only work with the money raised by forced taxation. It was upon the latter ground that Mr. Ranger very properly recommended the town of Southampton to stop the philosophical experiment upon which they had already incurred so large an outlay; and it is certainly wiser to leave the solution of these problems to municipalities posessed of private resources, or to private enterprise, than to expend upon them the money wrung from the ratepayers. 3rd. And possibly this may be the most important conclusion of all—it would appear to be proved by the occurrence of the earlier strata in the geological series at Calais, Kentish Town, Harwich, and, if I be not mistaken, at Ostend also, that Mr. Goodwin Austin's theory of an upheaval of the carboniferous series existing between its extremity on the French coast, and its reappearance in the Bristol and the South Wales coal field, is correct. A full discussion of this important inquiry would be misplaced in this paper, but I cannot refrain from repeating what I myself have said before, viz., that from all which is at present known, it would be more rational to seek for coal under London, than for soft water. At the same time, I would guard myself against any appearance of encouraging an attempt of the former description, unless it were distinctly undertaken as a speculation, with great, nay, almost infallible chances of loss.

The next important artesian borings executed of late years in chronological order, were those undertaken under the superintendence of the French military authorities in the Desert of Sahara, avowedly for the purpose of forming stations for the caravans trading between Algeria and Central Africa. They were executed by means of tools made by Messrs. Degousse and Laurent, who seem also to have occasionally acted as consulting engineers, but the works were actually performed by the soldiers, or the labourers employed by the "Corps du Genie Militaire." It appears that up to the month of June 1860, no less than 50 of these wells have been sunk in the desert, and that they pour upon its thirsty surface no less than 7,920,000 gallons of water per day. Similar works were, according to Aime Bey, executed in the deserts of Ancient Egypt, as was before alluded to, and there are good reasons for believing that the system of artesian borings might advantageously be applied in the deserts of north-western India, and of Australia.

Some interesting artesian wells and borings have also been executed in various parts of England and of the continent, to a few of which I propose to return hereafter, but in the meantime I pass to the description of the great work lately completed at Passy, as being the one which has attracted the most universal attention. When the great works of the Bois de Boulogne were commenced, it was soon discovered that the pumps of Chaillot would not be able to furnish the quantity of water required for the lakes and waterfalls of the new park; and the municipal council of Paris, encouraged no doubt by the commercial results of the previous operation at Grenelle (which had eventually cost the sum of £14,000, and repaid its cost several times over), resolved to execute a second boring to the lower green sand, in order to secure an independent supply. It was originally proposed to execute this well of the same dimensions as that at Grenelle, that is to say, to finish with an eight inch bore; but before it was commenced, M. Kind, a German engineer (who had already carried out some very important works upon a system, and by the aid of tools patented by himself) offered to contract for the new well, to finish with a bore of 2 ft. in diameter, and to deliver the water at 92 ft. above the level of the ground, at the rate of nearly 3 million gallons per day. He undertook to complete the work for the sum of £14,000 within the space of two years. After some opposition, based principally on the doubts expressed by engineers who had been consulted on the subject, with respect to the increased delivery over that of the well of Grenelle, this offer of M. Kind's was accepted, and on the 23rd December, 1854, the vote of the municipal council in favour of the contract with him was passed. The work was commenced shortly afterwards, and by the 31st of May, 1857, the boring had already reached the depth of 1732 feet from the surface, when suddenly the upper portion of the tube lining collapsed, at a distance of about 100 feet from the surface, and choked up the bore hole. This accident delayed the completion of the work for three years, and led to the rescinding of the contract with M. Kind; but the engineers of the city of Paris were so satisfied with his zeal and ability, that they intrusted to him the conduct of the remaining works. A new well was sunk to a depth of 175 ft. 4 in., and the boring was then cleaned out and resumed. Much trouble was encountered in traversing the strata below the distance of 1732 feet above quoted, and at length, at the distance of about 1894 feet from the surface, the first water-bearing stratum was met with, but the water, after several oscillations did not rise to the level of the ground. The boring was continued below this level, until, on the 24th Septen ber, 1861, at midday, at the depth of 1923 ft. 8 in., the true artesian spring was tapped. When this spring rose to the surface it discharged at the rate of 5,582,000 gallons per day. The yield has since then oscillated, but so long as the column had not been raised above the level of the ground, the total quantity does not seem to have fallen short of 4,465,600 gallons. The well of Grenelle, (which by the way had been falling off in its yield for some time before the completion of the Passy boring, no doubt on account of some obstruction in its ascensional tube, but which for several days before the 24th September discharged regularly 200,000 gallons per day), fell in about 30 hours after the Passy spring had been tapped, to a yield of about 173,000 gallons, at which rate it remained stationary, until the tube of the Passy boring was raised so as to allow the water to stand at the same height in the two wells, when the original rate of delivery of the Grenelle well was resumed, but the rate of delivery of the Passy well fell to 2,000,000 gallons per day. It is intended eventually to cause the column of water of Passy to rise to a height of 1277 feet above the bottom of the boring, or about 54 feet above the surface of the ground. The horizontal distance of the Passy well from the one at Grenelle is about 3830 yards yards; and it will be observed that the water-bearing stratum is nearly 100 feet nearer the mean level of the sea at Grenelle than it is at Passy, whilst the surface of the ground is about 35 feet higher at the latter locality than it is at the former one.

Unquestionably the effect produced upon the respective sources of supply, by the alteration in the heights of the columns of water, proves that the wells of Passy and of Grenelle are fed from the same stratum; and there can be no reason, therefore, to suppose that when the Passy spring shall have cleared its water passages there should be any difference in the qualities of the waters at the two places. M. Peligot has carefully analysed the Grenelle waters, and he found that they contained 0·000142 of saline matters, composed principally of the carbonates of potash, lime, and magnesia, associated with a compound of sulphur and of soda of variable proportions and conditions, and with the carbonate of the protoxide of iron and silica. The salts of the sulphate of lime, or of the more permanently insoluble description, are absent, and it would appear that the gases diffused through the water are of considerable volume, the carbonic acid gas being one of the most so. There is a sensible evolution of sulphuretted hydrogen from both the wells of Passy and of Grenelle, and it is worthy of remark that the same gas is given off from the water in Mr. Gatehouse's well at Chichester, though in the latter instance the smell is sufficiently strong to render the water positively repulsive. At the present day the water at Passy is still foul, on account of the matters it brings up in suspension; but as in the case of the Grenelle well, this inconvenience will no doubt soon disappear. The temperature at which it reaches the surface is identical in the two wells, and is about 82° Fahrenheit.

(To be concluded in our next.)

LECTURES ON ARCHITECTURE AT THE ROYAL ACADEMY.

By Sydney Smirke, R.A.

Lecture I.

(Continued from page 56.)

Statues fringing the sky line, I said, should I think be subdued in attitude and treatment. Such however, as I have remarked, was most certainly not the opinion or the practice of the sculptors of the seventeenth century. Michelangelo had in the palmy days of art made his Moses look like no common piece of humanity, but rather like a sculptured fragment of rock, in solemn repose, and instinct with supernatural dignity; whilst the patriarch, when treated in the naturalesque school of the degenerate period I now refer to, never failed to be represented as a remarkably active, impetuous old man, admirable chiefly for the violent development of the muscles, throwing himself into very unseemly attitudes, and striking the rock with his rod more like an excavator than a patriarch. Such, also, is the general character of their architectural sculpture.

The apostles and fathers of the church were men upon whom we should be taught to look with reverence by the quiet dignity of their mien, and by that deep and intellectual abstraction which is best represented by a steady composure of manner and general absence of energetic action. But where are we to seek for such examples of architectural sculpture from the chisels of the eminent masters of the fantastic schools of this period? On the contrary, the holy fathers are made to look like posture-masters performing for the public diversion, and are seen on their pedestals, throwing their limbs about and ruffling their drapery in a way utterly subversive of that personal dignity which, as I have remarked, seems to appertain to their character.

It is not to be wondered at that when taste in sculpture had reached this bathos, our own art should have been dragged down with it to the same level. Indeed, there is, I think, good reason to apprehend that far too intimate a union had unhappily subsisted between those sister arts.

So long as a fine taste and a high æsthetic feeling prevailed, no danger came nor could come from the cultivation of both these arts by one mind; indeed, it was the glory of our art to be intimately allied to the sister arts. But when that truth of feeling and nicety of judgment had passed away which taught those who practised both arts to discriminate well between the special requirements of each, a fusion was the result, mischievous to both, but which was more particularly injurious to our art; for a sculpturesque treatment of architecture is likely to lead to far graver errors than an architectural treatment of sculpture. The latter may be liable to become cold, rigid, formal, and even unnatural; but the former is sure to become, as indeed it did become, insufferably lax and vicious, violating all the proprieties of our staid and sober art—an art which can never indulge in caprices without great risk to character and certain loss of dignity.

To say the truth, without however meaning the slightest disparagement of the sister art, I would express my belief that most of the errors of architecture in its decadence may be traced to the injurious influence that sculpture exercised over our art. The habit of a sculptor's mind would naturally lead him to exercise his inventive faculties in designing and modelling, out of the plastic material with which he is most familiar, forms and combinations of forms that would produce picturesque groups, and an ornamental or at least pleasing arrangement of lines, and of chiaroscuro; and, when he comes to execute his conceptions in stone or marble he would of course seek to construct his work, if not out of a single block, at all events in as few as possible; because joints, and especially bed-joints, he is of course always anxious to avoid or conceal. All the proprieties therefore of *masonic construction*, the sound bonding together and truthful bedding of stones, the avoidance of false bearings, and all such-like considerations, are entirely foreign to his art, and are in fact subjects which never, or rarely, demand his study, nor even need his attention, *as a sculptor*. Hence it is, probably, that we find that the sculptor of the seventeenth century, when he produced works of architecture, was very prone to treat his buildings, however large, rather like magnified copies of small sculptural models, than as purely architectural works, that is to say, works built up on the true principles, and according to the known rules, of good architectural construction.

When we call to mind the practice so prevalent and so popular, at the period of which I treat, of erecting in churches huge architectural pageants of a most ostentatious character, but of very slight and temporary materials and construction, as chapelles ardentes and catafalcos, when the funeral obsequies of some high ecclesiastical or political dignitary were performed, it seems not unlikely that this prevalent fashion, on which, as it is well known, artists of highest eminence were often engaged, conduced to, or at least accelerated, that degraded character of architecture which we so much deplore, and which so injuriously influenced our art in subsequent times.

Those vast architectural shams, the catafalcos, were put together by the flimsiest contrivances: there was, of course, a lavish superfluity of statuary; for it was of mere lath and plaster, and the drapery was often—I believe usually—real linen steeped in glue and whiting, to give it a fictitious rigidity and something of the superficial aspect of stonework.

By such-like artifices it became easy to "body forth" for a day's ceremony some "baseless fabric of a vision," highly picturesque and imposing perhaps; indeed, when treated by men of genius and ability, very striking and even magnificent; for as I have said, men of the highest rank in art were not in those days averse to lend themselves to these ephemeral productions.

In presenting such unreal mockeries to the view, masonic proprieties were neither required nor regarded. The boldest and least fastidious practitioners would probably indulge and amuse their fancies in realising the semblance of impossible structures; and as it was just as easy and inexpensive out of the lath and plaster or clay and stucco in which they worked to present to the devout and admiring congregation a galaxy of clouds and glories, and to group together all the cardinal virtues and the whole hierarchy of saints, as it was to exhibit the most gorgeous domes and the richest colonnades, it is not to be wondered at that the productions of the two arts got irretrievably intermingled and confounded, as well as corrupted.

That such a practice or fashion, prevailing among a people of strong æsthetic feeling, but of lax principles of taste—and such were the Italian people of the seventeenth century—should lead to a similar style of designing in works of a more permanent character, seems natural and almost inevitable.

First, in interior architectural design we should expect to find, what in truth we do find, that altar-pieces, baldachinos, and monuments, became strange medleys of the two arts, although worked out, perhaps, in real marble and brass; and then the vicious tendency would necessarily spread itself to exterior architecture.

I think that it may be said with strict truth, that exactly in proportion as this sculpturesque spirit pervaded architecture, so that art became deteriorated. It has been truly said by a high authority from this place, that painting and sculpture each excite our admiration the most when their special characters are kept most clearly defined, and when each art limits itself to the doing that which it is by its nature best qualified to do. Sculpture can very imperfectly represent distance; and should, therefore, avoid as much as possible attempting backgrounds. Painting, on the other hand, is peculiarly competent to produce such effects, by its power to represent space and distance; and therefore the painter who places all his figures on the same plane does not avail himself fully of the capabilities of his art. So also the painter abandons one of his highest privileges when he neglects to use colour; whilst the sculptor who uses colour (unless he does so with infinite caution, and exercises great moderation and abstinence) runs serious risk of turning his statues into dolls.

Our own art is amenable to the same law. It is always most triumphant when it attempts to do that only which it is its special province to do. Thus then, to apply our remarks to the subject in hand, I should say with great confidence that the architect who so designs his building as to render it doubtful whether sculpture may not legitimately lay claim to the work as its own, is a traitor to his art, and despoils it of its birthright.

Many instances of such self-debasement present themselves among the works of the degenerate days of which I treat. It seems an ignoble task to hunt up for criticism and condemnation such examples of the abuse of genius; but such is the task I have imposed upon myself. Italy well earned the honour of having been the garden in the soil of which were nurtured all the most beautiful productions of modern art; but it was unfortunately in that same too fertile soil that with greatest exuberance sprung up those wild extravagances which ultimately brought so great discredit on the arts, and on none more so—perhaps on none so much—as on architecture.

I believe that it is to that fatal facility which characterised the practice of all the three arts at this period that we must mainly attribute their common decline. Wholly wanting in the thoughtfulness and deep feeling of Raffaelle, and of some who preceded, as well as of some who immediately followed him, the painters sought for the most part gorgeous and showy effects, at the expense of all the higher qualities of their art: so, as I have already remarked, the sculptors of this declining age designed impetuously and executed dexterously, but the sentiment of their art had evaporated, and its greatness had gone; and so, to return to our own art, the architects of the happier and earlier period were enthusiastic without wild extravagance, refined without pedantry, and always knowing well when to refrain from and when to indulge in the graces of decoration: none knew more thoroughly than the latter more advanced quatro-centists *how* and *when* to give a zest to their work by the most charming ornamentation; whilst none appear to have known better than they the value of breadth, simplicity, and even of perfect plainness, when their good taste and judgment prompted an abstinence from ornamentation. But I have on former occasions dwelt sufficiently on the merits of the masters of that great period, and have already endeavoured to urge on you the careful study of their works. I name them now, that you may feel more sensibly the contrast presented by the architecture of the degenerate age which followed. It is my aim to deter you from the evil examples set us by the licentious throng of the seventeenth century, by holding up their errors for your reprobation and rejection. Through the ignorance of some, the contumely of others, and the loose habit of speaking common enough to most of us, the term "Italian architecture" is apt to be applied to buildings of the most diverse and opposite character. It is an instance of the same laxity of speech by which styles of the utmost contrariety, from the simple, austere, and honest architecture of the early Rhenish buildings, down to the florid extravagances of Adam Kraft, have all been indiscriminately classed under the one large, unmeaning, and inappropriate term "Gothic." It is through the same thoughtless and perhaps ignorant way in which the general term "Italian" architecture has been customarily applied, that gross injustice has been done to works of the highest quality.

The vague and superficial knowledge, both of some of those who have written and of those who have spoken on our art, has too often led them to place under the same category the beautiful works of Bramante, Raffaelle, and Giulio Romano with the truly barbarous architecture of Borromini, Fischers, and too many others. The Italians were, as I have already said, themselves the first corrupters of the Italian style; and among those corrupters Borromini stands out in strong relief, as a prominent delinquent; for, as he was one of the most reckless practitioners, and one of the most sinful contaminators of style, so was he, one of the most active and prosperous. Prosperous he truly was; for, with that fatal facility on which I have been animadverting, he occupied a long course of practice in spreading over Italy a numerous and conspicuous progeny of ugliness. Prosperous, however, he was not to the end. By a kind of poetical justice which does not always attend upon the guilt of offending artists, he died miserably, the victim of jealousy and envy. Bernard Fischers was another instance whom I have adduced as one of the false lights of this vicious period. Vienna, to this day, is, in its public buildings especially, distinguished by the bad taste of Fischers; and I know no city so sadly disfigured by the school to which he belonged.

Milizia is a cantankerous critic, it is true; but he is perhaps justified when he condemns Fischers' triumphal arch at Vienna as "un capo d'opera di stravaganza." The wildest disciple of Borromini, he says, could not have invented a more capricious and irrational design.

I revert now to the question, What was the cause of this great and general degradation of art in Italy? It may be that the political and social condition of that country had for some time been degenerating; whilst other more northern countries were rising into wealth, and advancing in the political scale of Europe. Yet it cannot be said that political preponderance will always be found on the same side of the balance as æsthetic excellence. We might readily point, in the history of Europe, to notable instances of the contrary. For example, I am aware of no wonderful development of artistic taste having accompanied the brilliant epoch of Frederick the Great, or the extraordinary political ascendancy of Charles V. Going back to an earlier period, we shall find that in Mediæval times, when the social and political condition of Europe was very dark; and when, in the language of an old contemporary chronicler, "nobles and bishops built castles, and filled them with devilish and wicked men, and oppressed the people;" at that very period, foul as it certainly was with most of the vices which disgrace Christianity, a school of art existed which has been advantageously compared by many with that of the Greeks.

It is clear, therefore, that there are more subtile influences, which will, at least sometimes, operate favourably for the development of art, besides the accumulation of mere material wealth and political power.

Neither will peace alone, of necessity, bring æsthetic excellence among other blessings in its train, as we are very apt to say, and very willing to believe, when we would paint the horrors of war. The Greek states, for example, brought the fine arts to a climax of excellence never since fully attained, although they were for ever engaged either in warring on each other, or in preparing and defending themselves against extermination from barbarian hordes. So the Italian states, among whom art received its second birth, were constantly plunged in internecine wars. How often were the great masters of our art called away to superintend the erection of gloomy fortifications, and ponderous, unseemly, loop-holed walls, for the protection of those very cities which they were engaged in beautifying! How often were great and glorious works of art arrested in mid progress by the incursions of neighbouring rivals, or by the threatened devastations of foreign hosts, or by the exhaustion of the public purse consequent on these deadly strifes!

These instances, which might be greatly multiplied, are sufficient to show that a stormy political atmosphere is by no means of necessity inconsistent with the existence of a highly excited state of artistic ardour.

I would not, however, for a moment be supposed to pledge myself to the paradox that war is favourable to the cultivation of art. Very far, indeed, from that is the fact. All that I would wish you to infer from the remarks which I have just been making is that the arts have been found to prosper notwithstanding war. But there is one condition which I believe to be clearly and positively essential to the permanent well-being of the arts, and that is public prosperity. I suppose it to be impossible to cite an instance of the general decay of the material interests of a country not being accompanied by a corresponding degradation of the fine arts in that country; whilst, on the other hand, the sound social prosperity of a people will generally be found to be accompanied by an elevation of their standard of taste, as well as by a widely spread appreciation of the fine arts.

The proudest works of Mediæval France date about the period when St. Louis, by his wise government, raised the character and consolidated the strength of his country. In England, the rule of Edward III. marks the periods of the highest point of excellence to which Mediæval art reached in our country; and precisely that warlike and heroic period was the most brilliant in the political annals of our middle ages.

I need not do more than point to the age of the Medici, in Florence, as the period most embellished by the fine arts, and as the period when the Italian Peninsula stood foremost as the most politically eminent among all civilised nations; and we have already seen, from the retrospect I have been taking of the architecture of the Italian Renaissance, that the debasement of the three sister arts was simultaneously with the decay of Italian political greatness. It is not for me to attempt to explain these coincidences. It needs a larger and far clearer view of the philosophy of history than that to which I can pretend before I can presume to lay open the causes of these phenomena, the existence of which is all I can venture to assert.

Perhaps, too, the inquiry into those causes would hardly profit us here, for it belongs rather to the domain of the political economist than to that of the artist. No doubt every ingenious mind must feel an interest in these general views, but they can scarcely be expected to bear us much fruit, nor to afford us practical rules of conduct in our search after æsthetic excellence, a search which should ever be uppermost in the artist's mind, be he student or professor. To trace the progress—not the occult causes—of decay in our art has been my chief object in the few desultory remarks which I have this evening addressed to you. It is but a sorry theme; and I may be blamed, perchance, by some, for having lingered so long among these ruins of a fine art, and for having sauntered so long upon the banks of that stream of polluted art which deposited its slime over so wide a portion of Europe, and during so long a period; whilst I might, with so much more pleasurable a feeling, have been leading you on to admire beauty amidst the charms of a happier age. But it is my conviction that much benefit is to be derived from the bold and unhesitating denunciation of whatever we must recognise as faulty. There are sermons in stones, whether they be fashioned by the hand of a master, or rudely hewn by the chisel and mallet of a 'prentice hand. The diagnosis of disease is in truth best studied, not in the healthy, but in the disordered subject. I have laid bare before you some sad cases of such disordered subjects this evening. It was, as you well know, the Spartan philosophy to deter the youthful mind from vice by exhibiting openly to the public gaze the unhappy and repulsive results of vice.

All that I ask of you is that you will note and heedfully observe these errors of our art, even whilst you pass them contumeliously by; and that you will study them well, for the mere purpose of propounding them as objects which neither love of novelty, nor the attractions of singular ingenuity or of great technical skill, should ever tempt you to imitate or to repeat.

Lecture II.

Dr. Moore tells us somewhere, of his having met on his continental travels with a Scotch tourist, who was delighted with the mountain scenery of Italy, and was expressing his admiration of one of the sub-Alpine lakes, when he was rebuked by the doctor, who assured him that there were some scenes of similar character in Scotland of not inferior beauty and sublimity; and specified one as particularly worthy of his admiration, which turned out to be part of the Scotch laird's own paternal estate. He had in fact, been born in the midst of natural beauties, so familiar, or so lightly regarded by him, that they had escaped his recollection, or, perhaps, even his notice. A similar indifference is apt to be felt by us towards all objects that are too easily accessible. In such cases familiarity breeds contempt, whilst we are wont to show and feel unusual zeal and animation when the object of our research is remote, or accompanied in its attainment by the stimulus of difficulty.

Thus it is that we live surrounded by stores of knowledge of which we rarely avail ourselves; museums which we seldom visit and libraries which we never consult. Many such neglected mines of knowledge exist in London: many a rich vein is daily trodden as it were under our very feet, without tempting us to extract from it the treasure it contains.

I purpose on this occasion to invite your attention to one of the greatest of these depositories of intellectual wealth,—the Library of the British Museum.

Without attempting to bring before you even the shortest or most meagre enumeration of all the objects of interest to the architectural student which that vast repository may contain (such an enumeration would, indeed, be as much beyond my powers as it would certainly be beyond the narrow limits of a lecture)—without attempting any such task, I propose now to indicate to you a few of the more striking specimens of the literary and artistic wealth which are in so great abundance in the library of the British Museum at our disposal; accompanying them with such remarks as may be naturally suggested by the consideration of the objects themselves, as I enumerate them, I do not design here to touch upon the antiquities at the British Museum: a critical examination of these, or even a correct appreciation of them, would be beside my purposes as well as beyond my power. To enter that department would assuredly lead us into antiquarian disquisitions, which I am anxious to avoid, as being foreign to my duties within these walls.

The first book I shall advert to is a very large folio volume, descriptive of the great Flavian Amphitheatre in Rome; and appears to have been the result of long and careful examinations, made chiefly during the excavations by the French whilst in military occupation of Rome in 1811, 1812, and 1813. The author was a French architect, Mons. Paris, who had long been a resident in that city, having quitted his native country at the outbreak of the great Revolution. He seems to have been a painstaking and intelligent observer; and the delicately executed drawings of which this volume consists, with the minute notes explanatory of them, bear testimony to his great carefulness as an architectural draughtsman. He appears to have quitted the practice of his profession as an architect early, and to have been engaged for some years in the decorations of the royal theatres and of the opera, at Paris. During his subsequent exile in Italy those studies were made, one of the fruits of which was the magnificent volume I have alluded to.

Probably there never was executed so complete a monogram of any one building. The only subject of regret is that the drawings generally do not distinguish so clearly as one would wish between those parts which are the representations of the actually surviving portions of the building and those parts which are the conjectural restorations of the ingenious antiquary himself. Some of the drawings, however, are not open to this criticism, but are beautiand fully executed delineations of the edifice in its revived state; I can safely affirm that all the drawings bear very strong marks of having been the work of a painstaking and scrupulous artist. The work was intended and fully prepared for publication: it has remained however in MS., and ultimately became by purchase the property of the trustees of the British Museum in 1847.

In many respects the Colosseum at Rome is one of the most remarkable buildings of antiquity. It has all the attributes of grandeur. In its actual dimensions I believe it to be the largest single building ever erected; unless we except the Pyramids of Egypt, which are, perhaps, hardly to be classed as works of regular architecture. Its simplicity of character and unity of design are sources of grandeur. There is a breadth of manner, and a noble abstinence from trivial ornamentation in its external architecture, which greatly elevate the character of the building. There is a majesty, even, in its stupendous strength. It stands a monument of consummate constructive talent; a talent not parading itself, like a Mediæval cathedral, by the perpetual manifestation of great efforts,—lateral thrusts and counterbalancing weights, huge picturesque masses of masonry piled up solely to resist the tendency to self-destruction constantly operating on the structure. This immense building, on the contrary, stands, and has stood for eighteen centuries, not by any straining exertion, but simply because all the laws of static science have been scrupulously regarded. I am justified in saying that it has stood for eighteen centuries; because, notwithstanding the concussions of earthquakes and tempests, and the erosive agency of natural causes, it still stands, with few marks of substantial injury, except those which it has received from the destructive hands of man.

It has been for ages the quarry whence ready-worked stones have been continually abstracted, and whole palaces have been the result of such spoliation. Yet it survives, next after the Pyramids, the greatest architectural monument in the world—

"A ruin, yet what a ruin! From its mass
Walls, palaces, half cities have been reared;
Yet oft the enormous skeleton ye pass,
And marvel where the spoil could have appeared."

I must not dwell on the structural merits of the building; but I cannot refrain from expressing my persuasion that the very ablest practical mason of the present day might study with great profit the jointing, bonding, and bedding of this mass of masonry, while the brickwork is equally admirable;—the dexterous economy of labour by which rubble-work, consisting of broken fragments of stone embedded in Pozzolana cement, is strengthened by an artful introduction of bonding courses of brick: these bricks being often of very considerable size, and always of excessive hardness. All this union of economy of labour with the utmost strength is indeed well calculated to excite the admiration of every practical eye; yet this wise economy of labour and materials, which is apparent throughout, was never allowed to interfere with that stability of workmanship which was evidently a paramount consideration with the builders. The three-quarter columns, for example, of which there are on the exterior so great a multitude, are not built as insulated blocks of stone applied to the surface of the wall for the mere sake of ornament, but are built in and bonded with the general masonry of the walls; contributing therefore to their strength quite as much as to their embellishment; in fact, the very reverse of what was very commonly the case with the slender shafts of Mediæval architecture, which were often inserted to give lightness and richness of effect to the pier against which they stand; serving, it is true, to convey to the mind's eye the idea of support to the corresponding members of the archivolts, and continue down their lines, but not practically forming any real integral part of the pier or jamb against which they stand. That this was, at all events, often the case, is obvious from the fact that there are few Mediæval buildings that have not been more or less deprived, either by natural decay or by violence, of their slender nook-shafts; the arch moulding which was made apparently to rest on them remaining nevertheless perfectly unaffected by the removal of them.

It must be remembered that in their working the column as an integral part of the wall behind it, as is, I believe, invariably done at the Colosseum, a considerable amount of extra labour and some loss of material were incurred by thus sinking the circular shaft out of the solid block,—a labour and waste, however, which appear never to have been heeded when the perfect stability of the work was in question. These columns, thus constructed, act strictly and effectively as buttresses, giving great lateral support, while they so largely contribute to the ornamentation of the structure.

In like manner we see the vast blocks of stone forming the entablatures tailed into and bonding with the rest of the masonry; —not merely laid upon the pillars to convey the idea of construction, but really forming an essential part of the wall masonry.

It is, indeed, very manifest that extreme durability was ever a foremost consideration in the mind of those able Roman masons. A curious instance of this feeling occurs in the construction of the steps of the numerous public staircases. Being open, and therefore constantly exposed to the weather, it is obvious that had the steps been simply laid on each other in the usual way now-a-days, the wet would have been liable to penetrate or be driven through the joints; and so, in the course of years the gradual but constant penetration of wet would have injuriously affected the vaults and arches beneath on which these steps were laid. To prevent this a very ingenious and, I should imagine, a very effectual contrivance was devised, consisting of a sinking cut into the face of the tread, where the riser of the step beds upon the tread of the step beneath it; which sinking, as Mr. Paris very satisfactorily shows, was made to receive a covering, or what workmen call a listing, of mastic or cement of some kind, well calculated effectually to exclude wet.

I must, however, no longer dwell on these practical subjects, which might be multiplied to almost any extent; all tending to prove that there were master-minds among the builders of Rome as well as among its military and political chiefs. Although this wonderful building now presents to our view little more than a vast mass of bare masonry and brickwork, deformed by time and barbaric depredations, it is not to be doubted that its internal embellishment was as gorgeous as might be expected from Roman builders, who were so addicted to magnificence, and who might be supposed to be especially lavish in the adornment of this the most highly favoured centre of attraction to the pleasure-loving citizens of Rome. Mr. Paris furnishes us with careful drawings of fragments of ornamental details which fully confirm this supposition; minutely enriched stucco linings appear to have decorated the interior of the halls and corridors; and notwithstanding the ravages that these ruins have for ages been subjected to in the search for precious marbles, fragments of fluted columns yet survive, of richly coloured marbles, carved most elaborately. The extent to which this elaboration was carried may be in some measure inferred from the immense amount of labour bestowed upon so subordinate a detail as the fluting of the shafts of the marble pillars.

It should however be observed, in justice to the architects of the Colosseum, that the somewhat excessive extent of minute decoration, as indicated by the few surviving specimens, is confined to the interior; whereas the exterior, both in the constructive features and in the details, is remarkable for general simplicity.

In this building, as in most of the Roman monuments of the best period, a greatness of manner eminently distinguishes its exterior architecture; a circumstance well worthy of your note in the proneness to crowded ornamentation at the present day so prevalent. Without going back to remoter and simpler times, we shall, indeed, find that in Roman art, in its best and purest days, and in Mediæval art at the justly-applauded epoch of the thirteenth century, and in Renascent art at its period of freshness and beauty, when Bramante and Raffaelle designed,—at all these epochs of art we shall find no vulgar overloaded decoration, but abundant evidence of that just appreciation of the value of ornament which knows how to use it with due effect, and when it may be usefully dispensed with.

I will not dismiss this remarkable volume from your notice without noting the extraordinary dimensions of the building which it illustrates. I find the length of the major axis to be 580 feet, and of its minor axis, 480 feet; whilst the height from the ground line outside the building to the summit of the exterior wall is 160 feet. Mr. Paris makes an elaborate calculation of the actual number of sittings afforded by its marble benches: the result is 44,090 persons. The stories, therefore, of those (like Fontana and others) who represent the number of persons accommodated to have been 80,000, or even more, were either wild exaggerations, or it may be that this high number might have been obtained by counting the multitudes who could have been crowded into the numerous corridors, on the broad platform at the highest part of the amphitheatre, and possibly, too, on the arena itself.

I will now invite your attention to two splendid folio volumes of drawings preserved in the Royal Library, of which they form a part. The drawings are executed very carefully and cleverly in outline, slightly shadowed and tinted, upon vellum. The series comprises plans and views of the chief royal palaces of France, together with some original designs, by Jacques Androuet du Cerceau, one of the most eminent among the originators of the Renaissance in France, born about 1515. These valuable and interesting drawings were made for Catherine de Medicis, and certainly formed part of the royal collection of France. How they subsequently became transferred to their present place on the shelves of our great public library is not recorded.

It is not my intention to particularise all the buildings represented in these volumes; indeed, so rich was the French crown in Châteaux and Maisons de Plaisance in the sixteenth and seventeenth centuries, that it would extend my notice far beyond its proper limits were I to do so. All the earlier examples are characteristic of the transitional period when they were erected. In plan they retain much of the type of a Mediæval fortification, and this may have been probably occasioned in some cases by the erection of the palaces on the foundations of some more ancient castles of a strictly military character. But there are few that retain any provisions whatever for active defence; the bastions become clusters of embowed windows, enriched with many architectural embellishments; and the intervening curtains are occupied entirely by wide windows, lofty chimneys, and other features of domestic architecture, to the exclusion of the loopholes and frowning machicolations of the preceding ages. Those highly-picturesque buildings, the Château de Chambourg and that of St. Germain au Laye, for example, are buildings of this mixed character. They are described as Bâtiments de Plaisance, and present throughout the evidence of their having been built for agreeable residences; whilst, on the contrary, the plan alone of these buildings would convey the idea of a strictly fortified place, with moat and drawbridge, and like appendages.

The Châteaux of Blois and of Amboise are interesting examples of this picturesque transitional style; one of the prominent features of which is the very steep and conical roof, enriched by most elaborate cresting and finials; the latter rising often to a considerable height, sometimes of metal, and sometimes executed in glazed and coloured terra-cotta. The variety imparted by these means to the sky-lines of the roofs is one of the chief sources of the picturesque in the buildings of this date in the north of Europe. It is worthy of note that at the Château Amboise, the chapel, which is conspicuous in the group of domestic buildings which compose the château, is strictly Gothic, in general outline as well as in its details; having lofty and slender pinnacles and buttresses, and traceried windows; whilst, as I have stated, every other part of the palace is in that particuar phase of the Renaissance which prevailed in France after the general discontinuance of the Gothic manner. This distinction would seem to indicate that a sense was felt of the propriety of adopting for ecclesiastical buildings a character of architecture differing from that employed in designing domestic buildings.

I have on a former occasion expressed my opinion that such a distinction seems not unfounded in reason and good sense. To adopt a strictly Mediæval style of design in all its purity and completeness in the erection of a domestic building—a private residence, for example, where all the luxurious requirements and refinements of modern social life are necessarily to be expected—is a task full of embarrassment and difficulty to the architect; necessitating frequent departure from ancient types: whilst, on the other hand, the Mediæval style lends itself with great facility to the construction of a church or chapel in its familiar form, and with its necessary adjuncts.

There seems, indeed, a moral as well as æsthetic propriety in thus setting apart a special style to buildings of a sacred character; visibly distinguishing it from a building erected for domestic and, as it were, vulgar uses;—a distinction analagous to that which led the Egyptians to preserve a hieratic character in their sacred writings, as well as in their sacred architecture, long after classic forms and demotic alphabets had become familiar to them. I may add, with reference to this example at Amboise, that there are no indications whatever to justify a supposition that this Gothic chapel is not coeval with the surrounding buildings of the château, which are, as I have said, of a perfectly Renascent aspect.

The Château Valeri, which is in the same early French style, is particularly notable for the boldness and vigour with which it is designed—a manner so broad and forcible as to well merit the character of grandeur.

The Château de Montargis is an example of great interest, having less of the Renaissance element in its style of architecture. The sectional views convey an excellent idea of the interior of the château as it appeared at the time of Catherine de Medicis. The capacious chimney-breast in the great hall is especially observable, as characteristic of the style of the period. On the front of this chimney-breast is represented, in sculptural relief, the romantic story, which tradition has handed down, of the faithful "Dog of Montargis," who avenged the death of his master. To quote the somewhat quaint old French phraseology in which the volume adverts to the legend, it describes the subject of the sculpture as "L'histoire digne de mémoire d'un combat d'un gentilhomme contre un chien, lequel gentilhomme, étant vaincre par le chien, confess a avoir tué son compagnon, maître du celluy chien."

This practice of sculpturing or painting some family legend, or other interesting historical incident, over the chimneypiece round which the members and retainers of a family were habitually assembled, seems agreeably characteristic of the habits of the time; and presents a contrast very unfavourable to the manners, and even to the taste, of the present day, when we compare these simple, and perhaps somewhat rude, yet vigorously-expressed illustrations of our social state, with the paltry ornamentation of a modern parlour, the shabby unmeaning looking-glass and putty frame which usually usurp this place of honour in the best living-room of our modern dwelling-houses. The chimneypieces or fireplaces themselves suggest similar observations. In the case before us of the great hall of the Château Montargis, the chimneypiece, as represented in this book, is typical of that feature in all the great halls of the fifteenth, sixteenth, and seventeenth centuries throughout Europe. A great canopy or hood advances forward, overhanging a hearth capacious enough for the combustion of fuel sufficient to warm the whole household collectively. This overhanging chimney-breast is not usually carried by the projecting piers of solid masonry or brickwork which now-a-days generally limit greatly the radiation of heat, and send it up the chimney rather than into the room. The breast, on the contrary, is usually carried by pillars, or other carved supports, attached to the wall, and ornamenting as well as supporting the hood which is to carry off the smoke; at the same time projecting so moderately, and occupying comparatively so small a space, as to cause very little obstruction to the radiation of warmth.

No doubt these rude contrivances may not be always very effectual in carrying off the smoke; but it may well be questioned whether a little smoke was not more than compensated for by the genial embrace which these old fireplaces offered to the old social circle. Besides, let us candidly admit, with all the unsociable contractions which modern science has engendered, are we not still occasionally a little troubled by smoke?—smoke, without any compensating beauty, and for which we get nothing in return but damaged furniture, and perchance a ruffled temper.

(*To be continued.*)

ON A NEW MODE OF COKING IN OVENS APPLIED TO THE STAFFORDSHIRE SLACK.*

By Alexander B. Cochrane.

(*With an Engraving.*)

Many varieties of coke ovens have from time to time been invented with a view to economise the cost of coking, which have met with variable success; and attempts have recently been made to perfect the adoption of flues underneath the floor of the ovens, which were tried so long ago as 1853 by Mr. J. Dunning, and have since been attempted frequently, but with only partial success. The subject of coking has a most important bearing upon railways especially; and if coke could be obtained at a cost approximating more nearly to the price of large coals than can possibly be the case under the ordinary system of coking whereby little more than a yield of 50 per cent. is obtained, the advisability of again reverting to coke in locomotives instead of coal would be considered, and would probably be judged expedient.

In the ordinary plan of coking, the oven in which the process is performed is a round chamber about 10 feet internal diameter, as shown in Fig. 7, Plate V., the floor of which slopes gently from the back to the front; the oven is covered in by a dome springing at about 4 ft. from the floor and rising to about 8 ft. at the highest point. At the centre of the dome the charging orifice is situated, which serves as a chimney in the simplest form of oven, and as the entrance into the general flue of a series of ovens where a separate chimney is employed; the coke is drawn out through the door in front of the oven, and in some instances the coals are also charged through the door. In such an oven, whether it be open-topped, or whether the gases and smoke instead of being allowed to escape immediately into the atmosphere are conveyed along a general flue to a suitable chimney, the process of coking is carried on from the top of the coals only, travelling downwards until it reaches the floor of the ovens. But the coking could not be carried on without a considerable quantity of air being admitted during a certain period at least of the process; and the fact is that the coking is effected at the expense of the combustion of a certain percentage of the coke which the charge of coals ought to yield. Were not air admitted, the process would stop; and as it is, the ovens are subject to great irregularities from the uncertain draught in variable states of the atmosphere. This is evidenced by the fact that if the draught of an oven is interfered with the oven does not get "burnt off" as it ought to be, requiring perhaps a day longer to be completed or even more: and when the oven is drawn it will be found that the coke is accompanied with the objectionable appearance due to what are called "black ends," or partially coked coals. This great evil has been in a measure corrected by the adoption of a tall chimney to a series of ovens, but in that case arises another objection: in a long series of ovens it is difficult to make the influence of the chimney felt throughout; and consequently of the two systems the original one is still preferred in some instances.

In connecting a chimney to a series of ovens the arrangement found best is to place, say 48 ovens in a double row of 24 each, back to back, with a central flue passing between the two rows into a chimney occupying a central position in the block of ovens. But even in such an arrangement, where the farthest oven is separated by only 11 intermediate ovens from the central chimney, it is found impossible to prevent the speedy burning off of the oven nearest the chimney and the tardy burning off of the farthest, the intermediate ovens varying in their regularity according to their distance. It is said the oven nearest the chimney is capable of being burnt off without intentional admission of air, which in the other ovens is equally allowed to enter by only partially closing the door; but the real fact is that the draught of the chimney exercising its greatest force on the nearest oven draws in a quantity of air, imperceptibly though not the less certainly, through the imperfect joints of the temporary door and of the external and internal masonry: and each oven only apparently requires more air as it recedes from the chimney. At the Gloucester railway station the writer believes it was attempted several years ago to correct this evil by arranging a series of ordinary ovens in a circle around a central chimney, and no doubt the difficulty as regarded the draught was removed; but from some cause or other the whole system is now swept away. Such an arrangement however as that of a central chimney with the ovens arranged in a circle round it would evidently constitute a marked improvement so far as regularity of draught for each oven is concerned; but it is equally clear that with the ordinary construction of ovens as above described much ground would be sacrificed by such a plan.

The yield of ordinary coke ovens rarely exceeds 50 to 52 per cent. of the coal supplied. The experiments which have been made to bring about the adoption of fluid ovens have pointed to the importance of making use of the waste heat from the ordinary coke ovens to assist in the process of coking. Indeed all fluid ovens have one common object: to make the waste gases circulate in flues either beneath the floor of the oven, where they are ignited by suitable admission of air; or, as in one instance, around the top, sides, and floor of the oven. As may be supposed, the rapidity with which the coking is performed is greatly increased, and the non-admission of air to the contents of the oven is a source of great increase in the yield: but the wear and tear on this class of ovens is excessive. In one instance, where the waste gases are made completely to envelope the oven, the wear and tear amounts to no less than 6*d.* per ton of coke produced; and in a recent plan the writer understands the flues underneath the floors of the ovens are in a very short time so destroyed that the oven must be laid off for repairs, far too frequently to make the plan commercially successful.

The plan of coke oven forming the subject of the present paper, the invention of Mr. Henry Eaton of Bordeaux, is believed to fulfil the requirements of a good coke oven more completely than ovens on the ordinary plan, or those having flues underneath the floor. About the middle of last year the writer, having to decide on the class of oven to be adopted at his Tursdale Colliery, in the county of Durham, after a careful investigation into the merits of various plans determined to build an experimental block of 12 ovens on Mr. Eaton's plan, at the Woodside Iron Works, Dudley, with the intention not only of testing the value of the ovens for coking North-country coal, but also of trying what could be done in coking the intractable slack of the Staffordshire thick coal, the "fine" of which has hitherto been thrown away as waste in very large quantities. The success was so far complete that it was both decided to adopt this system at the Tursdale Colliery, where two blocks of 12 ovens each are now in operation on this plan and a third in progress: and a second block has also been erected at Woodside, which has been at work for two months.

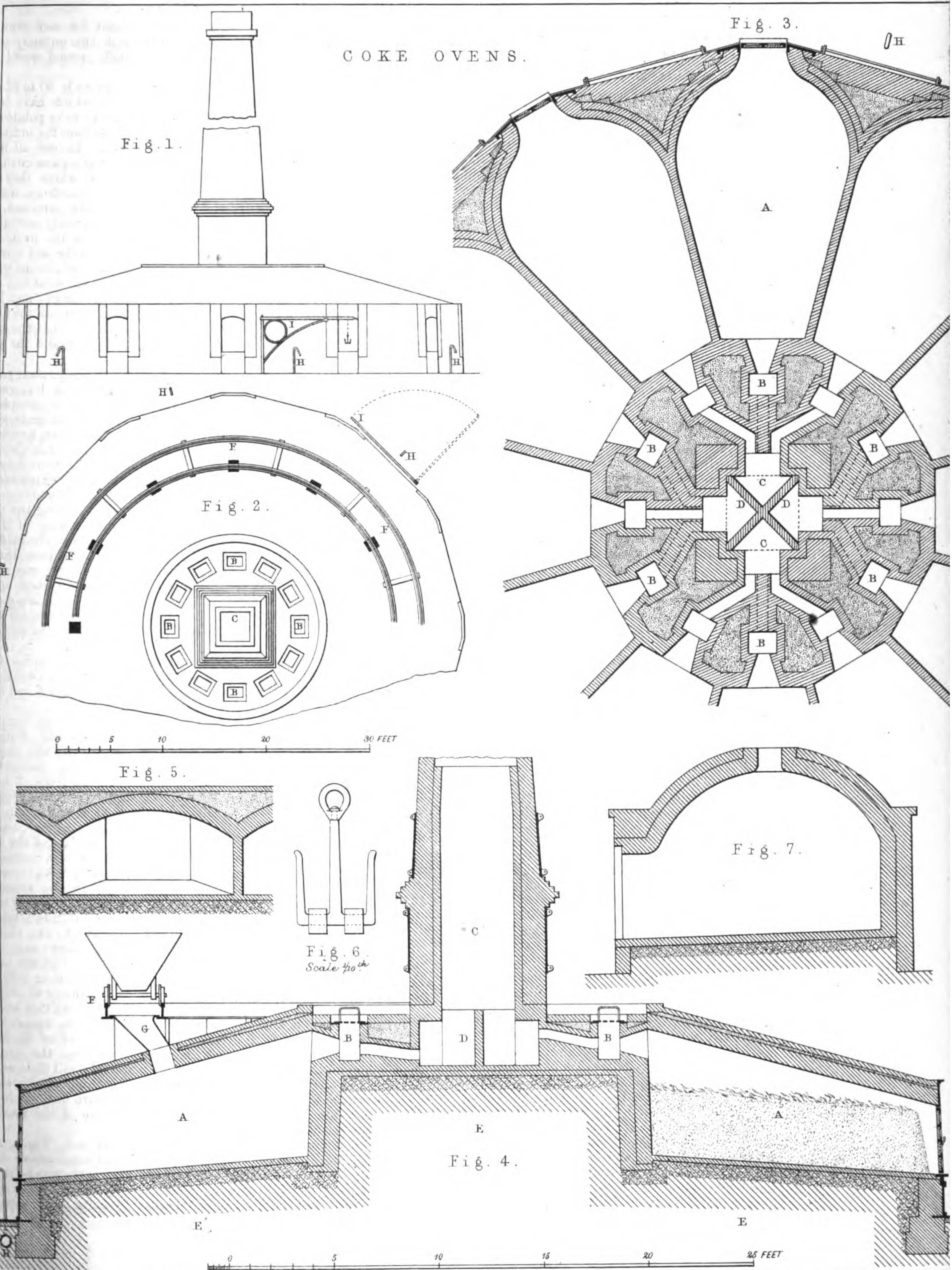
The new ovens are shown in Plate V. Figs. 1 and 2 are a general elevation and plan of a single block of the ovens; Fig. 3 is a part sectional plan to a larger scale, and Figs. 4 and 5 are longitudinal and transverse sections of the ovens.

The ovens, twelve in number, are arranged in the form of a circular block, as shown in Figs. 1 and 2, of 44 feet diameter, round a high chimney in the centre, which causes the draught to be equal upon all the ovens, so that the coking proceeds in all alike with equal regularity. Each oven A, Figs. 3 and 4, opens at the back by a flue into the regulator B, from which is a smaller flue leading into the chimney C. At its junction with the oven the size of the flue is about 18 inches square, reduced at the regulator B to 8 inches square, and at the foot of the chimney it is only 6 inches square. The regulator B is a rectangular chamber covered by a moveable plate perforated with holes for the admission of air to the gases disengaged in the process of coking. The square chimney C is divided at the base by diagonal partitions D, Fig. 3, rising a little above the flue levels, the effect of which is to distribute the draught of the chimney uniformly over the twelve ovens in four sets of three each. The flues do not enter the chimney at the same level, but the middle one in each set of three rises above the two on either side, and thus space is economised in the size of the chimney at the base. The top of the chimney is 3 feet square inside, but this is larger than necessary, and it need not exceed 2 ft. 7 in. square. The chimney is lined with firebrick for 12 or 15 feet of its height from the base, to protect the red brickwork from the intensity of the combustion which there takes place. It will thus be seen that the arrangement of a central chimney and its division at bottom by four partitions creates a most uniform draught in each oven of the block, and this uniformity is one of the most important elements to be secured in coking.

The chimney and ovens rest on a foundation E, Fig. 4, made up of cinders and dry rubbish free from any combustible ingredients, well rammed in to secure solidity, over which is laid about 9 inches of concrete. The whole block of ovens is contained by brick walls bound together by bolts and straps, the

* Read at the Institution of Mechanical Engineers.

COKE OVENS.



J.R.Jobbin

latter being wrought to the form of the door frames, which are thereby held in their places. Each oven is covered in by an arch, shown in the transverse section Fig. 5, every portion of which is an arc of the same circle. The turning of the arch has been found to be a matter of some difficulty, to ensure permanency; but has been satisfactorily accomplished in the following manner. To make a perfect skewback for this arch, the angle at which the arch beds on the partition walls of the ovens should vary at every point of the walls, on account of their diverging from one another, as they all radiate from the centre of the block. But it has been found best to adopt a medium angle throughout, and cut the last arch bricks on each side of the oven to bed properly to their place. The rest of the arch bricks are all bedded in planes parallel to a centre line through the middle of each oven; so that after starting from the skewbacks, as the lines of bedding planes lengthen and approach the centre, they leave a parallel strip the whole length of the oven and the arch is easily keyed in. This done, the centering being constructed in three convenient parts, can be easily taken to pieces, and removed through the mouth of the oven.

The charging of the ovens, where one kind of coal alone is used, is done by waggons holding about 10 cwt. of coal each, which run upon a circular railway F, Fig. 4, on the top of the ovens. When the charging is completed, the moveable hopper G is removed, and the hole in the roof of the oven closed by a large slab, and luted all round to make it air-tight. Where a mixture of coal is needed it is usually more convenient to fill at the mouth of the ovens. The plan, Fig. 2, shows half the block of ovens, with the railway for charging through the roof of the ovens, and half without the charging orifices in the roof. The progress of the coking can at all times be inspected through a sight hole in the top of the door of each oven, which is closed by a small fireclay plug. When completed the coke is withdrawn very easily fron the ovens, as the partition walls are radial and diverging from each other. For watering the coke previous to drawing, a water main H, shown in section in Fig. 4, encircles the block of ovens, having suitable standards fitted with india-rubber hose pipes; at the end of the hose is attached a long gas tube, which is put in through the mouth of the oven and moved about to direct the water over the surface of the coke. For facility of handling the tube and working the tools used in drawing the coke, a small portable crane I, Fig 1, is provided, easily shifted by a couple of men, having a double hook roller, shown in Fig. 6, over which the tools move easily.

The mode of working these ovens is in the first place to dry them off in the usual way, which takes four to six days from the first lighting of the fires. When sufficiently heated, the ovens Nos. 1-4-7-10 are cleared of ashes and charged on the first day, the heat being purposely kept up in the rest of the ovens till they are in their turn charged. On the second day the ovens Nos. 2-5-8-11 are charged, and on the third, Nos. 3-6-9-12. By this plan of charging the heat of Nos. 12 and 2 is assisting to impart heat through the partition walls to No. 1 between them; the same takes place with Nos. 4-7-10, each between a pair of warm ovens. For 24 hours therefore Nos. 1-4-7-10 have the advantage of adjacent heat, by which time they have acquired sufficient temperature to permit of the drawing and charging of the one set of adjacent ovens Nos. 2-5-8-11 on the second day without injury. Indeed the first ovens have acquired a sufficient degree of temperature to assist in starting the operation of coking in the ovens charged on the second day. The same remarks apply to the charging of ovens on the third day, those of the first and second day both now assisting to start the coking process in Nos. 3-6-9-12 charged on the third day. For 24 hours the ovens charged on the first and second day are now reacting upon one another, whilst those charged on the third day are being urged forward to a degree which will enable them on the fourth day to permit of the drawing and recharging of Nos 1-4-7-10.

In applying the new plan of ovens to the coking of the fine slack of the Staffordshire Thick coal, it is mixed either with bituminous slack from South Wales or with a smaller portion of pitch, in order to impart the necessary caking quality, the want of which has rendered the Staffordshire slack incapable of conversion into coke by any plans previously tried. In either case the requisite binding property is now obtained, and the coke is produced in lumps of large size and excellent quality, and is found of particular value in the blast furnace. With a mixture of 45 per cent. of Staffordshire slack and 55 per cent. of bituminous Welsh slack, the yield regularly obtained in the first block of ovens at Woodside, which is only 42 feet diameter, has amounted to from 55 to 60 per. cent of coke. With a mixture of 75 per cent. of Staffordshire slack and 25 per cent. of pitch, the yield has been from 50 to 53 per cent. of coke. The fluctuations in the yield arise from the variations in the quality of slack obtained from different places, some requiring more bitumen to bind it together. Where the binding is not perfect, considerable waste ensues in drawing the coke. To correct this has been the object of some recent experiments, in which a mixture of 44 per cent. of Staffordshire slack with 44 per cent. of Welch slack and 12 per cent. of pitch has been used, resulting in a regular yield of from 60 to 65 per cent. of coke. The best yields however, as may be supposed, are obtained from coals which contain a sufficient proportion of bitumen to secure binding without admixture: such as the bituminous or caking coals of Durham, Newcastle, and South Wales, from which results of 67½ to 70 per cent. yield of coke are uniformly obtained in these ovens. These results have been obtained from coals supplied from the Brithdir Colliery in South Wales, Pease's West Colliery in Durham, and the Tursdale Colliery in Durham.

(To be concluded in our next.)

RESISTANCE OF SQUARE BARS TO TORSION.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—It is very desirable that the attention of writers on the strength of materials should be called to the theoretical investigations of M. de St. Venant, especially those on torsion, which were published in the 'Mémoires des Savans Etrangers,' vol. xiv., about six years ago, but appear to have been almost wholly overlooked, although some of their results are of much practical importance.

According to the ordinary theory of the torsion of a straight uniform bar, each originally plane section perpendicular to the axis continues to be plane and perpendicular to the axis when the bar is twisted. It is easy to see that this supposition is rigorously exact for a cylindrical bar only; but it seems to have been generally taken for granted that the errors to which it leads when applied to bars of other forms are unimportant in practice. M. de St. Venant shows that they are of importance; and by a very skilful and laborious mathematical investigation he obtains approximate formulæ in which allowance is made for the effect of what he calls the "gauchissement" (which may be translated the *warping*) of the originally plane cross-sections of bars that are not cylindrical. He arrives at the result, that the whole of the ordinary formulæ relating to torsion are erroneous, except those for cylindrical bars.

The most important case in practice to which the method of M. de St. Venant has been applied is that of a square bar, wrenched asunder by torsion.

Let h denote the side of the bar; f, the modulus of rupture by wrenching, or greatest intensity of the stress when the bar gives way; then the moment M of the force required to wrench asunder the bar is,

According to the ordinary formula, $M = \cdot 2357 fh^3$;
According to the improved formula, $M = \cdot 281\ fh^3$.

In the reduction of experiments on wrenching equal bars asunder, the following are the values of the modulus f:

According to the ordinary formula, $f = \frac{M}{\cdot 2357\ h^3}$

According to the improved formula, $f = \frac{M}{\cdot 281\ h^3}$

To these may be added the corresponding formula for cylindrical bars, in which alone M. de St. Venant makes no alteration,

$$f = \frac{M}{\cdot 196\, h^3}$$

An easy test of the accuracy of the formulæ for square bars is to try whether, when applied to experiments, they give values of f agreeing, or nearly agreeing, with those deduced from experiments on round bars. I have lately applied that test to them by the aid of the experiments of Mr. George Rennie and Messrs. Bramah on square bars of cast-iron, and Mr. Dunlop on round bars of the same metal, as quoted by Mr. Hodgkinson in his work on Cast-iron (articles 201 to 204 inclusive), with the following results.

(See also, as to Mr. Dunlop's experiments, Tredgold on Cast Iron, page 98.)

	Modulus of Wrenching, *f*. Ordinary formula.		M. de St. Venant's formula.
	lb. on the sq. in.		lb. on the sq. in.
Square Bars.			
Mean of Mr. Rennie's experiments	32,227	......	27,070
Mean of Messrs. Bramah's experiments	37,747	......	28,640
General mean ...	34,987	......	27,855
Cylinders.			
Mean of Mr. Dunlop's experiments	27,534	......	27,534
Difference	7,453	......	321

It is obvious that the difference between the results of experiments on square and round bars, according to M. de St. Venant's formula, falls within the limits of the ordinary variations of experiments on the strength of materials; which limits it greatly exceeds when the ordinary formula is applied.—I am, &c.

W. J. Macquorn Rankine.

Glasgow, 4th February, 1862.

ON PHOTOGRAPHIC DISTORTION.

By R. H. Bow, C.E., Edinburgh.

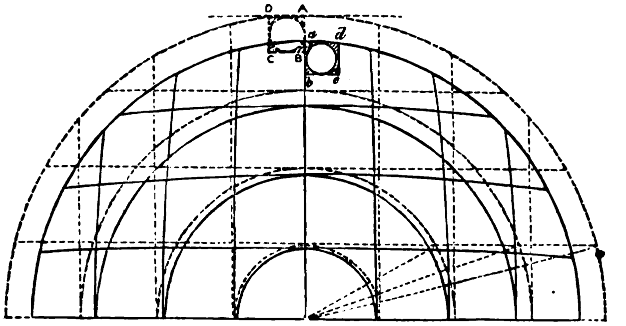
(*Concluded from page 58.*)

In the case of a small body at the extremity of any radius, the per-centages of distortion of that body in the two directions—1st, of the radius, and 2nd, at right angles to the radius—will be in the proportion of n to 1, or nearly as 3 : 1. For instance, if a small circular body were situated at a distance from the centre of the subject, then in the photographic picture the image of that body would show a compression in the radial direction about three times greater than in the lateral direction. This will be observed in the case of the square and circular objects, ABCD becoming *abcd*, shown in Fig. 3; but these objects are too large to give the proportions very correctly.

Fig. 3.

Diagram of the distortion produced by a plano-convex lens, with a focus equal to about 3⅔ times its diameter.

Angle of incidence of extreme rays = 30°, index of refraction = 1·5, $n=3$. The undistorted image, drawn according to the scale of the centre, is shown in broken lines: the distorted image is shown in continuous lines. The radial distortion at extreme circle = 30 per cent. Ditto measured over whole of longest radius = 10 per cent. The lateral distortion at extreme circle = 10 per cent.



It is evident that for every lens there is a range in the ratio of distortion, dependent upon the value given to DF, and varying from that borne by the tangents down to zero. The intermediate ratios required for the comparisons in Table II. are obtained thus:—The length of any radius, FT, of the image (see Fig. 2) is equal to LV + LT′ × tan. of TLT′. And when OA = 2, and R the radius of curvature of the lens = 3, the amount of refraction by the second surface is so trifling that, though it is taken into account in arriving at the inclination of LT, we may adopt this more convenient formula for FT,—

$$FT = KD + DF \text{ (tan. of inclination of LT).}$$

The comparative results in Table II. are for the purpose of showing the power which one lens possesses to counteract the tendency to produce distortion in another placed on the other side of the same stop. And we see that when the amount of distortion produced on the radius drawn to the extreme standard ray by one lens, at the distance DF measured—say to the chart—is equal to the amount produced by the other lens at the distance at which the plane of the copy is placed, then the combination is almost perfect in its action upon the intermediate spaces also, and is sufficiently so for all practical purposes.

Thus in Table II., Example 2, we see that, if we use the two lenses with the radii = 3 and 4, and the object is at an infinite or say at a great distance in front of the 4 rad. one, the image will be free from distortion if made to fall on a screen placed 12·15 behind the 3 rad. lens.

If only the lens of radius = 3 were used, with the stop and flat side towards an object *at any distance*, and the picture formed at 5 behind the lens, the principal radius would suffer a contraction amounting to 7·676 per cent.: if formed at 10 behind, the same would be distorted to an extent of 9·213 per cent.; and if we supposed it to be formed at a very great distance behind the lens, the distorting contraction would amount to 11·523 per cent. Of course the per-centage of radial contraction at the extremity of the radius would be n, or nearly three times the above.

These results and the diagram, Fig. 3, will serve to convince us of the very great amount of distortion existing in photographs taken with plano-convex lenses; and I think it will be admitted that the amount of curvature in the lines gives us a very inadequate idea of the excessive amount of radial contraction which is produced in a body situated near the margin.

We have shown that it is possible to correct the distorting tendency; but, to bring about the very nice arrangements required when the flatness of field is brought into the question, we confess that there appears little hope of any universal instrument being constructed to suit for copying charts to any scale. The case No. 1, in Table II, is given however to show that we are not called upon to change the value of R, the rad. of curvature, for every change of scale; for, by placing one lens nearer to the stop, we *virtually* lengthen its focus, or rather diminish its distorting power compared with the other lens, and a considerable range of scale may thus be attempted. It is probable, however, that the various changes would become so troublesome and complicated, that it would be better to construct a separate instrument for each particular scale; and, before concluding, I have another arrangement to propose suitable when a separate instrument is to be devoted to each particular scale—a combination in which the correction of distortion is mathematically perfect, and the calculations very simple.

One use to which the results in Table II. may be turned is, to warn us of the imperfections of some arrangements put forth as producing pictures free from distortion. Thus, if we take two lenses, say each with R = 3, with the stop and negative arrangement exactly midway between them—which I believe correctly represents Mr. Sutton's symmetrical triplet—then, if the chart and the copy be on the same scale there will be no distortion, since the distances are equal; but if the chart be at a very great distance, and the image or copy at, say 5, then the distortion on the longest radius will be equivalent to an increase from 0·884014 to 0·92324, or about 4.438 per cent. on the radius, or a marginal

$$\text{radial distortion} = \frac{76{\cdot}97 - 65{\cdot}20}{65{\cdot}20} \times 100 \text{ per cent.} = 18{\cdot}05 \text{ per cent.}$$

Or, taking a less extreme case, let the respective distances of the copy and chart be 10 and 50; the extreme radii will be as 0·907873 to 0·890314

Per-centages of contraction on the radii = 9·2127 and 10·9686.
Per-centage of enlargement of radius of copy =

$$\frac{0{\cdot}907873 - 0{\cdot}890314}{0{\cdot}890314} \times 100 = 1{\cdot}97.$$

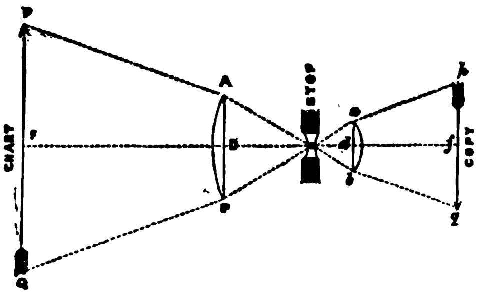
Per-centages of radial contraction at margin = 27·638 and 32·906; difference = 5·268.
Radial scales for margin = 72·362 and 67·094.

$$\text{Per-centage of marginal radial enlargement } \frac{5{\cdot}268 \times 100}{67{\cdot}094} = 7{\cdot}84$$

In proposing such a combination Mr. Sutton (see 'Photographic Journal,' 1860, p. 58) takes for granted that, when the emitted rays are made parallel to the corresponding incident rays, there is no distortion. But this ignores altogether the effect of the size of the lens, and is only true in the case of the lenses being exactly alike, when the scale of the copy is equal to the original, or when both chart and copy are at great distances from the lenses in proportion to their common diameter.

MR. BOW'S CHART COPYING LENS.

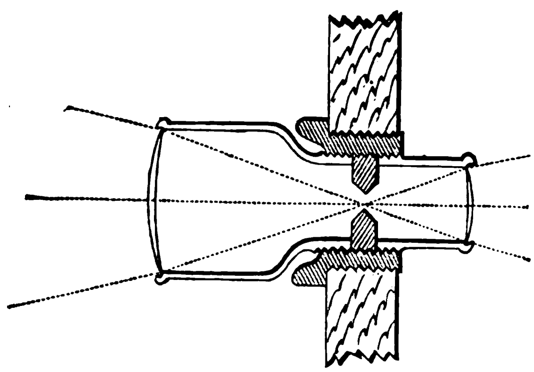
Fig. 4.



The combination which I propose for copying charts, &c. is as follows:—

Suppose that the copy is to be in size $\frac{1}{m}$ th of the original. Then I make all the dimensions and distances of the parts on the *chart*

Fig. 5.



side of the stop equal to m times the corresponding dimensions and distances on the *copy* side of the stop. Thus in Fig. 4 we have $pq = \frac{1}{m}$ PQ, $Fo = m \, . \, of$, $AB = m \, . \, ab$, Rad. of lens $D = m$. rad. of lens d, $Do = m \, . \, od$.

The introduction of a negative lens at O will not affect these ratios; but I hope to arrive at a combination such as Fig. 5 (the lenses being still similar), which will give a flat field without the use of a negative lens at the stop.

In arranging for a given number of scales it will not be necessary to use double that number of lenses, as one lens may in turn be employed in combination with several of the others, of similar forms but of different dimensions.

Table II.—*Of series of contracted radii of the image produced by different lenses.*

Arranged to show the degree of accuracy with which the distortions—at different distances from the centre of the picture produced by one lens—may be corrected by a second lens placed at the other side of the stop, when the distances of the object and picture, the foci of the lenses, and their *distances from the stop are all properly adjusted.*

The diameters of all the lenses are taken = 2, and all are plano-convex. The usual distance of the stop from the flat side of the lens = 1·732051, or such that the extreme ray passing through the stop is inclined at 30°. The index of refraction = 1·5.

	Distance of stop from the lens.	Radius of convex side of the lens	DF, or the distance of object or image from flat side of nearest lens.	Extreme ray at 1. from centre Angle = 30°	Third ray at 0·75 from centre. Angle = 23° 24'·8.	Second ray at 0·5 from centre. Angle = 16° 6'·13.	First ray at ·25 from centre. Angle = 8° 12'·79.
		∞		1·0000	·7500	·5000	·2500*
1	1·732	3	4·515	·9259	·7175	·4904	·2487
1	0·866	3	∞	·9259	·7172	·4903	·2486†
2	1·732	3	12·15	·9045	·7081	·4876	·2484
2	1·732	4	∞	·9045	·7081	·4878	·2484
3	1·732	3	7·34	·9141	·7123	·4888	·2484
3	1·732	4	20·	·9141	·7120	·4888	·2484
4	1·732	3	4·25	·9275	·7182	·4906	·2488
4	1·732	6	∞	·9275	·7187	·4906	·2488
	1·732	3	5·00	·9232	·7163	·4900	·2487
	1·732	3	∞	·8846	·6994	·4850	·2480

* No contraction.

† The rays cross this lens at only half the distances (from its centre) of heads of cols.

ON BENSON'S HIGH PRESSURE STEAM BOILER.*

By John James Russell.

(*With an Engraving.*)

The boiler forming the subject of this paper is the invention of Mr. Martin Benson, of Cincinnati, U.S., where it has been in operation from three to four years, and about fifty of them are in use for various purposes.

A boiler of this construction having since been erected at my works at Wednesbury, and having now worked satisfactorily for ten months, the further results are given in the present paper. This boiler has been in constant work during the whole of the time with entire success, driving an engine of 60 indicated horse power; and the writer has been so thoroughly satisfied with the results and the correctness of the principle upon which the boiler is constructed, that he has since erected a second and larger one upon the same plan, but with some improvements in the details of construction, results of experience derived from the former boiler. This boiler is now at work on the same premises, and is shown in Figs. 1, 2, and 3, Plate 6. Fig. 1 is a front elevation, showing the receiver and circulating pump; Fig. 2 is a longitudinal section of the boiler, and Fig. 3 a transverse section at right angles to Fig. 2.

The boiler proper is composed entirely of tubes A, Fig. 2, arranged in a series of horizontal rows over the fire. BB are doorways at the front and back of the boiler, for fixing, disconnecting, and taking out the tubes. C, Fig. 1, is the water and steam receiver; D the circulating pump, which draws its supply of water from the receiver C, and is worked by the small donkey engine E, above. F is the main supply pipe from the circulating pump, to which the lowest tubes of each section of the boiler are connected. G is the main delivery pipe, to which the top tubes of each section are joined, and into which the water and steam together are delivered from the tubes, and thence discharged into the upper part of the receiver C.

The circulating pump D is shown enlarged in Fig. 8, and is a simple direct-acting pump, with a metallic packed piston, constructed with a single slide valve H, instead of suction and delivery valves, so that it is certain and constant in its action; the slide valve is made without any lap or lead, and thus agrees exactly with the motion of the piston. The pump draws its supply of water from the receiver through the ordinary exhaust port I, running round the cylinder, and discharges it by the outlet pipe K, forcing it into the tubes through the pipe F, Fig. 1. The steam generated in the tubes is driven up with the water through the tubes, and discharged through the pipe G into the receiver C, where the steam and water are separated; and the water is then again taken by the circulating pump and returned into the tubes. In starting the boiler the receiver is supplied with water until

* Read at the Institution of Mechanical Engineers.

its level reaches the fifth or sixth row of tubes from the bottom, as shown by the dotted line in Fig. 1; as the circulating pump is standing still at first, in consequence of having no steam to work it, the slide valve H, Fig. 8, is allowed to be lifted off its face by the pressure of the water, and lets the water flow past the pump direct through into the tubes. The fire is then lighted, and steam raised from the water in the tubes, which starts the circulating pump to work.

More water is forced through the tubes by the circulating pump than is evaporated in them. The circulating pump of the boiler, now used for ten months, is double-acting, 6 inches in diameter, with 9 inches stroke, and makes 40 revolutions per minute, against a resistance of from 7 to 10 lb. pressure per square inch; the power required to work it is therefore about ½-horse power, including the friction of the pump. At this speed it forces through the boiler from 9 to 11 times as much water as is evaporated, which has been found too much to get the greatest efficiency of the boiler; and from 6 to 8 times the quantity evaporated is considered about the proper proportion. In this instance, owing to the construction of the donkey engine, the pump cannot be worked at less than 40 revolutions per minute, at which speed it is fully capable of supplying a 100-horse-power boiler at ordinary working pressures, instead of one of only 60-horse power. With high-pressure steam superheated and worked expansively, the pump is large enough for a 150 horse-power boiler, in which case ⅓rd per cent., or $\frac{1}{300}$th of the whole power produced, is all that is required for working the circulating pump; and with the improved circular bends that have now been adopted for uniting the ends of the tubes in the boiler, there is reason to expect the circulation can be maintained with much less power. No more power is required to work the pump with 80 and 100 lb. steam than with 20 lb., since the pressure is the same on both sides of the piston, and the only resistance to be overcome is the friction of the water in the tubes, which of course is increased in proportion to the speed; with the boiler now at work the resistance on the piston at the pr0per speed does not exceed 7 to 10 lb. per square inch. Originally the delivery pipe G, Fig. 2, into which the steam and water from the tubes are discharged, was only 5 inches diameter inside, which was found too small; in the present boiler it has been made 10 inches diameter. The receiver C is supplied with feed water by one of Giffard's injectors, L, Fig. 1, instead of an ordinary feed pump.

It was originally supposed that the mechanical circulation of the water, with 9 to 11 times more water forced through the tubes than is evaporated, would be sufficient to prevent deposit, by keeping them washed out clean; and this is the case to a certain extent, as all loose matter is washed by the circulation from the tubes into the receiver. Some incrustation however does take place, but not sufficient to present any practical difficulty or cause any damage to the tubes. One of the tubes from the first boiler is exhibited as a specimen, showing the amount of deposit that has been formed during the ten months it has been in use. The deposit is greatest in the lower tubes of the boiler, and decreases in the upper rows: practically it is prevented from accumulating so thick as to cause the tubes to be injured by the heat, since it becomes cracked and loosened from the tubes by their alternate expansion and contraction under the varying temperature of the fire. At times also nearly all the water is worked out of the tubes, so as to let them get quite hot, but not hot enough to cause injury by overheating; and when the deposit is thus loosened in the tubes, it is washed out into the receiver by the circulation of the water. The dirt and scale are cleared out of the receiver by a blow-off cock, which is opened for blowing off two or three times a day. It takes about a quarter of a minute to free the blow-off cock from the deposit lodged in the receiver before a full body of water issues from it. Pieces of deposit are blown off which have a circular form, showing that they have been formed in the tubes, and then scaled off and washed into the receiver. The semicircular form of the bends uniting the ends of the tubes prevents any incrustation lodging in them, by giving an unobstructed passage.

The mode of uniting the tubes together in the former boilers of this construction was with right and left handed screws cut on the ends of the tubes and screwed into the bends: but this make required an entire section of the boiler to be taken out when a new tube had to be put in; and with large boilers this is too much trouble, owing to weight, difficulty of handling, and the impossibility of unscrewing many of the tubes in the bends after they have once been screwed up and put to work. To meet these difficulties a new form of bend has been made in the present boiler, which admits of any one of the tubes in any part of the boiler being taken out, without removing that section of the boiler or interfering with any other joints than those of the tube to be removed. Figs. 4, 5, and 7, show enlarged views of the improved bends as fixed in the boiler. Instead of screwing the ends of the tubes, they are made with collars of suitable size welded on, and the ends of the bends are recessed out to receive them: the bends are brought up tight against the collars on the tubes by the centre screw bolt M, Fig. 7, which passes through a hole in the bend in line with the centres of the two tubes, and is screwed into the crossbar N, bearing against the outside face of the collars. The passage through the bend is made on one side of the fixing bolt, to prevent it from obstructing the flow of steam and water. By this plan any of the bends can be taken off through the doorways at the front and back of the boiler, and any tube can be taken out and replaced. The ends of the tubes are passed through the end bearing plates PP, Figs. 4 and 5, which serve also as shield plates to protect the cast-iron bends from the heat of the fire; these plates rest on the walls of the furnace, or are suspended at the top from the girders Q, as in Fig. 2. Fig. 6 shows the mode of joining the tubes to the main supply and delivery pipes, which is done in a similar manner by collars upon the ends of the tubes fitting into recesses in the main pipes, and held up tight by a crossbar N and stud bolt. By having valves for cutting off the communication between the receiver and tubes, the steam and water can be retained in the receiver during the time of removing a tube; and when distilled water from a surface condenser is used in the boiler, the water can by this means be saved, if a tube should burst, and shut off from the boiler while the repairs are done.

The special advantage of this boiler is that steam of high pressure is generated in it with greater safety than steam of low pressure in ordinary boilers. Its construction insures almost perfect safety; for the receiver C, Fig. 1, the only portion containing any quantity of steam and water capable of causing damage by explosion, is of the strongest form for resisting pressure, of simple construction, and removed from the action of the fire, so that it is entirely free from the injurious effects of overheating and the alterations of expansion and contraction, which are considered to be the cause of so many injuries and explosions of ordinary boilers. The only portion of the boiler exposed to the fire is the tubes, which are of such small capacity that their explosion is incapable of doing any damage, and can only cause the fire to be put out by the water escaping from them. This has been confirmed by the experience with the boiler at the writer's works, where a tube has burst on more than one occasion, whilst the boiler and engine were at work; and the effect was so small, that the accident was not immediately perceived, until shown by the loss of steam pressure, the steam and water blowing out upon the fire through the leak in the split tube and putting it out. The advantages of high-pressure steam are now generally recognised; but a much higher pressure than can be obtained in ordinary boilers and superheating of the steam are required to develop these advantages fully, by cutting off the steam earlier with a higher degree of expansion. The economy of expansion is now limited by the weakness of boilers in general use; and a large increase of economy may be obtained if much higher pressures can be safely used.

(To be concluded in our next.)

REVIEWS.

The Cathedrals of the United Kingdom; and, *The Minsters and Abbey Ruins of the United Kingdon.* By Mackenzie Walcott, M.A.—London: Stanford, Charing-cross. [Second notice.]

We return to our notice of this book, which as therein stated want of space prevented completion at the time.

Apart from the matter of the heraldry, in which as previously stated there is occasionally confusion, as is shown in the reference to the arms of Worcester, mentioned on page 8 of the introduction and page 271, which concludes the description of Worcester Cathedral—where in the first case the arms of the see are stated to be ten hosts, and in the latter ten torteauxes—the observations and descriptions of Mr. Walcot are generally correct and very instructive. They embrace all the main points of interest both historical and architectural, in relation to our cathedrals, and they are conveyed in a terse yet sufficiently comprehensive shape. Beyond this, they contain notices of many other objects of attraction, both in the cathedral cities themselves and in their respective neighbourhoods; so that his book is, to some extent, a general guide to the antiquities of their locality.

Some of the introductory remarks of Mr. Walcott are worthy of particular attention. Speaking of Christian architecture, and its expression as evidenced in cathedral structures, he says, "A cathedral 'is a mighty maze, yet not without a plan;' it is the embodied idea of the 'Spiritual house built of living stones'" (1 Peter, ii. 5.); and further on he adds, "the visible expression of abstract ideas: in every part the ingenious builders contrived to embody a suggestive symbolism, with a high devotional sentiment and great poetic beauty, even as the Temple of Jerusalem served as an example and shadow of heavenly things and a pattern of things in heaven" (Heb. viii. 5.; ix. 1, 23.)

In relation to this symbolism he observes, "The prominent principle is triplicity; thus a church contains in length—1, choir, 2, transept, 3, nave; in breadth—1, mid alley, 2, north, and 3, south aisles; and in height—1, base tier, 2, triforium, 3, clerestory." Again he continues, "The church points to the east, as to the place of nativity, sacrifice, and the second coming of the Redeemer; the first and last object in the mind and heart of a ransomed world. It was placed on an elevated site, or removed from common buildings and open to the light, emblematically of its destination, a place consecrated to the Most High for intercession between earth and heaven. The porch, nave, choir, and sanctuary, represented severally the penitent, christian, saintly, and heavenly life. The entrance door, with its imagery of saints, signified Paradise; the stone screen before the choir, the portals of glory, through the power of the cross which was elevated upon it; the crypt, the moral death of man; the cruciform shape, the atonement. The apse indicated the place where the Redeemer's head was laid; the great transept, where his arms were laid; the choir transept, the scroll of the cross; the radiating eastern chapels, were the rays of the aureole about his head: hence we speak of the head, arms, and body of a church. By the cock upon the spire, the beholder was reminded of St. Peter; how, when apostles ceased to pray, they fell."

Mr. Walcott is disposed, in common with others equally enthusiastic on the subject, to carry this reference to symbolic intention to the still greater length of affecting every moulding and ornament. Referring to the cable, chain, saw-tooth, lion head, and the faces and beaks of monsters seen in early decoration, as the memorials of the martyrs and their instruments of suffering, he says, "It was only when the church had peace, that she exchanged those symbols for the flowers, the foliage, and palm leaf of the succeeding styles." It is questionable, however, how far this dictum can be so extensively admitted.

Recurring to that which is less hypothetical, we find an interesting notice of the peculiar characteristics of the cathedrals at page 4, which we quote in full.

"There are three towers and spires at Lichfield; three towers at Canterbury, York, Lincoln, Durham, and Ripon. Salisbury, Norwich, Chichester, and Oxford have spires. There is no cloister at York, Winchester, Peterborough, Ripon, Rochester, Exeter, Ely, Lichfield, St. David's, Carlisle, Ripon, Manchester, or the Welsh cathedrals. Bangor, Manchester, and Ely, have each a single western tower. Ely and Peterborough have central lanterns. Exeter has transeptal towers. Lincoln, Ely, and Peterborough, have western transepts. There are aisleless transepts at Canterbury, Bristol, Norwich, St. Asaph, Bangor, Carlisle, Winchester,, Worcester, and Gloucester. Llandaff and Manchester are not cruciform. Norwich and Peterborough end in apses. There are western screens at Salisbury, Lincoln, Peterborough, and Exeter. There is an eastern screen at Durham. York, Salisbury, Rochester, Hereford, Wells, and Worcester have a choir transept. Lincoln, Ely, and Durham have galilees. The cloister is on the north side at Lincoln, Canterbury, Chester, and Gloucester. Wells, Chester, and Chichester possess only three alleys; Hereford and Oxford two. Bangor, St Asaph, and Carlisle have no Lady chapel; at Rochester it is on the south side of the nave, on the north side of the choir at Ely and Canterbury; at the west end at Durham; at the east end at Peterborough. It is equal in height to the choir at Lichfield. At Bristol all the aisles are of the same height. Llandaff had only two western towers. Chichester and Manchester have additional aisles to the nave; Oxford to the choir. Chichester retains a detached bell-tower. At Wells, Gloucester, and York, the chapterhouse is on the north side. Canterbury has a circular chapel at the east end. There are crypts at Canterbury, York, Winchester, Rochester, Worcester, Hereford, Gloucester, and Ripon."

The classification of the cathedrals given at page 9 is also worthy of particular observation, as a catalogue distinguishing the cathedrals of the old foundations from the conventual establishments of corresponding character, and those of the later institution by Henry VIII.

Taking the English cathedrals first in order, Mr. Walcott next proceeds to like notices of those of Ireland and Scotland, each being preceded, as in the case of the English, by some very useful observations on the general architecture of each country in the way of introduction. Those relating to the Irish churches are particularly interesting, and we therefore give them extenso. Commencing with the several periods of Irish architecture, Mr. Walcott divides the same as follows:—

"I. Native or Celtic style, much anterior to the incursions of the Danes or the Norman Conquest:—Churches of small size, like a Roman basilica shorn of its apse; rude massive buildings oblong in plan, with triangular-headed small windows; pyramidal-shaped doors, and Cyclopean or Pelasgic masonry. This and the following style occupied the interval between the fifth and sixth centuries, and the year 1176. The early Scottish, Anglo-Saxon, and French churches of the sixth century were all parallelograms. It is remarkable that the Greek oblong temple, composed of a nave and shrine, like the Temple of Jerusalem, also consisting of oracle and nave, 116 ft. 3 in. by 37 ft. 6 in., and 58 ft. 1¼ in. in height, were both derived from an Egyptian original. The architect of the temple on Zion was of Tyre, a Phœnician colony; and while the legend of Cadmus, a Phœnician and the civiliser of Greece, denotes a correspondence between those countries, the commerce of Tyre with the western isles is boldly asserted by many writers. These early churches, rather oratories than capable of holding a congregation, range from 20 feet to 60 feet in length; they are aisleless, rectangular, have no apse, and are never found in a circular form; sometime they are provided with a small chancel, and occur in groups. On Mount Athos, in other parts of Greece, and in Asia Minor, churches were usually built in groups of seven, in remembrance of the seven churches of the Apocalypse. The *round towers* are of this period, which lasted till the 11th century, but are continued until the 13th century. Their form was adopted in consequence of the difficulty of obtaining cut limestone for the corners. Their purposes were various; they have been variously represented as serving for a belfry, a beacon, a treasury, and a retreat for the priests. In the 14th and 15th centuries, they were replaced by tall narrow square central towers. In the earlier towers the parapet is plain, with a range of holes instead of gurgoyles for letting off the water; in later buildings there are stepped battlements resting on corbels.

The *Saints' houses*, the beehive houses of Connemara, and the oratory of Gallerus, are of "Cyclopean masonry," built of masses of rock, and vaulted with stone roofs; but the latter are of a later date, and are provided with chambers. In St. Kevin's, Glendalough, the lower structure is of the 7th century. The upper tunnel vault was provided with ribs, on which were laid the horizontal courses of the outer roof, which was built up straight to throw off the rain; this plan was also adopted in Cormack's chapel, Cashel, built 1127-34. The vault, upper chamber, and belfry are of the 12th century.

The cathedral of Glendalough is full of interest as one of the earliest Irish structures. The east window and south door, however, are of the beginning of the 13th century. In the succeeding style of native architecture, the roof became flattened, chevron mouldings were introduced, the arches received semicircular heads in place of triangular pediments or square lintels; windows became larger, and chamfered beadings ran round the inner arch, and the masonry was inferior. The peculiar cairn-like shaped door, formed of three stones, two jambs sloping upward towards a horizontal lintel, lasted throughout the various styles, and took its origin, like the round tower and Cyclopean masonry, in the stubborn nature of the building material. Within the pale the English introduced the Early English, after the Norman style. But the early architecture of the Isles, Northumbria and North Wales, bore a great resemblance to each other. Dublin appears to have been the architectural school of North Wales later.

II. Norman and Ostmen's style:—remarkable for the absence of enrichment, and frequently of aisles, and the presence of continental features, and lasting longer in Ireland than in any other country. St. Bernard tells us, that when St. Malachy (O'Magair, bishop of Connor, 1124), in the 12th century, replaced a wooden structure in Ulster by a church of stone, the Irish protested against it as a Norman and extravagant innovation. The bishop, however, merely introduced the use of hewn, in place of rough stone, and of mortar instead of mud. The early Irish churches were of timber.

III. The Lancet:—found mostly on the eastern side of the island, having been introduced by the English, though on the western side it seems to have been a native discovery, or a developed or Transitional Norman style. At Kilconnel a small cloister, 48 ft. square, resembles cloisters in Spain and Sicily.

IV. The Later Pointed—has many continental features.

The churches and monasteries were fortified, and rooms built above the vaulting and in the roofs. At Cashel Cathedral, of the 13th century, the Castle forms the west end of the building, and passages communicate from it with the vaulting and the central tower. Holy Cross, on the road to Thurles, was at once castle and minster. A similar combination of a baronial and ecclesiastical structure is found in St. Mary's Abbey, Crossraguel, in Scotland, where a rough square tower immediately adjoins some very delicate architecture. The lesser cathedrals commonly appear to be of the 12th or 13th century."

The church architecture of Scotland, observing that the earliest churches "were probably constructed of wicker work," Mr. Walcott divides into four great periods, which he says were distinctively marked. "The first has many features in common with Ireland; for instance, its round towers, sculptured crosses and tombstones, with the small size, and the combination of buildings in one inclosure. Brechin, Abernethy, and Iona, offer the most remarkable specimens. At Iona, there is a priest's chamber over the aisle, a common feature in early Irish architecture."

The second period, our author says, "Has at an early age—the twelfth century—a Norwegian character." Later the influence of England continued to prevail (dating from 1070 to 1371), as it did "in ecclesiastical synod, constitution, and liturgy." Subsequently to the latter date here mentioned, a continental character appears. Mr. Walcott enumerates several examples of either phase, and enters with considerable ability into a brief notice of the prevailing characteristics exhibited in each—both as regards detail and general construction.

A large amount of very useful information is thrown together in Mr. Walcott's book, and in a manner by which the acquisition of it is attained without extraneous trouble. It is in this respect a very satisfactory addition to the architectural notices of our cathedrals.

The 'Minsters and Abbey Ruins' Mr. Walcott deals with after the same fashion as that adopted in the Cathedrals, the salient points in each case are embraced, and all unnecessary verbosity avoided. He indulges by way of addition, occasionally, it is true, in the introduction of the legendary with the historical in some of these instances, but this is much to the advantage of his notices in a popular point of view, for most of us yet feel interest in the tales and traditions as well as the absolute facts of the past. It is to be regretted however that inaccuracies in respect to the heraldry, and a similar hurried compilation, are exhibited here as in the Cathedrals: the former is in many cases incorrectly given. The arms of St. Alban's, for example, are blazoned as Azure, a *cross saltire*, Argent; instead of Azure, a cross, Or. And as respects the latter the wording is sometimes very loose. For instance, speaking of Malmesbury Abbey, our author says, the Norman south porch "has a door 19 feet square." The outer porch again he describes as "18 feet by 20 feet and 11 feet deep, and the inner porch, 17 feet by 12 feet and 16 feet in depth." What is to be understood by a Norman door 19 feet square? and does the 18 feet and 17 feet, by 20 feet and 12 feet respectively, refer to width and height, seeing that the 11 feet and 16 feet respectively refer to depth? The horizontal superfices on plan can only be architecturally described by reference to the latter in connection with breadth; to what then does the intermediate dimension relate? Typographical and descriptive errors also occur: at page 42, Simon, Earl of *Leicester*, intended to be referred to, is called Earl of *Lancaster*; at page 137, "the stone vaulting of St. George's *window*," should be St. George's, Windsor. As to description, that of Doncaster Church, at page 172, is in many particulars incorrect. In that of Malvern Abbey, again, it is said, "the refectory is now a barn." This has been removed now some years. These are matters which should be corrected as opportunity may occur, and which we have little doubt, from the great general interest and value of the work, will be given.

A Manual of Civil Engineering. By W. J. Macquorn Rankine, C.E., LL.D., F.R.S., &c. London: Griffin, Bohn and Co. 1862.

Prof. Rankine's name is so well known in questions of engineering science, that this new production of his pen can hardly fail of meeting with a favourable reception. The volume consists of 780 pages, is illustrated with numerous diagrams, and contains several tables. "The work," to quote the author's preface, "is divided into three parts, the first relates to those branches of the operations of engineering which depend on geometrical principles alone, that is to say, *Surveying*, *Levelling*, and the *Setting out* of works, comprehended under the general name of *Engineering Geodesy*, or *Field Work*. The second part relates to the properties of the *Materials* used in engineering works, such as earth, stone, timber, and iron; and the art of forming them into *Structures* of different kinds, such as excavations, embankments, bridges, &c. The third part, under the head of *Combined Structures*, sets forth the principles according to which the structures described in the second part are combined into extensive works of engineering, such as Roads, Railways, River Improvements, Water Works, Canals, Sea Defences, Harbours, &c.

We have not space in our present number to do more than simply record the appearance of the Manual, reserving for an early occasion the more extended notice of its contents. Without a full and careful examination, it would be impossible to do justice to a work comprising so much original research as well as comprehensive study. In turning over the pages we find them to contain a large amount of instructive matter, very clearly arranged, and put into a shape readily available both to scientific and practical students.

Examples of Building Construction. Nos. 58 to 66 (elephant sheets). London: J. R. Jobbins.

The parts under notice fully sustain the reputation this work achieved during the issue of the first two volumes; the third volume is completed, and the fourth is progressing in a way that must greatly conduce to its value. The plates are well chosen and of practical utility. They embrace among others constructional working drawings from many important buildings recently erected by Messrs. Prichard and Seddon, R. P. Pope, R. Brandon, Messrs. Burnell, R. J. Withers, Messrs. Willson and Nicholl, &c., which may be considered as a guarantee that there is much in them that may be advantageously studied. The plates of the porches of Maindee church, and Archbishop Holgate's Hospital, will bear investigation, and the staircases and screens from the latter building by R. P. Pope, in Nos. 62, 63, and 64, are designed with considerable chasteness and simplicity. Some effective gates by the same architect, are given in No. 65,—and the iron gates in No. 66, by Messrs Willson and Nicholl, to the New Cemetery at Low Leyton, are bold and appropriate, and evince great ingenuity in their design. The separate staircases in St. James' Schools, Marylebone, by the same architects, are excellently arranged, and carry out admirably their avowed intention of giving separate entrances for the boys and girls, and with great economy of space. We heartily recommend the work as an adjunct to the office of every architect and builder, who will find its contents very valuable as affording examples of every variety of detail connected with building construction.

NOTES OF THE MONTH.

New School Buildings at Eton College.—Great inconvenience having arisen from the insufficiency of school accommodation at Eton, a plan has been prepared by Mr. Henry Woodyer, architect, for new schoolrooms in accordance with the style of the other college buildings, which, as they will occupy a central position, are calculated to present a very beautiful and imposing appearance. The building will consist of two wings, in the angle of which will rise a tower, which will be seen throughout the main street of the college. The new building will supply thirteen additional schoolrooms, for the use of the boys, at the cost of £10,000; the college having also undertaken to rebuild Mr. Waytes' house, at a further expense of £6000. The greater part of the sum required for the schools has already been subscribed. Her Majesty has subscribed £100, and his late Royal Highness the Prince Consort £50. Messrs. Lawrence, Brothers, of Waltham St. Lawrence, Berks, are the builders.

Improvements in Rio Janeiro.—A prospectus has been issued of the Rio de Janeiro City Improvements Company, with a capital of £850,000, in shares of £25 each. The company have a concession from the Brazilian government for draining the city of Rio de Janeiro on plans of Mr. Gotto, approved on behalf of the Brazilian Government by the late Sir W. Cubitt, Mr. Robert Stephenson, M.P., and Mr. Rendel, and which stipulates an annual payment to be made direct by the imperial government to the company of £6 5s. per house. An absolute contract for the work and its subsequent maintenance has been entered into by Messrs. Brassey and Co., on terms which, after providing for 7 per cent. interest during construction, will leave a permanent net divisible profit to the shareholders of 8½ per cent.

South Kensington Museum.—The plans of Capt. Fowke for the Great Museum at South Kensington are estimated at 214,000*l.*; part of which has been already expended. Of the need of such a building, it is only required to state that the Art-Museum is obtaining objects, many of them inestimable treasures, at an average rate, including prints and drawings, of 1,500 each year, and has the loan of more than a thousand articles; amongst which have been, quite recently, the Devonshire gems and Magniac enamels. The Architectural Museum alone contains 5,000 casts of the finest examples of the art, and is worth 3,000*l.* At Thames Bank there is stowed away a magnificent collection of casts from mediæval sculpture and ornament, made by Sir C. Barry for use as models for the Houses of Parliament decorations; 500*l* a year rent is paid for stowage. The whole cost about 7,000*l.* More than one private collection of fine pictures is promised as soon as the nation makes decent provision for the gift. Some day or other the Soane Museum, so ludicrously managed now, that each visitor costs from 5*s.* to 7*s.* for his entry—must come hither; some of the Trustees are it is said assenting to this matter. At present the schools of the department are of wood, exposed to fire risks. The Female School is most unsuitably housed; and its officers located in tumble-down houses. The Male Schools are in constant danger from fire; and the iron "boiler" building (although well enough adapted for the display of casts and architectural models, or coarse materials such as could be replaced or would take little hurt from the drip through its roof) being supported on cast-iron shafts, might, as the experience of the recent fire in Southwark proved, come down, as Braidwood described it, "like a dish-cover" immediately on water being applied to the shafts heated by fire.

New Westminster Bridge.—It is expected by Mr. Page, the engineer, that the whole roadway of the new bridge at Westminister will be finished in May next. The last vestiges of the old structure have now been dredged out, and all the arches of the remaining half, save the fifth and sixth, are completed. The two latter will have their crowns of wrought-iron girders bolted in in a few days, and as fast as each is placed the buckle plates for the roadway will go down. Over these plates comes a packing of blocks of pine wood and asphalte, and over all the stone pitching pavement of the road. Up to the present the eastern half has been entirely disconnected from that which is finished. It is now being joined by a number of short cross girders or stay pieces of cast iron, and over these, as soon as the timber scaffolding is removed, the plates and roadway will be laid, so as to form one complete structure of the two halves. When the two are connected into one rigid mass, it is expected that the vibration now experienced on the western and smaller half will entirely disappear. Before the bridge can be opened, however, the half that is now finishing and closed must be entirely complete. A very broad foot pavement will be laid down with small handsome terra-cotta tiles, crossbarred in contrary directions, to give firm foothold, and these are to be edged in with a kerb of red granite. These terra-cotta tiles are coming much into use. It is stated, as the result of experience, that they are better, drier, more easily repaired, and more durable for passenger traffic than granite itself. It has been decided to place the tramways for heavy traffic to and fro in the centre of the bridge, leaving two roadways of 20 feet wide on each side for the lighter vehicles. The side next the Houses of Parliament is completely finished, except some ornamental shields, that can be bolted into the Gothic quatrefoil spandrils of the arches at any moment. From this point, therefore, the effect of the whole structure can well be judged. The conventional street lamp-post will not intrude upon this thoroughfare, as handsome lamps and posts of cast-iron have been designed, in keeping with the main architectural features of the rest of the work, and all the iron portions of it are to be painted of a pale neutral tint, excepting only the ornamental shields before spoken of, which will be emblazoned with the arms of England and Westminster, in gold and enduring colours. Since the western half has been opened for traffic not the slightest sinking of the piers has taken place. When the entire bridge is finished there will be two footways of 15 feet wide each, two tramways in the centre of 7 feet 6 inches wide, and two roadways for the light traffic of 20 feet each. The extreme width of London-bridge is only 56 feet from parapet to parapet, or exactly the space of the roadway of the new bridge exclusive of footpaths. When all is complete, the bed of the river is to be dredged out of rubbish, &c., some 10 or 12 feet below its present level beneath the new arches. In a month or two more, for the first time within the last twenty years, the tide will flow unimpeded up and down the Thames.

Remains from Halicarnassus.—Among the remains brought from Halicarnassus is an alabaster scent-vase, eleven inches high, having upon it the name of Xerxes in two languages—one Egyptian hieroglyphics, and the other the arrow-headed characters of Assyria. It would seem to have been buried by Queen Artemisia in the celebrated mausoleum, the tomb of her husband Mausolus, as one of his most valued treasures.

Restoration of St. Mary's Church, Youghal, Cork.—This church has been recently restored. It is one of the largest, most ancient, and beautiful in Ireland, erected in the thirteenth century, most probably by Lord Thomas De Clare, son of the Earl of Hertford, on an ecclesiastical foundation still more ancient. It was re-edified by Thomas FitzGerald, Earl of Desmond, in the latter part of the fifteenth century. It is perfectly cruciform, and of the Early Pointed style of architecture, consisting of a choir, two transepts, a nave, and aisles, having a lofty tower of Norman foundation adjoining. The choir, which had been a ruin for many centuries, is now very beautiful, and its eastern window is grand in its dimensions, admirable stone tracery, and rich decorations of coloured glass, exhibiting an unusual number of armorial bearings. The monuments, also, are numerous and interesting, some very ancient. The roof of the nave is of massive Irish oak, of at least five centuries' standing, and in the walls on each side are six lofty pointed arches, the angles of which are faced with hewn stone. A modern lath-and-plaster ceiling, in accordance with churchwarden taste in general, had concealed this noble roof for a great number of years, and hideous galleries had occupied all the arches. The pulpit is richly carved in the style of the fourteenth century, and the baptismal font and sedilia are beautiful specimens of their early period.

Safety Haven for Miners.—Mr. George Walcott, C.E., suggests the following with reference to the late deplorable accident at Hartley Colliery. He says:—"Colliery proprietors are now impressed with the necessity of having two shafts to every pit, or at least a staple (communication) between upper and lower seams of coal, the want of which caused the fatality during the late tragedy. Permit me to suggest another safety-valve, which would protect the lives of miners. A brattice (division of a shaft) occasions generally sufficient ventilation in a pit to enable men to work in any part. When a brattice is disarranged the upward current of gas and downward passage of air cease, and probably at the same time the mode for pitmen leaving is ungeared. Imprisoned miners should then have the facility of escaping to prepared places in all the seams, where they might safely assemble and wait for relief. This object could be secured by imbedding under the casing that surrounds the perpendicular sides of a shaft a diaphragmatic or a double concentric pipe, laid from the outer air to the spots chosen as "havens of safety," which would thus ventilated perfectly distinct from and independent of the mode adopted for the rest of the underground workings. At each of the prepared places facility should be afforded for closing the branch pipes in seams where no men are staying. Particular rooms in buildings are often ventilated in a something similar manner."

New Roman Catholic Church, Rusholme, Manchester.—This edifice has just been erected in Thurloe-street, Rusholme, one of the suburbs of Manchester. The edifice is wholly built externally with Yorkshire stone "parpoints" and dressings of Hollington stone, and consists of a nave and side aisles, with aspidal chancel, and a lady-chapel at the extremity of its south aisle. A tower at the south-western angle serves as a porch, and it is intended to be crowned with an octangular spire about 130 feet high. The style of architecture is Geometric Middle Pointed, the details being treated with considerable originality. Internally the building is about 95 feet in length by 46 feet in width; the nave and aisles separated on each side by six cylindrical piers of polished Aberdeen granite, resting on octangular bases of white Sicilian marble. These piers support the arches on which rest the clerestory and roof of the nave, the aisle roofs abutting against them, and divided into bays by internal flying buttresses of brick, so designed as to present a continued series of transverse arches, seen from either extremity of the aisles. The high altar will be of Caen stone, having pillars of serpentine, and a rich tabernacle and canopy. The church will seat about 600 worshippers, and its cost (exclusive of fittings, but inclusive of the spire and architect's commission) will be about £3200, £1000 of which is the gift of two brothers, Messrs. B. and P. O'Connor, of Rusholme. Mr. Edward W. Pugin is the architect; and Mr. John Eaton, of Ashton-under-Lyne, the builder.

New Schools at Long Ashton, near Bristol.—The new parochial schools for Long Ashton were opened on the 22nd January. The new building comprises a boys' and girls' school, with two fine classrooms, cap and cloak rooms, and a master's house. It has suitable playgrounds, and the whole is surrounded with handsome railings in front, and neat fences at the sides and back. The erection is in the Early Decorated style, of Nailsea Pennant, with freestone dressings, and is ornamented with a handsome bell turret, supported with polished Purbeck marble columns, with carved capitals. The masonry is of the best description; the details have been carried out with much care and fidelity. The architect is Mr. J. Wilson, F.S.A., of Bath. Each of the rooms is light, airy, and well ventilated. The boys' schoolroom has an open roof, and is 50 feet in the clear by 20 feet, and is lighted by seven triple-light windows and a stained rose window. The girls' schoolroom is 48 feet by 18 feet, and has three large triple-light windows. The builders are Messrs. E. and J. Tucker, of Ashton.

CLASSIFIED LIST OF PATENTS SEALED IN FEB. 1862.

Arrangements are in progress by which increased facilities, in connection with the management of this Journal, will be afforded to Inventors for securing valid Patents.

1943 Brooman, R. A.—Locks and keys (com.)—August 5
1998 Wigzell, M.—Manufacture of screws and nails—August 10
1999 Wigzell, M.—Manufacture of nails, spiral throughout or in part—August 10

1959 Silvester, F.—Improvement in watches—August 6
2118 Coathorpe, H. B.—Improvements in timekeepers—August 24

2132 Peltier, E.—Improvement in manufacture of metallic boxes—August 27
1986 Chatwin, H.—Ornamenting card, pin, and needle cases—August 9

2009 Jacob, J.—Improvement in gilding porcelain and ceramic wares—August 13

1957 Newton, A. V.—Reversible seats (com.)—August 6

2026 Wilds, W.—Improvements in ventilating—August 14
2120 Jones, R.—Heating and ventilation—August 26

3124 Bell, W.—Cooking-ranges—December 13
2027 Billing, J.—Improvement in stoves—December 14
2053 Bennett, W.—Fuel for lighting fires—August 19

2045 Hill, H. C.—Fireproof buildings—August 17

2244 Birkbeck, G.H.—Improvement in saddles (com) September 7
2575 Adams, J. J.—Flexible backed horse brushes—October 19

2070 Ellis, J.—Apparatus for assorting corks into sizes—August 20
3031 Bousfield, G. T.—Stopper for bottles, jars, &c.—December 3

2066 Emes, H.—Improvement in dress fastenings—August 20
2109 Player, W.D.—Improvement in linen buttons—August 23
2556 Twigg, G.—Fastenings for stay busks—October 12
2004 Salomons, A.—Improved bodice skirt (com.)—August 12
2086 Desborough, S.—Improvement in umbrellas and parasols—August 15

2224 Mennons, M. A. F.—Motive power in connection with the Archimedian screw, (com.)—September 6

2061 Pedrick, T.—Application of water as a motive power—August 19
1952 Toluhasen, F.—Improvement in increasing the effect of motive power—August 6

2063 Ingram, G.—Trams in connection with wheels for common roads—August 20

1997 Barclay, A.—Machinery for raising or lowering heavy weights—August 10

1990 Godwin, R. A.—Improvement in pumps—August 9

1953 McMorran, J.—Machine for mincing meat—August 6
2665 McCall, J.—Improvement in preserving articles of food—October 24
2067 Brooman, R.A.—Preserving articles of food—August 20
3005 Labaume, J.A.—Refrigerating machines—November 28
2186 Muller, W.—Roasting coffee, cocoa, &c.—September 2

1981 Mott, A. J.—Improved vent for beer and other casks—August 9

1944 Seiler, F.—A method of overleaping low levels—August 5

2092 Graham, T.—Construction of boats and other floating structures—August 21

2017 Rippingille, E. A.—Improvements in steam engines—August 14

1948 Gallway, W., Gallway, J.—Improvements in steam boilers—August 6
2258 Barre, L. P.—Tubular steam boiler—September 11
2108 Elson, S.—Heating feed water of steam boilers—August 22
2961 Newton, A. V.—Preventing steam boilers from incrustation (com.)—November 25
2130 Attwood, H.—Cleansing and feeding boilers—August 26
2113 Bousfield, G. T.—Improvements in feeding boilers (com.)—August 23

2222 Mennons, M. A.—Smoke consuming furnaces (com)—September 6

2900 Parry, G.—Improvements in the manufacture of iron and steel—November 18

2197 Bischof, G.—Improvements in extracting copper and silver from ores—Sept. 3
2102 Baines, W.—Improvements in the construction of girders &c.—August 22
2230 Russell, J. J.—Improvements in attaching welded tubes to fixed plates—Sept. 6
3066 Russell, J. J.—Improvement in manufacture of taper tubes—December 6
2524 Russell, J. J.—Hand stocks and dies—October 9

2201 Bowns, J.—Railway brakes (com.)—September 4th
1995 Clarke, W. S. T.—Railway brakes—August 10
2069 Whittaker, S.—Railway signals—August 20

2185 Clark, W.—Railway signals (com)—September 2
2174 Pemberton, C.—Railway and other signals—August 31
2234 Henry, M.—Railway telegraph signals (com)—September 6
2725 Cook, W.—Improvements in printing telegraphs—October 30

2810 Berard, A. B.—Separating metals from their ores—November 8
2024 Edwards, E.—Improvements in apparatus for purifying mineral ores, &c.—August 14

2104 Whitworth, J., Wilson W.—Improvements in sights for small arms and ordnance—August 23
2042 Marcott, T., Hansom, C.—Improvements in breech loading fire arms—August 15
2284 Newton, W. E.—Improvements in guns (com.)—September 13
2453 Wyley, A.—Fire arms—October 2

2863 Bousfield, G.T.—Manufacture of soap—November 13
2162 Matthews, J.S.—Manufacture of starch—August 30

2058 Smith W.H.—Manufacture of peat—August 19

2029 Carey, S., Morgan, W.—Improvement in reburning animal charcoal—August 15
2032 Martin, J.C.—Improved method of treating bones and their products—August 15

2074 Lambert, R.S.—Vessel for removing boiling liquids from pans &c.—August 20

2012 Remy, J.G.—Utilizing the waste of the cedar tree—August 13
1928 Schinz, C.—Improvements in glass furnaces—August 3
1966 Webb, T.G.—Improvement in the manufacture of articles of glass—August 7

2088 Mennons, M.A.F.—Presses for lithographic printing (com)—August 20

2268 Mennons, M.A.F.—Manufacture of paper pulp (com)—September 12
2108 Richardson, T.—Improvement in manufacture of paper—August 22
2096 Johnson, J.H.—Manufacture of pulp for paper (com)—August 22

1934 Prince, A.—Improvement in palate plates for teeth (com)—August 3
2065 Fitkin, W.—Improved apparatus for extracting teeth—August 20

2064 Rostaing, A.—Improvement in spectacles—August 20
2083 Clark, W.—Improvement in optical and illuminating apparatus (com)—August 21

2676 Schalkenbach combination of keyed and percussion musical instruments—Oct. 25
2152 Jewell, P.—Improvement in concertinas—August 29

2159 Jaille, A.—Manufacture of manure—August 30
2043 Balmain, W.H.—Manufacture of salts of potash—November 28

2123 Nye, E.—Improvement in enemas and such like instruments—August 26

2057 Cathels, E.S.—Compensating gas meters—August 19
2607 Webster, J.—Manufacture of oxygen gas—October 19
2075 Gye, F.—Gasometers—August 20
2071 Somerville, J.—Tapping gas and water mains—August 20
2692 Stevens, C.—Mode of detecting the leakage of pipes &c.—October 26

2086 Salamon, N.—Sewing machines (com)—August 21
2086 Salamons, N.—Sewing machines (com.)—August 21
2115 Driver, J.—Washing machines—August 24
2143 Guiness, W. S.—Sewing machines—August 28

3093 Newton, W.E.—Improved knapsacks (com)—December 10
2114 Hyams, M.—Manufacture of smoking pipes—August 24

2223 Mennons, M A.F.—Ribbon looms (com)—September 6
2954 Lowry, G.—Carding and hackling machine—November 25
1989 Gray, J.—Improvements in mules for spinning—August 19
2015 Cooper, B.—Spinning machinery—August 13
2008 Horner, J. C.—Improvement in looms—August 13
2267 Mennons, F.—Lace machines (com.)—September 12

2126 Tolhausen, F.—Artificial fur worked in the loom (com)—August 26
3153 Davies, E.—Improvement in manufacture of textile material (com)—December 16
2166 Bishop, J.—Improvement in manufacture of velvet &c.—August 30
2038 Kesselmeyer, C. W.—Improvements in manufacture of velvets, &c.—August 15
2048 Livesey, J.—Textile fabrics for embroidery and trimmings—August 16
2094 Kano, J.—Preparation of fibres for yarn or thread—August 21
2011 Andrew, S., Hornby, S.—Cleaning and preparing cotton—August 13
2047 Sutton, E.—Cleaning and preparing cotton—August 17
1968 Eastwood, J. and J. C.—Converting waste fibrous material into yarn for spinning—August 8

2148 Corbett, S.—Crushing and grinding machines—August 29

2078 Fisher, N.—Improved implements for cultivating land—August 20
2354 Perman, C.—Implements for cultivating hard soil—September 20
2576 Newton, A.V.—Grain and grass harvester (com)—October 16
2060 Firth, W.—Improved implements for cultivating land—August 19
2169 Hensman, W.—Steam ploughs—August 31

3047 Carr, A.T.—Improvement in horse shoes—December 5
1993 Stocker, S.A. Stocker, R.A.—Improvements in horse shoes & boot heels—Aug 10

2107 Childs, A.B.—Dressing of mill stones (com)—August 28

2117 Cranston, J.—Improvements in constructing conservatories & large sheds—Aug 24
1982 Moody, C. P.—Improvement in manufacture of gates—August 9

1950 Wappenstein, R.—Improvement in cop tubes and roller covers—August 6

2089 Murat, J. M.—Manufacture of military hat tufts—August 21
2168 Clark, W.—Improvements in manufacture of shirts (com)—August 30
2124 Lechêne, A.—Imitation of lace and embroidery—August 26
2140 Grange, A.—Manufacture of shirt collars, cuffs, fronts, &c.—August 28
2262 Birkbeck, G. H.—Improvement in needles (com.)—September 12

2100 Casella, L. M.—Mercurial thermometer—August 22

2135 Azémar, J. C. C.—Instrument for facilitating the practice of the drum—August 27

2295 Jenning, H. C.—Preparing hides and skins—September 14
2037 Menard, A. F.—Improvements in tanning—August 15

2686 Sicard, J. L.—Machine for purifying and weighing grain—October 26
2738 Williams, W. J.—Improvements in weighing machines—November 1

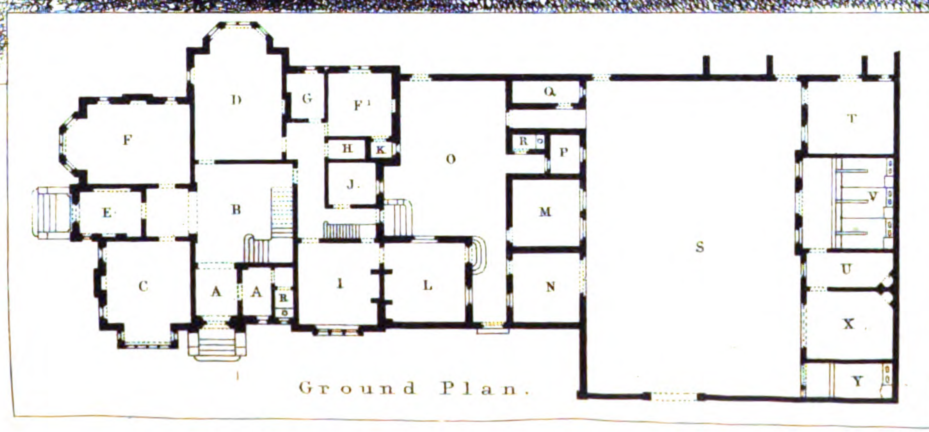
2153 Newton, A.—Machinery for cleaning rice and other grain, (com.)—August 29

2220 Greenwood, T.—Wood sawing machinery—September 5

ERRATA.

Ante page 86, col. 2, line 36, —w should be —w_1.

J.R.Jobbins.



Ground Plan.

S.E. VIEW OF H. OXLEY, ESQ.RE RESIDENCE AT WESTWOOD.

WILL.M HILL, ARCH.T

SUBURBAN VILLA, WEETWOOD, NEAR LEEDS.

(*With an Engraving.*)

This Villa, of which we give a perspective view and ground plan, is now in course of erection at Weetwood, near Leeds, for Henry Oxley, Esq., banker, of that town. The plan shows the accommodation and arrangement of the principal floor, which comprises entrance-hall, staircase saloon, 21 feet by 21 feet; dining-room, 28 feet by 18 feet; drawing-room, 25 feet by 17 feet; breakfast-room, 22 feet by 17 feet; waiting-room, store-room, butler's pantry, housemaid's closet, plate store, larder, kitchen, 17 feet by 17 feet; scullery, 17 feet by 16 feet; washhouse, stables, and other out-buildings. The staircase saloon is lighted by a central ceiling-light; the staircase is of stone; and communication is made to the principal bed-rooms on chamber floor by a spacious gallery. The chamber floor comprises six principal bed-rooms, dressing-rooms, closets, bath-room, water-closet, and housemaid's closet; attics are also provided for servants. At the entrance to the grounds it is intended to erect a lodge, and recessed carriage-gates and piers. The building is faced with Potternewton wall-stone, and Weetwood sandstone dressings. It is from the designs of Mr. William Hill, architect, Leeds, and is being carried out in a very satisfactory manner, under his superintendence, by Messrs. J. and B. Pounder, of Leeds. The estimated cost of the buildings, including lodge, entrance-gates, stables, &c., is £3700.

REFERENCES TO GROUND PLAN.

A. Entrance hall and cloak-room.	M. Washhouse.
B. Staircase saloon.	N. Coals.
C. Breakfast-room.	O. Kitchen-court.
D. Dining-room.	P. Dust.
E. Ante-room.	Q. Hen-roost.
F. Drawing-room.	R. Watercloset.
G. Store.	S. Stable court.
H. Housemaid's closet.	T. Mistal.
I. Kitchen.	V. Stable.
J. Larder.	U. Harness.
K. Safe.	X. Coach-house.
L. Scullery.	Y. Loose box.

THE BUILDING FOR THE INTERNATIONAL EXHIBITION.

This great undertaking has advanced rapidly since our last notice of it, and yet now, within a month of its opening, the amount of work still remaining to be done appears overwhelming —especially in the preparation of counters, fittinggs, and all other arrangements for the display of goods.

The building however is far advanced, and it becomes possible to form a judgment upon its interior effect without much liability to error, while externally it is for all purposes of criticism complete. The unfavourable opinion expressed by us from the first (Journal for April 1861) is—we say it with regret—fully confirmed by the appearance of the building as seen from any adjacent spot, and worst of all, as seen from the spot where it would be desirable that it should show to greatest advantage, namely, the upper part of the Horticultural Gardens. The domes especially show singularly the desirableness of qualifications in the designer of large ornamental features, which seem, naturally enough, not to have been possessed by the author of this design. We mean the faculty of judging beforehand of the *effect* of certain forms when seen at a height above the eye and in combination with adjoining features. Any real architect would have both foreseen and avoided the distortions of outline to which these unhappy domes are subject as the spectator changes his point of sight; distortions so remarkable, as in themselves to be worthy of some study and attention on the part of professional men, as examples of what to avoid.

The felt covering of the exterior of the roofs, has now had a covering of zinc superposed over it, which will we hope, secure the interior from serious leakage, although the building is not yet thoroughly water-tight. The scaffolds on which the domes were erected, and which were retained to facilitate the painting of them, are now being struck; from their massive character, this is a very long process, and it will not be quite completed for some little time; the preparations for laying the floors under these domes are, however, fast advancing, and the raised floors, which it will be remembered were proposed to be formed there, promise to form very effective features. Except in parts of the nave, where much heavy work is being done in the way of preparation of foundations for trophies, fountains, &c., the floors throughout are nearly all laid, and are covered in all directions with unopened packages of goods. A wilderness of wooden partitions, to afford hanging room, is springing up in various directions, while in other spots the localities for such erections are distinguishable, set out upon the floor in red lines.

The most interesting novelty however to a visitor entering the building after an absence of a few weeks, would undoubtedly be the coloured decoration of the interior. This it was decided, after numerous experiments and considerable consultation, to commit to the experienced hands of Mr. Crace.

Without for a moment asserting, or supposing that this colouring will be pronounced so brilliant a success as that of the Exhibition of 1851, done by Mr. Owen Jones, we cannot but recognize Mr. Crace's work as in the main successful, and as having to a very great extent done good to the internal effect of the building; though we cannot help expressing regret that the same cause which prevented recourse being had to the best sources for advice as to the design of the building, or a similar one, should have deprived us of the services in its decoration of Mr. Owen Jones, undoubtedly the first colourist of this, perhaps of any nation.

The colouring of the nave-roof is of course one of the most important features of the work, and is the one which can be best judged of at the present moment, as the domes are still partly filled by scaffolding, which interrupts the view both of themselves and the transepts.

The boarding of the roof is painted a light and delicate pearly grey, the purlins are white, slightly relieved by red patterns, and between each pair of trusses three bands of light red, with a little ornamental scroll-work, in the same colour, not occupying too much of the plane surfaces, are carried across the ceiling. The polygonal ribs of the trusses have a sort of billet moulding in black and white on their soffits, forming a continuous line, while their sides are coloured with alternate lengths of red and blue—upon which a rather too elaborate and busy pattern is executed in lighter lines of colour. The columns from which these ribs spring are of a light sage green with a tinge of bronze, and have vertical lines in yellow; a little gold is introduced in the capitals, and a little decided colour on the bases, bands, and at one or two other points, while the ornamental balustrade forming the fronts of the galleries is coloured of a tint to correspond with the columns, heightened with gold on the prominent parts of the pattern.

One principal aim of any colourist would have been to attempt to give as great an air of height to the roof as possible, and here Mr. Crace has been decidedly successful, perhaps as much so as possible. He has also adopted a very happy and simple expedient for producing a blending of colour, in painting his ribs so that when seen in perspective, the red portions of one are seen close to the blue portions of the next, and so on alternately; one of those methods the very obviousness of which might have made a less less experienced hand overlook it. It seems a matter of doubt whether more positive colour ought not to have been put on to the columns, so as to carry the line of colour down to the ground, this however is a matter which could easily be done, if, as the building approaches completion, it appears to be needed. One unfortunate result has, however, followed the method of colouring in lengths adopted for the ribs, a result we much regret. These lengths coinciding as they do with the boards of which the ribs are formed, destroy them entirely as apparent semicircles. Before being coloured however, these ribs really had the effect of being curved, without the difficulty or expense of being made so, and it is very unfortunate that the colouring has destroyed this illusion, which was one of the great merits of the roof.

The domes and transepts internally bid fair to be more effective than the nave; though, as we have said, they cannot yet be so well judged of. A broad band of blue, with an inscription in letters of noble height and size, runs round the drum immediately below the springing of the dome. The spandrels below are mainly of a dull red, and have large circles painted in them, each occupied by a figure. These medallions have been executed by Mr. H. Burchett and his pupils, at the South Kensington School of Art, in the short space of a fortnight.

The great arches are encircled by a broad band of sage green—a good deal broken however, as are the spandrels, by lines of colour. The transepts present a considerable amount of wall-space, which is coloured a dull red, of a most satisfactory shade, and one that throws up the colours above it extremely well. We have only to add, that the ribs of the glass dome, and the solid centre, are also painted; but, owing to the light which floods in past them, they are but dimly seen, and of course the brighter the day the less apparent they will be.

The courts and annexes appear to have been designedly coloured as unobtrusively as possible, pale sage green on the columns, and light secondary and tertiary greys, with a very sparing intermixture of positive colour is here employed, and the result is a very diffused, quiet, but light neutral tone. The columns however are decidedly too pale, and do not stand out enough from the grey shadows behind them, and the oblique lines of the roofs seen across them, the consequence of which is that a very unsatisfactory appearance of crookedness, the result of optical illusion, is to be seen in some of the courts. This excepted, however, the courts, airy, roomy, and light, seem to leave nothing to be desired.

In concluding these remarks, we must first observe, that the tones, tints, and shades of colour throughout are chosen with great judgment, and with a careful regard to the laws governing the harmony and contrast of colours; and, secondly, that the difficulty of the work, and the consequent merit of it, have been materially increased by three circumstances of unusual occurrence; the first, the vast magnitude of the surfaces to be dealt with; the second, the short space of time in which the whole had to be designed and arranged; and the third, the disadvantage that it has been impossible for the artist to form an opinion of the results of his work, by actual inspection of them, till a period when it had become impossible to introduce any modification, improvement, or correction.

THE ALBERT MEMORIAL.

The natural manifestation of sorrow for the public loss sustained by the decease of Prince Albert, and of sympathy for the private loss of the Queen, has we believe, no parallel for its unanimity in the history of England. It was natural and proper that this public sentiment should seek to record itself in a monument worthy of the Prince; and it was natural and proper that the Queen herself should be consulted as to the design of the memorial. The Royal wish that the intended monument should be an obelisk may without presumption be attributed in some degree to a supposition, encouraged by the press, that such a suggestion would be agreeable to public feeling.

We have no intention of criticising the suggestion. If it be not the best that could be made, it has yet considerable merits; and even if the merits were less than they are, the affecting circumstances in which the selection was made would silence the voice of criticism.

But it will not be inopportune to consider some of the principles which ought to govern the designs of monuments generally. What is a monument? If it be a monument and nothing else—if it be not made to serve some secondary utilitarian purpose—it is a structural record of some past event. It is obvious that the chief requisites of such a structure are expression, durability, conspicuousness, and artistic excellence: expression, because the monument has to tell a story; durability, because it has to tell the story to remote ages; conspicuousness, that the story may be proclaimed publicly; artistic excellence, because no permanent structure should be without that merit.

Two of these requisites an obelisk possesses in a high degree. It is usually very durable and very conspicuous. To the quality of expression also an obelisk has some claim. Its form shows that it is a memorial of *some* event, for it is obviously adapted to no other purpose. To designate the particular event intended to be recorded, this, like all other kinds of monuments, requires the accessories of sculpture or inscriptions.

The quality of artistic excellence is made up of so many elements, that the judgment of mankind with respect to the artistic merit of any work of art varies accordingly as men give predominance to this or that element. The least-educated judgment gives preference to the most costly and elaborate works. There is something gratifying to every taste—and especially to a vulgar taste—in seeing in a work of art evidences of great cost and labour. This merit is not to be under-estimated simply because it gratifies the uneducated as well as the educated taste. For the taste is reasonable; it is reasonable that a monument should be costly because it is a tribute of gratitude, and the gratitude is not earnest which pays its tribute parsimoniously.

But the costliness of an obelisk is, though a merit—a merit of the lowest kind: that costliness arises from the necessity of transporting a great stone from a distance, cutting it into a very simple form, and erecting it. In all these operations there is very little of mental labour—or at least of mental labour exclusively appropriated to the occasion. Almost all the labour bestowed is physical, and may be represented by so much steam power. It is true, there must be some engineering skill employed, but it is of a kind not peculiarly required for this one work and no other. The engineering contrivances wanted for erecting an obelisk are the same as those which would be required for moving other great weights of the same form; and it would clearly be as unreasonable to reckon these contrivances as special merits of the obelisk, as to put to its credit the thought and science which invented the steam engines which will be used to move it, shape it, or polish it.

If we regard it historically, the obelisk is only a simple improvement of the rudest of all monuments—a single unsculptured stone—such probably as the pillar which Jacob set up at Bethel. The artistic merit of these and similar structures, such as the Druidic, simply depends on the amount of labour involved in their erection; and that merit is less and less as machinery becomes more and more efficient to save labour.

It is true that the sculptural accessories of an obelisk may display any amount of mental labour and artistic design. But the merits due to this cause are no part of the merits of the obelisk, for they might exist if the same accessories were combined with a different monument. There are no sculptural graces, as far as we are aware, that are specially appropriate to an obelisk. On the contrary, there are special difficulties in combining an obelisk with statues on account of the excessive disproportion of their respective heights.

If, however, the artistic merit of an obelisk be not very great, it at least has this recommendation—that it does not grossly violate the principles of good taste. Experience teaches us that in London such an advantage is of great value. A monument which is not positively offensive becomes, by comparison with those which already exist in London, positively meritorious. The metropolitan monuments are objectionable, not merely by faults of execution, but also by inherent defects in their designs. They are principally uncanopied statues and isolated columns. The latter are architectural solecisms, for the form of columns is so manifestly contrived for the support of superstructures, that a column without a superstructure reveals itself to be a thing out of place. Again, uncanopied statues are in our climate at least objectionable, not merely because of the absurdity of honouring a man by exposing his unsheltered effigies to every pitiless storm, but also because the statue must be impaired and ultimately destroyed by the exposure. The erection of uncanopied statues in this country we believe to have been never practised until after the decay of our national architecture. The builders of our cathedrals placed their statues under canopies or in recesses; their delicate sense of propriety would have been shocked by the barbarous and irreverent treatment of statues to which we are now accustomed. If we mistake not, there is not a single instance of a mediæval uncanopied statue.

There is not in this country any form of out-door monuments free from all the defects above referred to, except the ancient Gothic "crosses," such as those erected by Edward I. to the memory of his queen, one of which—a very beautiful example—remains at Waltham. In these so-called "crosses" there is such a combination of architecture and sculpture as satisfies most completely all the essential requisites of a memorial. The cross is susceptible of infinite variety of design, magnitude, costliness, and decoration; it is durable, as the existing examples prove; it tells its story quite as intelligibly as an obelisk; and, probably, in a future generation, when the affectation of pagan forms is out of date, will be considered infinitely more beautiful.

THE ARCHITECTURAL EXHIBITION

In this important year, when, on a second occasion the world's gathering is to be assembled in our metropolis to do honour to an International Exhibition, it is satisfactory to believe that the claims of others, which about this time are accustomed to make their annual appearance, have not been forgotten, although for the nonce they must expect to shine with diminished lustre in the face of their more absorbing rival. Great efforts are being made, we are aware, in order that Architecture, among other fine arts, may be worthily represented at Kensington; but we are glad to see that the walls of the Conduit Street Galleries are none the less bare on that account, and that in some desirable respects this exhibition has made a step in advance towards becoming a more genuine, as well as a more useful, institution. In one department, however, there appears a deficiency which gives cause for regret. The space usually allotted to the display of materials, and of practical works, patents, &c. has been apparently this year less in demand (possibly owing in a great measure to the cause to which we have already adverted), while there is also a decided lack of novelty in the general character of the articles exhibited. Of course it is not to be presumed, or even wished, that this department should present an entirely different aspect on each successive season; we are only too glad to welcome the continual revival of those old and well-tried objects which cannot be placed too often or too prominently in view, especially the many economical and sanitary contrivances which have been devised of late, and which are to the public at large so inestimable a boon. Still, we cannot close our eyes to the fact, that this portion of the Architectural Exhibition does not keep pace with the march of improvement out of doors; that either inventors are not sufficiently alive to the expediency of thus making their products known, or that visitors to the galleries have been tardy in recognizing and encouraging such efforts as have from time to time been praiseworthily made. Now, whichever be the true cause (and there may be a blending of both), this is a state of things that ought to be remedied, for the well-being not merely of the exhibition itself, but also of the parties who it is intended shall be mutually and more immediately benefited by the plan. That the scheme has thus worked well no one can deny: that it is capable of producing much greater results is equally incontrovertible. Let, then, our men of science and skilful artificers not so much overlook the opportunity in future.

Reverting, however, to the Exhibition generally, and glancing at the catalogue, it is at once evident that our country friends have put forth greater strength than heretofore, while that in point of merit, as well as numbers, not a few of their works prove most valuable and acceptable contributions. In the matter of recent competitions, too, the drawings, which are liberally sprinkled over the walls, have been gleaned from various parts of the kingdom, and the means hereby afforded for duly comparing them one with another is one of the many evidences of the utility of the exhibition we are now commending. Among such competition subjects, designs for which are more or less elucidated in the present collection, may be mentioned—the Town Halls for Northampton, Hull, and Tiverton; the County and Borough Halls, Guildford; the Devon and Cornwall Bank; the Agricultural Hall, Islington; Bath Markets, &c. Then again, the "Architectural Publication Society," and the "Architectural Association," display, as usual, broadsheets of subjects, selected from those issued during the past year, while numerous large cartoons for stained glass, and a few smaller ones, interspersed among the ordinary pictures, serve to vary and enliven the general effect of the whole. Decoration, as such, would seem to be less represented than formerly, though on the opening night some beautiful specimens, lent for the occasion, and more particularly one, in which colours of the most vivid as well as sombre hues had been successfully transferred to a ground of pure white satin, were the theme of general comment and admiration.

One feature, in which the present exhibition differs from its predecessors, is due to the now almost universal application of photography in reproducing drawings, and fac-similes of the effect of sculptured and other works in relief. While fully sensible of the advantages which cannot but accrue to the cause of art by the liberal use of means such as these, when pursued in the right direction, we must take care that its facile assistance does not induce a laxity or carelessness among those to whom the practice of freehand drawing, and the power of ready expression of ideas either by pen, pencil, or brush, should be in constant exercise. There is an evident danger of this, and, as in some degree corroborating our apprehensions, we need only direct attention to the large ratio which the photographs on these walls bear to the more old-fashioned, yet (we venture to assert) more legitimate modes of representation, which, spite of all their shortcomings, are alike of infinite service to the experienced practitioner and to the comparative novice in art.

But it is time we should enter upon our task of examining the drawings seriatim, though we cannot but advert for a moment to that which may well be deemed a supplementary exhibition, separate and distinct, which occupies the whole of the ante-gallery, besides covering numerous screens, in the room, viz., the series of architectural sketches and drawings, some hundreds in number, made by the late A. Welby Pugin, and lent for the purpose by his Son, the present Mr. Edward W. Pugin. These constitute of themselves a perfect study, and are marvels of industry and artistic skill. Pugin might be termed a man of intuitive discernment in all that regards the principles of ancient art, and he pursued their many-phased developments with an ardour of devotion which never knew fatigue, but which brought him to an early grave. In the specimens as here arranged we can almost read the character of their author. Be they sketchy or detailed, in outline or colour, there can be no question as to the *motif* of each individual work, or as to the amazing power of hand, acquired by that constant "practice" we have been advocating, which could so readily and faithfully express the ideas he was anxious to bear away. Thus the infinite variety of subjects which are presented, and their mode of delineation, are alike evidences of the workings of a master mind, to which, in its peculiar line, it would be difficult to point out an equal. On this we shall, however, have more to say when we come to notice these drawings more minutely.

Among the first drawings which attract attention are (7 and 8), by Mr. E. W. Godwin, which consist of the principal elevations for the "Town Halls at Hull, and Northampton," the latter now in course of erection. These drawings are advantageously placed side by side, and present some degree of similarity to each other —in idea at least,—both being based upon the received interpretation of Italian Gothic, as now so largely practised in this country, and both being composed of the same elements of detail, into which figure sculpture and inlay surface-work are conspicuous features. It appears to us that in the former of these designs the statues ranging along the front are too large, destroying in effect the real scale of the building, which in other respects looks more broken up, and not so well balanced as the simpler and nobler façade at Northampton. As well drawn and effective sepia elevations, without adventitious aid, they deserve an appoving mention, and the same may be recorded of (31), Mr. Godwin's competition design for the "Public Hall and Market, at Swansea," though the design itself appears less successful than the others just mentioned. No. 2, shows some well photographed sculpture executed by Mr. Nicholls, for Gayhurst, from the design of Mr. Burges. It will be remembered that some other portions of this building were shown in last year's exhibition; those before us mark simply the enrichments of one of the fireplaces and doors. The subjects are in low relief, and illustrate respectively the Expulsion from Eden, and the Bringing in of the Boar's head; the latter occupying the whole width of the door between the architrave and the ceiling. 4, 5, Sketches in water colour of "Norwich Cathedral" and "St. Ersamus' Chapel, Westminster Abbey," by Mr. Warren, are unpretending, but cleverly touched in.

Mr. C. F. Hayward exhibits chiefly photographs, some being of subjects which have before appeared in the shape of larger drawings. Two of the best of these are comprised in (9), Schools and a Shop erected at Halstead; (47) is a photograph of the Lodge of the Tailors' Benevolent Institution; and (35), is another, of the Chalêt erected by Mr. Hayward, at Lexdon, near Colchester. In these, as well as other contributions from the same hand, there is evidence of an originality; which, if not always equally successful, is to be commended, so long as it oversteps not the bounds of correct taste. Mr. Whichcord, in the "Parade now erecting at Blackheath" (6), presents what consists mainly of a row of shops, the houses themselves being set back; and, excepting it be the extent of the undertaking, there is really little on the face of it to call for so pretentious a drawing. The "Offices and sale-rooms" being erected from Mr. Whichcord's designs, in Water-lane, City, as shewn in (20), though more characteristic, are yet deficient in effect, compared with the majority of the noble structures of this class, which have especially marked the metropolitan improvements of the last ten years. It is wanting in boldness and relief of parts; the main cornice being sadly at fault. Mr. Corson is, as usual, an exhibitor of some of the numerous works he is executing near Leeds, (10 and 11) being photographs of a large mansion, in design, perhaps, not one of his happiest efforts, but yet with some very good points. The vignette additions to the drawing are tasteful. We should be glad to omit reference to Messrs. Francis' "Redhill Market Hall and Assembly Room" (12), but its very absurdities press it into notice. What can be more incongruous than the mixture of Italian in a portico, Elizabethan in windows and parapets, and Gothic diagonal buttresses at the angles, each of the most unmistakable kind? Yet this is the composition which exists, not only on paper, but was "erected 1860." This drawing reappears, moreover, among a group of other photographed designs in (57). In a "Competition design for Schools at Caistor" (14), Messrs. Hooker and Wheeler have shown considerable taste. The arrangement and outline are unusually satisfactory,—the material chiefly red brick. Many of the competition designs for the "Godolphin Schools, at Hammersmith," were contributed to last year's exhibition; we have in the present one (15), a view of the building, as just completed, the architect being Mr. C. H. Cooke. The central portion, including the oriel, is its most satisfactory part, and the least so is the tower immediately above, but the whole mass has a rather heavy and ungainly look, and some of the details would have been better if bolder.

The beautiful photograph etching (19), of "Archbishop Holgate's Hospital, York," by Mr. R. P. Pope, will be recognised as a reduction of the skilful drawing which lately enriched the Royal Academy walls, and which we then took occasion to notice. (22), another photograph—that of the "Tomb erected in Lichfield Cathedral to the Memory of Major Hodson," and sculptured by Mr. Earp, from designs by Mr. Street,—will remind our readers of the lithograph of the same subject which accompanied our number of this Journal for Sept. 1860. In (48) also, Mr. Earp has photographed various groups of sculpture, mostly executed for Lord Calthorpe's new mansion at Elvetham. One of these photographs consists of portions of a reredos erected at Wymering Church, Hants, and designed by Mr. Street. These subjects represent—Our Lord bearing his Cross, the Crucifixion, and the Descent from the Cross. The "Torquay Gas Company's Labourers' Cottages" (23), by Mr. Appleton, are tolerably good-looking, and have the recommendation of being comfortably planned. Each cottage contains several rooms, with the usual out-buildings; the cost of the six, including fittings, being £833 2*s.* 8*d.* The materials used are local red sandstone, with white and red brick dressings, but the doorways are of rounded fire-clay bricks.

In (24) is shown an ingenious "slip roof" for building iron-cased frigates, and now erecting at Millwall, for Messrs. C. J. Mare and Co. Though this is essentially a constructive work, and of a kind usually entrusted to engineers, in the present instance we are glad to find that it is under the direction of an architect, Mr. Edmeston, and the result is an evidence of no little thought and ingenuity well applied. There is no pretension to extraneous ornament, which, indeed, would be out of place; but it consists of a well-balanced system of iron construction. The length is 410 feet, and the width 82 feet 6 inches. The roof is wholly of bar and angle iron, the standards being of cast-iron. These standards are 4 feet wide at the base, and diminish towards the top. The total height is 70 feet. The roof is entirely glazed, the sides are closed, and to be covered with De Vaux's zinc. Mr. Edmeston also exhibits (50), "Messrs. King's Premises, No. 77, Thames-street," a lofty brick building of six stories; and (242, 244) "Homes for Poor Merchants' Clerks," erected at Muswell Hill, in memory of the late Matthew Uzielli, Esq. Nos. 25, 177, are in continuation of the series of continental sketches furnished from time to time by Mr. I'Anson, and are as usual interesting and cleverly sketched; his two other pictures this year (30, 49), explain the designs of a "Villa at Dulwich." A modern Classic Font is a rarity; but it would seem, from (26), that Mr. Knightly has placed one in St. Matthew's Church, Bethnal Green. The bowl is circular—basket-work, in fact—and is supported by four figures of rather disproportionate size. Mr. C. F. Hayward's "Roof of the Chapel of the Tailors' Benevolent Institution, Haverstock Hill" (27), is ceiled to a polygonal form, of low pitch, the trusses are on the hammer-beam principle, and have moulded ribs, and traceried spandrels. Altogether the design is a very successful one. (28), Messrs. Green and De Ville's Competition Design for Hull Town Hall, shows an Italian composition, hardly equal to some we have seen before from the same quarter. The intercolumniations of the Corinthian order are far too great, this unwonted lightness of effect is not being compensated for by the coupled columns at the angles. The basement story is rusticated. We are sorry we cannot say a word in favour of their adjoining drawing (29), a "Design for a Chapel at Hampstead," a would-be-gothic elevation of the strangest kind.

No. 44 is a proof of the increasing use of sculptured decoration, and especially in figure subjects, for domestic as well as ecclesiastical purposes; and consists of four photographs of part of a series of sculptures of this description decorating the corridor of a house at Sydney, and executed by Mr. Nicholls. Mr. Phene Spiers sends, as he has before done, some delicately-tinted drawings—viz., (45, 247, 248.) In these the Classic feeling decidedly predominates. The "Cemetery Chapel," &c., erected at Low Leyton, Essex, by Messrs. Willson and Nicholl, is well situated, and the design is happily adapted, indeed one of the best of the numerous edifices of this kind which have been necessitated by the recent enactments. These several buildings are well shown by photographs in (46). Messrs. Dobson and Kyle's "New Buildings at Newcastle-on-Tyne" (51), will hardly sustain the character for good street architecture for which that town has long been famous. This design is an extensive pile, and erected on the site of the great fire which took place in 1854. (54) is a frame containing three very good designs by Mr. M. P. Manning, the first of which, the New Chapel at Hampton, Middlesex, though very plain, possesses great merit.

(To be continued.)

In spite of adverse weather, the attendance of members and their friends, including not a few ladies, was considerable on the occasion of the inauguration of the Twelfth Exhibition, by the usual *conversazione*, on the 25th ult., the evening preceding its being open to the public. Speech-making was wisely as much as possible curtailed, so as to leave the greater part of the evening free for visitors to examine the works of art around, and to renew associations among friends who rarely, perhaps, meet but under these or similar circumstances. The principal speakers were the chairman, the Rev. Mr. Burgess, who descanted on the greater public spirit and liberality which, on the whole, characterise our continental neighbours in reference to national projects, as compared with ourselves,—a theme suggested by looking at some of the drawings on the walls;—and Professor Kerr, who threw out some remarks on past exhibitions, and some excellent hints as to future ones. A brief report of a satisfactory nature was also read by one of the hon. secretaries, Mr. Edmeston. During the time of the Exhibition, the following lectures will be given on Tuesday evenings, in the galleries:—

May 6. On the transport and erection of Obelisks, and other large Monoliths, in ancient and modern times. By Prof. Donaldson.
May 13. The Character and Career of the late A. W. Pugin. By Prof. Kerr.
May 20. Pagan Architecture. By W. Burges.
May 27. Conventionality in Ornament. By J. P. Seddon.
June 3. The Truthful in Art. By R. W. Edis.

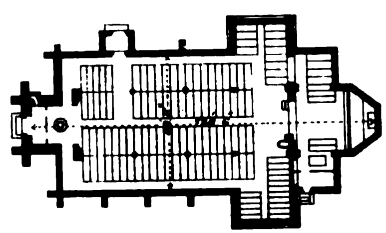
Though the Exhibition will remain open till the 30th of June, we recommend our readers to pay it an early visit, and they will probably repeat it once and again. To facilitate such intentions, season tickets admitting at all times to the Exhibition, the Pugin Collection, and the Lectures, are obtainable as heretofore at half-a-crown each; these tickets have invariably commanded, as might be expected, an extensive circulation.

NEW CHURCH, OVER-DARWEN, LANCASHIRE.

(With an Engraving.)

The Church forming the subject of our illustration is now in course of erection at Over-Darwen, and is intended to supply a want long felt—of additional church accommodation in that rapidly-increasing district. The entire expense of its erection, we understand, is to be borne by Mr. and Mrs. Graham, of Turncroft, Over-Darwen. The edifice stands within their grounds, on a beautiful site at the south end of the town, where it forms an imposing feature. The structure will be entirely erected from the stone found in the vicinity, a "strong-gritted" durable freestone being adopted for the dressings and hewn work, and for the exterior walling "parpoints." These latter are procured from Mr. Graham's flag quarries, in close proximity to the new church; and, being set in narrow courses of from three to five inches, make a very pretty and durable wall. The small plan accompanying the view will be found to explain the general arrangements. The columns and arches, and all internal window-jambs, arches, &c., are worked in stone, relieved by a few small detached shafts of polished Aberdeen granite. All doors and the chancel seats will be executed in Dantzic oak; the seats in the body of the church of pitch-pine, varnished. The roofs, worked out of red deal or Baltic, are of massive construction. The chancel will be vaulted with hood ribs, filled in with narrow boards, with carved bosses at the intersection of the ribs; the whole being decorated in colours. The cost of the church will be about £6000. The architect is Mr. E. S. Paley, of Lancaster.

April 1862 J.R.Jobbins.



NEW CHURCH ABOUT TO BE ERECTED AND ENDOWED BY Mr. AND Mrs. GRAHAM OF TURNCROFT, OVER DARWEN.

E. G. PALEY, ARCHITECT

THE ECONOMIC ANGLES IN PARALLEL OPENWORK GIRDERS.

(*Continued from page* 69.)

Let N be the number of bays into which the span S is divided by the points of concentration of the loading. Let θ represent in a general manner the angle which a brace makes with the vertical direction, and V the vertical component of the stress upon the brace.

In our last paper we have shown that when N is of any previously assigned value, the economic values of θ as calculated for the bracing taken alone will also be the economic values of θ for the whole girder, that is, for the bracing and booms taken together. The question is therefore reduced to the determination of the economic angles for the bracing. This, however, ignores the end pillars: but as these more properly belong to the piers, and may, in fact, have no separate existence, they may very properly be excluded from the more general investigations; but in some of the examples to be given in our next paper, their influence will be pointed out.

The effect of the depth of the girder upon the weight or cost of the web.—Before proceeding to the more immediate objects of this paper, we may here state at somewhat greater length a fact first published in 1855 (see vol. xviii.* page 236): we refer to the constancy of the amount of material required for the bracing of an openwork girder, when the values of S, θ, W, and a* are constant, although the value of D, and with it the amount of the material in the booms, may undergo any degree of change.

This will be most convincingly shown by direct calculation of some extreme examples.

Let us assume, then, as in some of the cases in our last paper, that S = 12 units, $\theta = 45°$, and W = 6 units, and that the braces are in pairs, or the numbers of struts and ties equal.

Fig. 1.

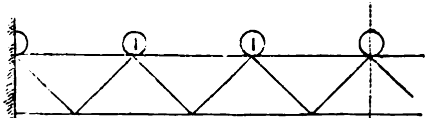
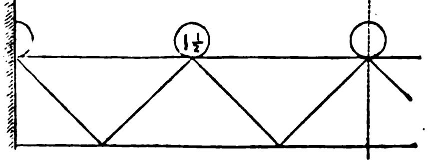


Fig. 2.



Now, the weight of any brace is $= V.D.\sec^2\theta.a$; and since here we have $\sec^2\theta = 2$, and $D = S \div 2N$, and the portion of the loading at each supported point $= W \div N$, the material in the bracings for the case of a fixed load, half only of each structure being taken, will be as follows:—

Fig. 1.

$\left.\begin{matrix}N=6\\D=1\end{matrix}\right\}$ Bracing$=(\tfrac{1}{2}+1\tfrac{1}{2}+2\tfrac{1}{2})D2(a_1+a_2)=9(a_1+a_2)$

Fig. 2.

$\left.\begin{matrix}N=4\\D=1\cdot5\end{matrix}\right\}$ Ditto $=(\tfrac{3}{4}+2\tfrac{1}{4})D2(a_1+a_2)=9(a_1+a_2)$

$\left.\begin{matrix}N=2\\D=3\end{matrix}\right\}$ Ditto $=(1\cdot5)D2(a_1+a_2)=9(a_1+a_2)$

$\left.\begin{matrix}N=12\\D=0\cdot5\end{matrix}\right\}$ Ditto $=(\tfrac{1}{4}+\tfrac{3}{4}+1\tfrac{1}{4}+1\tfrac{3}{4}+2\tfrac{1}{4}+2\tfrac{3}{4})D2(a_1+a_2)=9(a_1+a_2)$

So that, in the case of a fixed loading, there is absolutely no change produced on the amount of the material in the braces, estimated with fixed values of a_1 and a_2.

On the other hand, when the loading is treated as wholly moveable, we find that on increasing N, the increase of the stresses on the braces resulting from the mobility of the load, is augmented. The calculations are more complicated than the above; but the results given below will show the character of the increase. (See table next column.)

If we exclude from these results the exceptional case of N = 2, we see that the variations produced in the amounts of material in the bracing, by changes in the value of D, are very moderate, even when all the loading is treated as moveable. When, however, the question is treated practically, the slight advantage shown on the side of a high value of D will be more than destroyed by the necessary increase of a_2 for the struts on account of their increased lengths.

*For the meaning of the symbol a, see *ante* page 1.

N =	2	4	6	8	10
D =	3	1·5	1	0·75	0·6
Material in Bracing when loading all fixed. =	9	9	9	9	9
Material in Bracing when loading all moveable. =	9	10·125	10·333	10·406	10·440

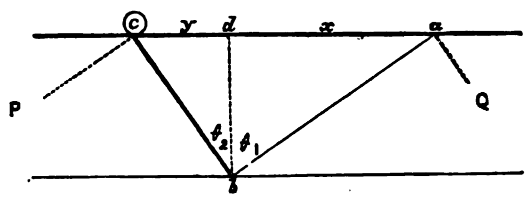
The economic angles for the struts and ties of the bracing.—In the following investigation we shall confine ourselves to the consideration of structures made up of an even number of triangles, or, in other words, an equal number of ties and struts; further, we will assume, that the loading is all collected at the upper or lower boom of the girder. Under these circumstances the braces are arranged in pairs, each of which pairs consists, as in fig. 3, of a strut and a tie having the vertical components of their stresses equal.

Let a_1 represent the cost, weight, or bulk of a *tie* constructed of the material of the ties (a—b, &c.), and capable of conveying one ton of stress through one foot of length. Similarly let a_2 represent the cost, or other quality to be considered, of a *strut*.

Now, all that is required is to determine the two values of θ for each pair, viz., θ_1 for the tie ab, and θ_2 for the strut cb; and so long as the values of a_1 and a_2 bear the same proportion to one another, the angles obtained for any one pair will be those also for all the others, since the question is not affected by the absolute amount of the vertical component V of the stresses to be transmitted through the braces. Should, however, the ratio of a_1 to a_2 vary for the different pairs, the economic values of θ must be obtained by so many independent calculations.

Let V be the accumulated portion of the loading on the P side of point c and at point c, which it is necessary to convey to the pier on the Q side. The stresses on the braces will consequently be $= V\sec\theta$. Let the depth $ab = D$, then the lengths of the braces will be $= D\sec\theta$. The work performed by these braces is the conveyance of V towards Q, hence the amount of such work done by any brace, or its efficiency, is expressed by $VD\tan\theta$.

Fig. 3.



Now let it be the *cost* of a brace, in proportion to the work done by it, which is to be rendered a minimum; this is represented by $V\sec\theta.D\sec\theta.a \div VD\tan\theta = a\sec^2\theta \div \tan\theta$, or we have for the pair—

$$\text{cost}\div\text{efficiency}=\frac{a_1\sec^2\theta_1+a_2\sec^2\theta_2}{\tan\theta_1+\tan\theta_2}=\frac{a_1(x^2+1)+a_2(y^2+1)}{x+y}\ \ldots\ (1)$$

Let $x+y=s$.

The cases, the solutions of which follow, are,

1. When s is fixed, but x and y variable.
2. When s, x, and y are all variable.
3. When $x \div y$ is fixed.
4. When x or y is fixed.
5. When x or y=0.

Case 1. In equation 1 by substituting s for $x+y$, and $s-x$ for y, we get:

$$\frac{\text{Cost}}{\text{Efficiency}}=\frac{1}{s}\,(a_1x^2+a_1+a_2s^2-2a_2sx+a_2x^2+a_2)$$

Differentiating this with x as the variable, putting the coefficient = 0, and reducing, we get for a minimum, when s is constant,

$$\left.\begin{matrix}x=s\,\dfrac{a_2}{a_1+a_2}\\[2ex] \text{and similarly we have}\quad y=s\,\dfrac{a_1}{a_1+a_2}\end{matrix}\right\}\ \ldots\ \ldots\ \ldots\ (2)$$

Whence $x:y::a_2:a_1$; and $x=y\,\dfrac{a_2}{a_1}$, and $y=x\,\dfrac{a_1}{a_2}$

So that, whatever value may be assigned to s, the tangents of θ will be to one another inversely as the values of a.

Case 2. We have now to determine what value of s will give the absolute minimum value to equation 1.

Substituting for x and y in equation 1, their values as given in equations 2, we get,

$$\frac{\text{Cost}}{\text{Efficiency}}=\frac{1}{s}\left\{a_1s^2\left(\frac{a_2}{a_1+a_2}\right)^2+a_1+a_2s^2\left(\frac{a_1}{a_1+a_2}\right)^2+a_2\right\}\ \ldots\ (3)$$

The differential of this is

$$=\left\{2a_1s\left(\frac{a_2}{a_1+a_2}\right)^2+2a_2\left(\frac{a_1}{a_1+a_2}\right)^2\right\}\frac{ds}{s}-\left\{a_1s^2\left(\frac{a_2}{a_1+a_2}\right)^2+a_1+a_2s^2\left(\frac{a_1}{a_1+a_2}\right)^2+a_2\right\}\frac{ds}{s^2}$$

Putting the differential co-efficient $=0$, for a minimum, and reducing, we get,

$$s=\frac{a_1+a_2}{\sqrt{a_1a_2}}$$

Substituting this value of s in equations 2, we have,

$$x=\frac{a_2}{\sqrt{a_1a_2}},\ \text{and}\ y=\frac{a_1}{\sqrt{a_1a_2}}\quad \ldots\ldots\ (4)$$

Further, we have, $xy=1$, $\therefore\ \theta_1+\theta_2=90°$.

Table of Economic Angles, &c., calculated by Equation (4).

a_1 : a_2	y.	x.	θ_2	θ_1	s.
1 : 1	1·000	1·000	45°	45° 00′	2·000
1 : 1·5	0·816	1·225	39° 14′	50° 46′	2·041
1 : 2·	0·707	1·414	35° 16′	54° 44′	2·121
1 : 3	0·577	1·732	30°	60°	2·309
1 : 4	0·500	2·000	26° 34′	63° 26′	2·500
1 : 0·5	1·414	0.797	54° 44′	35° 16′	2·121

Case 3. When a definite value is assigned to the ratio of $x:y$. Let $x=cy$, then $x:x+y::c:c+1$, and

$$x=s\frac{c}{c+1}\ \text{and}\ y=s\frac{1}{c+1}$$

Substituting these values of x and y in equation 1, we have,

$$\text{Cost}\div\text{efficiency}=\frac{1}{s}\left\{a_1s^2\left(\frac{c}{c+1}\right)^2+a_1+a_2s^2\left(\frac{1}{c+1}\right)^2+a_2\right\};$$

differentiating and putting the co-efficient $=0$, arranging and reducing, we get for a minimum,

$$x=\left(\frac{a_1+a_2}{a_1c^2+a_2}\right)^{\frac{1}{2}}\ \text{and}\ y=\left(\frac{a_1+a_2}{a_1c^2+a_2}\right)^{\frac{1}{2}}\quad \ldots\ (5)$$

When $c=a_2\div a_1$, we have the absolute minimum as by Case 2.

Table of Examples.

a_1 : a_2	c.	s.	θ_2	θ_1
1 : 1	2	1·897	32° 19′	51° 40′
1 : 3	2	2·268	37° 5′	56° 31′

Case 4. When a given value x_1 or y_1 is assigned to one of the tangents, the other and s being variable.

Let x be the variable tangent, then equation 1 becomes,

$$\text{Cost}\div\text{Efficiency}=\frac{a_1x^2+a_1+a_2y_1^2+a_2}{x+y_1}$$

Which, by the calculus, we ascertain to be a minimum, when

$$x=\sqrt{\left(1+\frac{a_2}{a_1}\right)\cdot(y_1^2+1)}-y_1$$

and similarly, $$y=\sqrt{\left(1+\frac{a_1}{a_2}\right)\cdot(x_1^2+1)}-x_1\quad \ldots\ \ldots\ (6)$$

Table of Examples when $a_2=2a_1$.

When $x_1=0·5$, $y=0·8693$.	When $y_1=0·5$, $x=1·4365$
„ „ $=1·0$, $y=0·7320$.	„ „ $=1·0$, $x=1·4495$
„ „ $=1·5$, $y=0·7079$.	„ „ $=1·5$, $x=1·6225$
„ „ $=2·0$, $y=0·7386$.	
„ „ $=4·0$, $y=1·202$.	

Case 5. When one of the braces is perpendicular, x_1 or $y_1=0$, and equations 6 become,

$$x=\sqrt{1+\frac{a_2}{a_1}},\ y=\sqrt{1+\frac{a_1}{a_2}}\quad \ldots\ \ldots\ (7)$$

Table of Examples.

a_1 : a_2	θ_2 x being $=0$	θ_1 y being $=0$
1 : 1	54° 44′	54° 44′
1 : 1·5	52° 14′	57° 41′
1 : 2·0	50° 46′	60° 0′
1 : 3·0	49° 6′	63° 26′

We now offer some applications of these formulæ.

TABLE I.—*Of results for various examples arranged to exhibit the per centage of excess of cost or weight or bulk, incurred by a departure from the economic values of the angles.*

We here assume that $a_1=a_2\ \therefore$

Cost or weight or bulk $\div$ efficiency, varies at $\dfrac{x^2+y^2+2,}{x+y}$

x.	y.	θ_1	θ_2	Per centage of cost.	REMARKS
1	1	45°	45°	100·00	Absolute minimum of cost. Published in January, 1851, by the writer, in his "Treatise on Bracing."
0·577	0·577	30°	30°	115·47	Warren & Monzani's Patent, 15th August, 1848.
0·425	0·425	23°	23°	139·0	Nash's Patent, 21st Feb., 1839. See Newton's Journal, vol. 15, p. 355.
0·557	1·056	30°	46° 33′	105·59	Economic value of θ_2 when $\theta_1=30°$
1·732	1·732	60°	60°	115·47	
1·414	0·000	54° 44′	0	141·42	Economic value of θ_1 when $\theta_2=0$,
1·000	0	45°	0	150·00	American "Rider" Bridge shown at Exhibition of 1851. Cast-iron perpendicular struts, and wrought-iron ties.
2·667	0	69° 27′	0	170·83	1851 Exhibition Building, 48-feet girders, (approximately.)
0·268	0·268	15°	15°	200·00	Chelsea Suspension Bridge, principal girders.

TABLE II.—*General Examples to exhibit the additional cost incurred by various departures from the economic values of θ.*

a_2 is here assumed to be equal to $2a^1\ \therefore$

Cost $\div$ efficiency varies at $\dfrac{x^2+2y^2+3}{x+y}$, and for the per centages given in the table, this is divided by 2·8284.

x.	y.	θ_1	θ_2	Per centage of cost.	REMARKS.
1·414	0·707	54° 44	35° 16	100	Absolute minimum of cost.
1·061	1·061	46 41	46 41	106·20	In these five examples the value of $x+y$ or s is made constant, and $=2·1213$ or that required for the above minimum.
2·121	0	64 46	0	125·	
0·707	1·414	35 16	54 44	125·	
0	2·121	0	64 46	200·	
1	1	45	45	106·1	
1·449	1	55 24	45	102·5	Minimum when $y=1$
2	1	63 26	45	106·1	
1	0	45	0	141·4	
1·5	0	56 19	0	123·7	Minimum when $y=0$
$\sqrt{3}$	0	60	0	122·4	
2	0	63 26	0	123·7	
1	0	45	0	141·4	
1	0·732	45	36 12	103·53	Minimum when $x=1$
1	2	45	63 26	141·4	
2	0	63 26	0	123·7	
2	0·739	63 26	36 27	104·46	Minimum when $x=2$
2	2	63 26	63 26	132·58	
0	1	0	45	176·8	
0	$\sqrt{1·5}$	0	50 46	173·2	Minimum when $x=0$
0	1·5	0	56 19	176·8	
4	1·202	75 58	50 15	148·77	Minimum when $x=$
2·605	0	69	0	144·30	C. P. Sydenham, cast-iron girders (approx.)

In our next paper we purpose treating of some of the more practical applications of the principles discussed above.

R. H. B.

Edinburgh.

FOREIGN PUBLICATIONS.

Encyclopédie d'Architecture.—This journal has not of late contained in its letterpress matter of a nature to interest our readers, although many of its beautifully executed illustrations would have afforded pleasure could we have reproduced them. They present a very miscellaneous assortment of objects, showing the great variety of styles practised in France, and evincing the strong hold which many of the details of the style called after Louis XIV. still keep upon the public taste. Rococco work, and that purer style which some of the modern French architects have created for themselves, by a blending of Renaissance richness with Greek mouldings and forms, are executed to great perfection in France; but there appears a striking falling off when we critically examine the Gothic works even of their greatest artists.

Révue de l'Architecture.—In the columns of this journal a series of essays on coverings for roofs with elaborate illustrations are now appearing. The subject of tiles has been very carefully analysed, and a large mass of valuable and detailed information collected together. The improved tiles shown on some of the plates would be very desirable additions to the not too extensive list of materials available in England for the covering of roofs; and those of our readers who are interested in this subject will find it quite worth their while to consult the *Révue*, where all the principal varieties in use in France are carefully illustrated, and their size, price, weight, and other properties are to be found tabulated. Reference is also made to a series of specimen tiles of each sort in the Conservatoire des Arts et Metiers, a collection analogous to our Museum of Patents, only of a magnificence in accordance with the national character of the collection, instead of being crowded into a limited space and seen under every disadvantage. The use of enamelled roofing tiles (so little known in this country) and the substitution of flashings, &c. in zinc or lead for fillets of plaster on tiled roofs, is strongly recommended.

"The rougher the suface of a tile, and the more numerous the corners, projections, and angles which it presents, and the larger the number of the joints in a given superficies of roof-covering, the more easily will dust settle upon it, and the more will those mosses flourish on it which result from moisture. * * * We learn, from actual examples, this lesson. Strong roof-timbers, inflexible battens (or laths), tiles of good quality and smooth surface, a steeper pitch than that ordinarily found sufficient, no external mortar or cement work, easy ventilation of the inner face of the tiles and the battening (or lathing); such are the conditions necessary for a desirable covering, costing little to maintain. There is, perhaps, one objection which may be raised to all this—the high price of its first erection. The reply to this objection is, that money expended upon the fundamental portions (*parties mères*) of a structure is always well invested, and of these the roof-covering is one. To stand in no danger of destructive and defiling infiltrations of water is something. To be safe from the cost of constant repairs, and the necessity of at no distant date entirely renewing the covering, is something more. These substantial advantages soon defray the additional prime cost; and, from this point of view, the use of enamelled tiles is excellent. The art of enamelling tiles, bricks, and facing blocks goes back to the highest antiquity. It appears to have had its origin in the East. Numerous traces of it are discovered at the foot of the Caucasian range, in Egypt, and in Babylonia. In those countries whose primeval civilization has now disappeared, the art of the potter had attained, ten centuries and more before our era, a degree of perfection unknown at the present day to the same art among modern nations. In our own day, the enamelling of tiles is most followed in Bavaria, and applied to flat tiles, either pointed or scaled on the portion exposed to sight. The enamels are fine and the tints subdued. In France their use is not yet common, but is extending. Already, subsequently to the Universal Exhibition of 1855, it has developed itself in Maconnais, Franche Comté, and Picardy; it has long been customary to employ in this last-named county, lead-enamelled ridge-tiles; that is to say, prepared with an enamel principally composed of lead ore, and approaching all tones of yellow, and all tints of brown colour; these tiles are now also prepared there with silicate of potash; they become waterproof, and retain their natural colour. At Paris, the employment of enamelled tiles is commencing, thanks to the intelligent and active exertions of a manufacturer who has taken up the speciality, Mons. Richomme, already referred to. The enamelled tiles of this maker are similar in form to the Bavarian tiles, and, like them, variously coloured in white, yellow, brown, green, blue, &c., delicate in their tints, perfectly durable, and affording a means of forming rich mosaics. These tiles, which are only enamelled externally as far as their uncovered part extends, measure 0·24×0·18=9¼×7 inches, and are laid with an uncovered part (*pureau, almost the exact reverse of the English "lap"*) of 0·08=3¼ inches. The pointed ones weigh dry, 0·708 kil., and 0·750 after a quarter of an hour's immersion in water; 69·44 of them are required per square metre, and the corresponding weights are 49 and 52 kilogrammes. A square metre of roof covering in these enamelled tiles, pointed or semi-circular at the lower end, and inclusive of battens and laying, comes to 7 francs 75 centimes (approximately equal to £2. 6*s*. 6*d*. per English square.")

We may add, that the writer of this does not mention the fact that enamelled roofing tiles, especially ridge tiles, and also enamelled paving tiles, were, during and since the Mediæval period, much employed in other districts of France besides Picardy. On this point the curious will find some information in the intrduction to the abstracts of specifications relating to bricks and tiles recently issued by the Commissioners of Patents.

Motive zu Ornamentalen Zimmerwerken (Designs for Ornamental Carpentry, by Louis Degen, Engineer: Munich.)—This work, published by the author in parts, consists of a large number of sheets of quarto size, of designs for various ornamental structures in wood, sketchily, but effectively, executed in lithography. This sort of work is necessarily less employed in England than in countries where the mildness of the climate renders balconies, verandahs, summer-houses, and similar works, objects of daily use. Still these things are erected from time to time in England; and to those who have to design them this will be found an eminently suggestive book, especially in detail. Some will, perhaps, object to Herr Degen's designs, taken as a whole; but it would not be easy to surpass the graceful fertility of design shown in sheet after sheet of barge-boards, finials, brattishings or spandrils designed to be cut out of flat boards without any moulding, and in several sheets of cleverly designed stoppings, corbels, ends of rafters, and other portions of framing. To those, too, who are aware of the value of flat ornamental gratings as accessories to street architecture, the motives and treatment of many of the pierced patterns here given will be interesting.

Nouvelles Annales de la Construction.—New Annals of Construction for January and February of this year are before us. Their contents include an account of the Suez Canal, and the methods of procedure adopted there, with a short résumé of the history of the undertaking. The works were commenced in April 1859; and the methods of carrying them on are shown by illustrative woodcuts. It appears that mechanical contrivances have been, as far as possible, employed of a nature designed to facilitate the removal of the earth from the excavations. Some of these are interesting; but as the editor of the *Annales* promises, at an early day, to give a more detailed account, not only of the machines themselves, but of the experience which the engineers have had of their working, we propose to defer our notice of them.

ON THE METHOD OF DETERMINING THE QUANTITY OF MATERIAL NECESSARY FOR THE SOILING OF THE SLOPES OF RAILWAY CUTTINGS AND EMBANKMENTS.

By Thomas Cargill, C.E.

It frequently happens during the progress of the works of a line of railway in which the cuttings and embankments are of considerable magnitude, that due precaution is not taken to reserve in their vicinity a sufficient amount of material for soiling or top-dressing the slopes, and the consequence is, that either they are not covered with the proper quantity, or the contractor is obliged to bring the soil from some distance along the line, or procure it elsewhere at more than the ordinary expense.

The quantity requisite for the different cuttings and embankments depends principally on the depths and heights, and varies also as the ground is more or less sidelong.

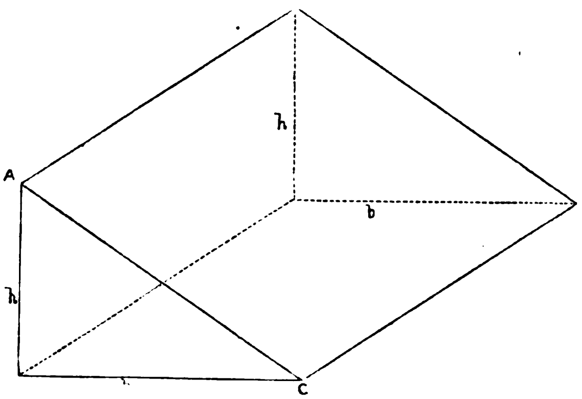
The simplest case which can occur is when the height is constant for a given length of the longitudinal section of the line, and when the cross-sections also for that distance are level. This is shown in Fig. 1, which represents one of the slopes of either a cutting or embankment, the other being supposed to be precisely similar. As the soil is always of a uniform depth, its quantity is taken out in superficial yards. In Fig. 1, let AB or CD=L= the length on the longitudinal section, let h=the height constant for the length L, and let S be the number of superficial yards of soil required for both slopes; all other dimensions being in feet: then

$$S=\frac{2 \text{ area of ABCD}}{9}$$

but, from the figure, area of ABCD $=$ AC$\times$L, and $S = \frac{2AC \times L}{9}$

AC is the length of the slope, and is unknown, but supposing b to be constant, as it always is in practice, AC depends on h.

Fig. 1.



Now by construction $AC^2 = h^2 + b^2$, and substituting for b its value R$\times h$, R being ratio of slope,

$$AC^2 = h^2 + R^2h^2 = h^2(1+R^2) \text{ and } AC = h\sqrt{(1+R^2)}$$

Putting this value of AC in the equation for S, we obtain

$$S = \frac{2h\sqrt{(1+R^2)} \times L}{9}$$

R is almost universally $= \frac{3}{2}$ and $\sqrt{(1+R^2)} = \frac{\sqrt{13}}{2}$ which gives us by substitution in the above equation

$$S = \frac{2h \times L}{9} \times \frac{\sqrt{13}}{2}$$

Multiplying out and reducing we obtain

$$S = h \times L \times 0{\cdot}4 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

which is a general formula applicable to any height and distance. If we make L$=$1 chain$=$100 feet, the formula becomes very simple, for $S = 40h$ ... ... (2)

if L$=$the statute chain$=$66 feet, $S = 26{\cdot}4h$ ... ... (3)

Another case which is more frequently met with, and the solution of which is of greater practical utility, is when the heights at the two ends of the given length of the longitudinal section are unequal, as is represented in Fig. 2; h and h' are the two heights, and the remainder of the notation is the same as that employed above.

As before $S = \frac{2 \text{ area of ABCD}}{9}$; area of ABCD $= L \times \left(\frac{AC+BD}{2}\right)$

From above $AC = h\sqrt{(1+R^2)}$, and by similar reasoning $BD = h'\sqrt{(1+R^2)}$; therefore area of ABCD$=$

$$\frac{L}{2} \times \left\{ h\sqrt{(1+R^2)} + h'\sqrt{(1-R^2)} \right\}$$

which gives us $S = \frac{L}{9}\left\{ (h+h')\sqrt{(1+R^2)} \right\}$

Substituting for the expression $\sqrt{(1+R^2)}$ its equivalent $\frac{\sqrt{13}}{2}$ and reducing we obtain finally

$$S = L(h+h') \times 0{\cdot}2 \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

if L$=$100 feet, then $S = (h+h') \times 20$ ... ... (5)

if L$=$66 feet, then $S = (h+h')13{\cdot}2$ ... ... (6)

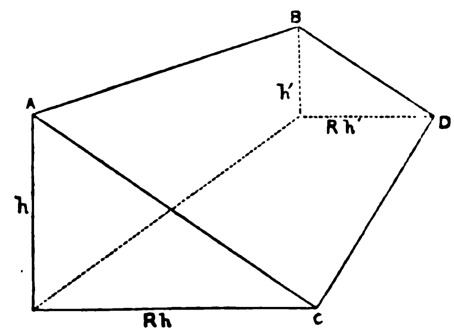
It is evident that by making $h = h'$, equations (4) (5) and (6) became identical with (1) (2) and (3), but I have given a separate proof and demonstration, not only to preserve uniformity in the different examples under investigation, but because I think it may serve to render the subject clearer to many persons, especially those perusing it for the first time.

Equations (5) and (6) will be found particularly useful to those engaged in making the estimates for "contract work" of a line of railway, as the ground may generally be considered level between any two ordinates on the longitudinal section, which are at the distance of one chain from one another; unless it be exceedingly rough and irregular, and even then any deficiency or excess in so inexpensive an item as "trimming and soiling slopes" is not of much consequence.

All the foregoing formulæ have been calculated on the supposition that the cross sections of the ground are level, or, in other words, that the quantity of soil required for one slope is the same as that which is required for the other. It is manifest that, in sidelong ground, this would not be the case, and in some instances, where the difference of the heights on the two sides of the line is great, it might be necessary to allow for it in taking out the quantity. This might be accomplished in two ways, either by applying any of the above equations, which suit the particular case in question, to each respective side of the cutting or embankment, and dividing the result by 2; or by making use of the following formula. Let H, H′, h, h', be the four different heights, then from Fig. 2, and equation (4) the number of superficial yards of one slope$=$L $(h+h') \times 0{\cdot}1$, and of the other$=$L $(H+H')\,0{\cdot}1$, and total number $S = L\,(H+H'+h+h')\,0{\cdot}1$, which can be simplified in a corresponding manner for the different values of L$=$100 or 66 feet. In any instance in which the sidelong ground continued to slope uniformly in the same direction across the line for a considerable distance, it might be found quite as advantageous if not more so, to take out each side of the line separately, and so employ the former instead of the latter method.

In the preliminary estimates of a line of railway for parliamentary purposes, "trimming and soiling slopes" is so insignificant an item, that it is hardly ever taken into account; but in a case where the cuttings and embankments were excessive both in number and magnitude, and where a close and vigorous oppo-

Fig. 2.



sition would render an equally close and accurate estimate requisite, it would be prudent to ascertain its amount either by direct calculation, or, allow a sum for it, suggested by experience.

In such calculations, it would be convenient to take out a whole cutting or embankment at one operation; and quite sufficiently accurate to consider the cross sections of the ground level, and consequently the area of the two slopes equal to one another. The following formula is general for any length L and number of heights $h\ h_1\ h_2\ h_3 \ldots\ldots h_n$, which for simplicity's sake may be taken at equal distances; let x=number of heights taken, then

$$S = \frac{L}{x-1}\,(h + 2h_1 + 2h_2 + 2h_3 + \ldots + h_n)\,0{\cdot}2$$

If L be taken an even number of hundred feet, as it may be in such examples, and let N$=$number of 100 feet lengths, and allowing one penny per superficial yard, we obtain, by putting M for the amount in pounds, &c.

$$M = \frac{N}{12(x-1)}\,(h + 2h_1 + 2h_2 + 2h_3 + \ldots + h_n)$$

It will be at once seen, that where the length admits of it, this substitution can be applied to all the other formulæ, and the price therefore obtained at once from the values of the lengths and heights or depths.

ON A NEW MODE OF COKING IN OVENS, APPLIED TO THE STAFFORDSHIRE SLACK.

By Alexander B. Cochrane.

(Concluded from page 85.)

In the first block of the new evens at Woodside, which gave the yields of coke above stated from the Staffordshire slack, the partition walls between the ovens were built 9 inches thick. It is evident, however, that the thinner the partition walls the more perfect is the communication of heat between the ovens; and the writer found in the erection of the first block of ovens that 9 inches make too thick a wall. The consequence of this mistake was that the quantity of coke produced was not so great as expected, since it was absolutely necessary to assist the progress of the coking by a large admission of air. In France, where Mr. Eaton made his first experiments, and where the new ovens have been in operation for several years, the partition walls were about 6½ inches thick. At the Briton Ferry Iron Works in South Wales, where it was decided to adopt this plan of ovens from the success of those at Woodside, when they had been at work only a few weeks, the partition walls were built only half a brick or 4½ inches thick, and the results were more satisfactory than any that Mr. Eaton had obtained in France. This was to be attributed solely to the diminished thickness of the partition walls, and led the writer to test the point practically in the first block of ovens erected at Tursdale. In order to make a fair comparison, six ovens of the block were built with 4½ inch partition walls, and six with 9 inch walls. The result was that in the same time 12½ per cent. more coal could be coked in the ovens separated by only 4½ inch walls than in those with 9 inch walls. The thickness of 4½ inches is as little as can be safely used for the partition walls, and it was at first feared they might prove a little weak, being 8½ feet long, with an average height of 4½ feet; but, bound as they are on all edges, they have proved to be thoroughly substantial, and it is intended to adopt this thickness in future. It has already been adopted with perfect safety in the two instances above mentioned, at Briton Ferry and at Tursdale.

The economy secured in the new plan of oven arises from the circumstance that the heat requisite to start and urge the oven forward is supplied chiefly by radiation from the partition walls; and in a few cases only, owing to peculiarity of coal, is it at all necessary to assist the progress of the oven by the admission of air. The principle of the oven aimed at is the entire exclusion of air, in order to prevent entirely the waste that takes place by partial combustion of the coke in the ordinary process; and this object is attained with certain rich gaseous or bituminous coals. But when dealing with intractable material, air is still needed; from 2 to 3 square inches of air space given beneath the door are amply sufficient to meet the case of the mixture of 45 per cent. of Staffordshire slack and 55 per cent. of Welsh bituminous slack. Whatever air is given to any oven, it is of the greatest importance to introduce it at the commencement of the coking process, and not at the end. When introduced during the first period of the operation, its effect is to mix with and burn the gases which are being disengaged in great abundance from the coals, doing the coke very little injury; whilst its introduction towards the end of the operation is productive of serious mischief, for when the gases are beginning to clear off, the air is free to attack the surface of the coke, and does so. To this fact there is a remarkable and curious exception in the case of the manufacture of coke from a mixture of Staffordshire slack and pitch, which seems to be accounted for by the formation of a silicious film or crust over the entire surface of the coke, which most effectually shields it from the action of the air. In all cases however, after the gases have ceased to be evolved in quantity sufficient to fill the oven, the further admission of air is prejudicial to the finishing off of the charge, by cooling down both the coke and the oven which contains it. At this period of the operation, therefore, as is found the case in the first block of ovens erected at Woodside, it is necessary entirely to exclude the ingress of air, in order to prevent the rapid loss of heat which the oven otherwise sustains. When the air is thus excluded, the oven has acquired a sufficient heat to complete the expulsion of all the gases that remain to be evolved, which are seen to issue, burning as small jets of flame, from the cracks in the mass of the coke. The regulator B, Fig. 4, Plate V., allows the admission of air beyond the oven through the perforated cast-iron plate which covers it, forming a perfect smoke consumer.

The area of the flue opening from the regulator into the chimney is a matter of considerable importance, and admits of an efficient adjustment by simply inserting pieces of firebrick in the passage of the flue. This is a particular convenience, where from any exceptional cause the admission of a considerable quantity of air is needed, as already referred to in the case of the first block of ovens erected at Woodside. Here the simple reduction of the area of the flue from 49 to 30 square inches at its passage out of the regulator occasioned an increased yield of 5 to 6 per cent. of coke. For with the flue full open, the draught of the chimney drew in more air than was required when the greater part of the gas had been driven off, and a surface combustion of the coke ensued, with an intense heat, while the yield was sacrificed. It was found impossible to adjust the supply of air so nicely as to prevent waste while the coking proceeded, except by means of reducing the area of the flue, which proved quite efficient. Since in all classes of ovens perfectly air-tight work can scarcely be secured, the regulation of the area of the flue is a matter of importance, even where the air is purposely excluded during the coking, in order to prevent its being drawn into the oven through the innumerable small interstices in the brickwork. The prevention of the undue admission of air by this simple expedient was attended with a diminution of the quantity of coal which could be coked in the same time; but this was counterbalanced by the increased yield of coke from the smaller quantity of coal charged. It may be that the checking of the draught has a beneficial influence, by causing the gases to lie back a little longer in the oven, and there expend a little more of their heat by being more completely consumed. On the other hand it is possible to reduce the flue area too much; for, when it was attempted to work with the flue reduced at the passage from the regulator from 49 to about 23 square inches area, the effect ceased to be of any benefit, and on the contrary was slightly injurious, in retarding the rapidity of coking and perceptibly lowering the temperature of the oven.

When the coking is completed, the communication between the oven and the chimney is cut off by a damper, consisting of a plain wrought iron plate, which prevents air from being drawn in through the brickwork, whilst the coke is lying, as it should do from two to four hours after disengagement of gas has to all appearance ceased. The fact is, however, that a slight disengagement is still, though imperceptibly, going on, which is made manifest by opening the door of the oven, when immediately the gas is seen burning at the surface of the coke. It thus gives an improved appearance to the coke to let it lie a little, by getting rid of a tinge of dark colour which exists at the bottom of the coke if drawn too soon after being done.

As regards the general size of the new ovens, it is thought at present that 44 feet external diameter will prove the most convenient, as shown in Figs. 1 and 2, Plate V.; though at the Tursdale Colliery the first and second blocks are constructed 48 feet diameter. The objection to the large size is the necessity of providing for a greatly increased expansion of the structure.

As regards the quantity of coke which can be produced from a block of ovens, the second block at Woodside, 44 feet diameter, has turned out about 60 tons of coke per week during the two months that it has been in work. The first block at Woodside, 42 feet diameter, has scarcely turned out 55 tons per week, for the reason already given of too great thickness of the partition walls; whilst the first block at Tursdale, 48 feet diameter, where half the walls are 4½ inches thick, and half 9 inches, is capable of turning out 80 tons per week. The block of ovens at Briton Ferry, 44 feet diameter with 4½ inch partition walls, is turning out from 65 to 70 tons of coke per week; and so satisfied are the proprietors that a second block has been erected.

As regards the time occupied in coking, an ordinary oven of 11 feet inside diameter with 95 square feet of floor area will burn off a charge of 5½ to 6 tons of Newcastle or Durham coals in 72 hours. One of the new ovens with 97 square feet of floor area, in the first block at Tursdale, 48 feet diameter, with 9 inch partition walls, burns off 4¼ tons in 72 hours with only a trifling difference in the gross amount of coke produced. But no account is here taken of the irregularities to which ordinary ovens are subject, and of which some idea may be formed from an incident that took place with the first block of the new ovens at Tursdale. Red bricks having succeeded perfectly in the chimney at Woodside, were employed without hesitation in that at Tursdale; but owing to the increased size of the block of ovens, 48 feet diameter instead of 42 feet, and the more intense character of the combustion of the bituminous coals as compared with the mixture of Staffordshire and Welsh slack, the heat was too great, and caused the red brickwork to melt, and ended by closing up every flue. The chimney was then lined with firebricks; but during the time occupied in lining it, the ovens, which were then working in effect as ordinary open-topped ovens, worked most irregularly, never came up to their proper time, and in one instance a three days' charge occupied six days to burn off. It is not meant that ordinary ovens would be frequently subject to such an extreme irregularity as that just mentioned; for, in the absence of the central chimney an oven of the new form is ill calculated to create a sufficient draught; whereas, in an ordinary dome oven with chimney at top, everything is pretty favourable for the admission of the requisite air. Irregularities of one or even two days in ordinary ovens are, however, of not unfrequent occurrence; and coupled with the accident which led to the necessity of working the new ovens at Tursdale Colliery, without the assistance of the central chimney, they show of how great importance the chimney is to secure good and reliable results.

The cost of erection of a block of ovens on the new construction has been as follows at the Woodside Iron Works, the block being 44 feet diameter :—

	£	s.	d.
35,000 Firebricks and clay	£112	0	0
27,000 Red bricks and mortar	33	0	0
Cast and wrought ironwork	91	10	0
Tools	8	10	0
Labour in excavation, bricklaying, and concrete, &c.	70	0	0
	£315	0	0

This gives £26 5s. as the cost per oven, complete with water fittings, coke benches and tools, but exclusive of any attendant conveniences for keeping the coke in stock. The cost is of course subject to the addition of carriage of materials for erection at any other site, and minor modifications for the variation of circumstances. Where a mixture of coal is not wanted, the ovens can be made with a circular railway so as to be filled from the top, as at Tursdale, the additional expense of which is about £6 per oven.

The cost of working the new ovens where a uniform quality of coal is used is slightly in excess of the working of ordinary ovens in one particular only, that of loading up the coke from the benches into the wagons. In a straight row of ovens nothing is simpler than to run a train of wagons alongside the benches, off which the coke is conveniently filled at one lift. Against this there is the advantage that the labour of cleansing and charging the coal in the case of the new ovens is divided over a large quantity of coke produced from the same quantity of coal; so that really the difference, if any, is but slight. The working cost per ton of coke made has been as follows, in the ovens already at work at Tursdale, 48 feet diameter.

2 men drawing ovens, levelling coals, manufacturing, and keeping coke benches clean, at 3s. each per day (coke made per day 12 tons)	6d. per ton.
2 boys cleansing coals and charging with tubs at 2s. 8d. each per day, to feed 3 blocks of ovens	1¾
Wheeling and loading coke into waggons ...	2¾
Interest on outlay, say £450 to cover incidentals, at 5 per cent.	1¼
Redemption in, say 7 years	3½
Wear and tear, say	¾
Royalty	3
Total cost of coke exclusive of coals...	1s. 7d. per ton

In Staffordshire, with the mixture of slack and the charging done at the mouth of the oven instead of from the top, as might be expected, the labour is somewhat greater, while the outlay is about £75 less per block. The cost per ton of coke made in this case is as follows:—

4 men drawing and charging ovens, mixing slack, &c., at 3s. 4d. each per day, (coke made per day 9 tons)...	1s. 6d. per ton.
Interest on outlay, say £375, at 5 per cent	1¼
Redemption in, say 7 years...	4
Wear and tear, say	¾
Royalty...	3
Total cost of coke exclusive of slack, &c....	2s. 3d. per ton.

To the above particulars of cost it is simply necessary to add that of material to arrive at the total cost of the coke manufactured. Taking the value of a North country bituminous slack at 3s. 6d. per ton, and a yield of 68 per cent. of coke, the cost of coals would be 5s. 2d. per ton of coke produced. Adding this to 1s. 7d. the cost of working, the total cost of the coke into wagons would be 6s. 9d. per ton. It is of course impossible to fix on any uniform price at which to charge the slack: some collieries produce "duff," as the small of the coal is called, in such abundance as to make them glad to have a means of getting rid of it; others set a higher value upon it. Hence it is for each in his particular circumstances to determine how far the adoption of the new system is economical.

It is easier to arrive at the real cost of the coke manufactured in the Staffordshire district, where slack suitable for the purpose can be bought in any quantity at 2s. 6d. per ton. Assuming this price the mixture of 45 per cent. of Staffordshire slack at 2s. 6d. per ton, with 55 per cent. of Welsh slack at 12s. per ton, will cost 7s. 9d. per ton; and a yield of 57½ per cent. makes the cost of the coke 13s. 6d. per ton. Adding this to 2s. 3d., the cost of working, the total cost of the coke amounts to 15s. 9d. per ton.

The mixture of 44 per cent. of Staffordshire slack at 2s. 6d. per ton with 44 per cent. of Welsh slack at 12s. per ton, and 12 per cent. of pitch at 20s. per ton, costs 8s. 9d. per ton; which with a yield of 62½ per cent. makes the coke cost 14s. per ton. Adding this to 2s. 3d. the cost of working, the total cost of the coke from this mixture amounts to 16s. 3d. per ton.

The mixture of 72½ per cent. of Staffordshire slack at 2s. 6d. per ton with 27½ per cent. of pitch at 20s. per ton costs 7s. 4d. per ton, but the yield in this case, is only about 52½ per cent of coke, owing to the very volatile character of the pitch, and the coke therefore costs 14s. per ton. Adding this to 2s. 3d., the cost of working, the total cost of the coke made from Staffordshire slack with pitch alone amounts to 16s. 3d. per ton.

As regards the wear and tear on the brickwork of the new ovens, there seems every likelihood that this is very small and unimportant. A small allowance has however been made in each of the above estimates of the working cost. The first block of ovens erected at Woodside has been in operation since June last year, a period of nearly a year, and does not show the slightest indication of requiring repairs to the brickwork. A little repair has been needed at the door frame castings, owing to the irregular expansion of the casting by heat and its weak form; but the liability to fracture in the faulty plan first adopted has been in a great measure corrected by an amended form of frame.

Among the advantages which attach to the new form of ovens is its compactness, which is of importance, and is a reason why the oven should be much cheaper in its construction than ordinary round ovens. Taking the case of a double row of ordinary ovens placed back to back, 11 feet internal diameter, the floor area of which would be 95 square feet, with a flue between them common to both leading to a chimney, such a series of 6 ovens in length or 12 ovens in the double row would cover a space of ground $84 \times 28 = 2352$ square feet; whereas the space covered by the largest block of the new ovens yet erected, 48 feet external diameter, is only 1810 square feet, while the floor area of each oven is 100 square feet, the partition walls in this case being 5½ inches thick. Including the coke benches 9 feet wide, in the case of the double row of ordinary ovens, the ground occupied would be $84 \times 46 = 3864$ square feet; whilst in the case of the 48 feet block of the new ovens a greater area of ground is covered, taking a square larger by 18 feet than the diameter of the oven, giving $66 \times 66 = 4356$ square feet; with the advantage however of larger stacking room for the coke, for whilst the benchroom in the first case cited of 12 ovens in a double row is $84 \times 18 = 1512$ square feet, that of the 48 feet block is 2546 square feet.

In connexion with the subject of rapid coking, a few interesting laboratory experiments have been made at the writer's works. The material operated upon was the coal from the Tursdale Colliery, the composition of which was as follows:—

Carbon	81·46
Hydrogen	7·89
Nitrogen	2·91
Sulphur	1·34
Ash	3·26
Difference (oxygen)	3·14
	100·00

The yield of coke which any coal is capable of producing depends in a certain measure upon its constituents. In general the gaseous products cannot be expelled without carrying off with them a certain proportion of carbon. Could all the hydrogen, nitrogen, sulphur, and oxygen be expelled without carbon, the coal of which the above is an analysis should yield nearly 85 per cent. of coke: but the highest result obtained in the laboratory was only 69½ per cent. The yield of coke however is dependent also to a certain extent upon the rapidity with which the coal is raised to the coking temperature, as the following five experiments will show.

In the first experiment two crucibles carefully covered, containing Tursdale coal, were introduced into a close muffle, so that access of air to the contents of the crucible was rendered impossible. The muffle was at a very bright red heat, and the crucible having been put into it the mouth of the muffle was temporarily stopped. In one hour afterwards the crucible was removed, and the percentage of coke in one crucible was 62·18, and in the other 61·28.

In the second experiment a crucible was introduced into the muffle when cold, and the temperature gradually raised during one hour to cherry red, and then maintained for half an hour at a bright red heat. The yield in this case was 66·12 per cent. of coke.

In the third experiment two crucibles were introduced into the muffle when at a bright red heat, but not so hot as in the first experiment, and the temperature was maintained for an hour. One crucible gave 64·77 per cent. of coke, and the other 64·20 per cent.

In the fourth experiment a crucible as in the second experiment was introduced into the cold muffle, and the temperature raised in an hour and a half to cherry red, instead of occupying only one hour as in the former case. The resulting yield was 67·50 per cent. of coke.

In the fifth experiment, a crucible introduced into the muffle at a dull cherry red heat, and kept at that temperature for one hour, yielded 69·40 per cent. of coke. A second crucible raised in one hour to a dull cherry red heat, and kept at that for one hour, also yielded 69·40 per cent. of coke.

It appears from these experiments that the more rapidly the coal is coked or the higher the temperature of the oven into which it is introduced, the less the yield; and this is no doubt due to the greater readiness with which compounds of carbon and hydrogen containing an increasing proportion of carbon are formed, the more sudden or the greater the intensity of the heat. On the other hand, it was noticed in the above experiments that the coke more slowly made was more bulky, that is less dense, than that made more rapidly. This result fully accords with that obtained in some flued ovens in the north, the invention of Messrs. Breckon and Dixon; the coke produced by the flued ovens being much denser in character than that made in ordinary ovens. How far yield is interfered with by the use of flues is a question which admits of further inquiry; and at some future time the writer may be in a position to make a comparison between Tursdale coke produced in flued and non-flued ovens in order to determine this point. Taking an average however of several specimens of coke produced in ordinary ovens from North country coal, the specific gravity is only 1·00, whilst the specific gravity of Tursdale coke made in the new ovens is 1·47. However much therefore this high specific gravity of the coke may be due to some favourable peculiarity of the coal, it is evident that in the new mode of coking both yield and density are secured. There is a further objection to coking from the bottom of an oven upwards, as in ovens having flues underneath the floor, from the fact that the two processes meet in an irregular plane about one third of the way up from the floor of the oven, and there result two measures, so to speak, of coke. This is perhaps a trivial objection, inasmuch as it interferes only with the commercial appearance of the coke, and is no real detriment to its quality; still it is one which is obviated in the new ovens.

Mr. Cochrane exhibited specimens of the coke made in the ovens, illustrating the respective binding properties of the different mixtures of slack employed, and in the course of the discussion upon the paper observed that the main object of the plan of coking now described was to effect economy of material in ironworks, by making use of the great quantity of fine slack that was at present thrown away as waste; which was of particular importance in the South Staffordshire district, where they were gradually getting short of material by the rapid consumption of the thick coal within the limits at present worked. Attempts had previously been made to coke the fine slack by itself, but had quite failed; and he had then tried it mixed with Welsh bituminous slack, to impart the requisite binding property, and with pitch. By this means the refuse ordinarily thrown away was converted into a coke even superior to the best coke made from the large thick coal, the proportion of pitch mixed with the slack being about 27½ per cent. of pitch to 72½ of slack. The coke obtained had all the excellent qualities of the thick coal coke, and the same freedom from injurious ingredients, since the pitch imparted no noxious elements. In bringing the subject forward for discussion his object was to show the practicability of the plan by the results already obtained; and also to ascertain how far the same process was capable of being extended to other non-caking coals, and whether the new form of ovens was suitable for other districts, as had already been found to be the case in the trials of the ovens at Tursdale with North country coals and at Briton Ferry with South Wales small coals. He was indebted to his son for carrying out the several experiments that had been made with different mixtures of slack. If a smaller proportion of pitch were used with the slack the mixture was not sufficiently binding, so that the coke produced would not hold together, but came out of the oven all in small pieces. There was not the least accumulation of dust in the flues, the draught on the ovens being so strong as to carry off any fine particles of slack.

Mr. Samuel Lloyd suggested that a saving might be made by placing a vertical boiler in the centre of the block of ovens, where the chimney at present stood, so as to economise the heat passing off from the ovens. He thought the heat would be found considerable from so many ovens, as four moderate sized coke ovens at their works at Wednesbury gave heat enough to raise the steam of a boiler 28 feet long and 8 feet diameter. The chimney might be placed in any convenient position near, with an underground flue to it from the ovens.

Mr. Cochrane replied that in this instance the boilers were too far off from the ovens to make that practicable; and it would be a question whether it was really advisable to encumber the ovens with a boiler, as there did not appear to be gas enough escaping from the chimney to be worth the trouble of saving. He further remarked that the new ovens had an important advantage in the greatly increased density of the coke produced, which had a great deal to do with its quality as fuel and its value in the blast furnace: with the mixture of fine slack and pitch, the specific gravity of the coke produced was as much as 1·25 or 1·30; and the Tursdale coke made in the new ovens had a specific gravity of 1·47, while that of the best North country coke scarcely reached 1·00 in the regular make. This showed clearly the importance of preventing the waste of so much valuable material out of the coke, which at present took place with ordinary ovens. The specific gravity was ascertained by weighing the coke solid in air and in water.

In reply to a question as to what was the value in the blast furnace of the coke make by the new method, as compared with the best North of England coke, Mr. Cochrane said that there was no question as to the superiority of the Staffordshire slack; it made a better and purer coke than the North country coals, whether coked with pitch alone or with a mixture of Welsh slack and pitch. With Durham coke they were not able to make a good open-faced grey forge pig, but with this coke good grey pig was regularly made. It also gave a better yield in the furnace than either the Durham coke or that made from the thick coal. The slack was not picked or cleaned in any way before coking, but was put in the ovens just as it was thrown over the bank; the fine slack that he was using was the refuse left after the coarse slack had been screened for making what was called breeze, to be used under boilers and for other purposes. In this way 60 tons of good coke per week were now being produced from refuse coal slack, previously of no value whatever.

In answer to an inquiry whether the mixture of Welsh slack or pitch alone produced the cheapest coke, Mr. Cochrane said that the coke made with pitch alone was the cheapest at their works at Dudley, about 1*s.* per ton cheaper than with Welsh slack, on account of the price of the Welsh slack and the cost of conveyance from such a distance. The cost of the two modes of coking in any locality depended of course on the relative cost of the materials for mixing; and the estimated cost given in the paper was of a general character, based upon the full market value of the pitch and Staffordshire slack, which however had been obtained at a lower rate in this particular instance at their works at Dudley. The mixture with pitch alone gave the coke that made the best iron; with this coke grey forge pig iron could be produced with great facility, as the sulphur contained in the coke was not more than 0·8 per cent., whilst that quality of iron could not be made with Durham cokes at all.

Mr. J. PADDEN observed that the economy and advantage of any mode of coking would vary much in different localities, according to the quality and cost of materials in the district. In Staffordshire it was a great object to economise the waste slack now thrown away as useless; and the plan of coking just described converted into a valuable fuel what was otherwise worthless. In some parts of South Wales also there was material which had never before been converted into coke, such as the Aberdare slack and other small coals, and this was now coked in the new ovens by mixing with it a portion of bituminous slack. In other parts of South Wales however the case was not the same, the cost of slack being not more than 2s. or 3s. per ton less than that of the whole coal: where the slack was bituminous it made good coke by itself without any mixture, and anthracite slack was mixed with half as much of the bituminous slack, producing one of the best blast-furnace cokes in South Wales, which cost only 8s. 6d. or 9s. per ton. The value of the new ovens he thought had been rather understated in the paper than the contrary, the coke having being weighed dry immediately on being drawn; but if stacked and left exposed to the atmosphere some time, as was usually the case, it absorbed a considerable proportion of moisture, which increased the apparent weight; and in estimating the commercial value of the coke as compared with that made in the ordinary ovens, both should be weighed under the same conditions. Even without this precaution however, the new ovens appeared decidedly superior in yield; he was satisfied they would yield in regular work as much as 70 to 75 per cent. of the coal used, and knew of one instance in which the yield reached 78 per cent., when the coke would have weighed still more if it had been left stacked after drawing. As regarded the duty of the coke in the blast furnace, he had seen the new ovens working at the Briton Ferry Iron Works, and was informed by the furnace manager that the coke from the new ovens did fully 7 per cent. more duty, and was a finer coke than any made from the same coal in ordinary ovens. The new ovens had therefore a superiority not only in the greater yield and density of the coke produced, but also in giving the means of making a commercially valuable coke from a material never before successfully employed for any useful purpose; and he was sure the economical using up of the vast quantities of waste slack at present thrown away was a most important problem for the future prosperity of the South Staffordshire district.

ON THE PRESENT ASPECT OF THE FINE ARTS IN ITALY, WITH ESPECIAL REFERENCE TO THE RECENT EXHIBITION IN FLORENCE.

By M. DIGBY WYATT, Architect.

(Concluded from page 76.)

IN dealing with the subject of ornamental carving in wood, we have already taken cognizance of one of the most important elements essential to the production of beautiful furniture. There remain, however, two or three special processes, which have been classed by the Florentine Commisioners under the head of Furniture, and which merit particular attention.

The most important of these is unquestionably mosaic in pietre dure, glass, &c.; and the second, that form of mosaic which consists in the inlaying of different coloured woods, and which we generally understand by the name of marquetry.

The former of these processes embraces two distinct varieties, the one suited for internal use only, and the other for both external and internal use.

In the first named class, the now royal, but formerly grand ducal manufactory, for the execution of what we know as Florentine mosaic, naturally occupied the most eminent position.

Having, in a report I was employed to write for the Board of Trade on a class in which the productions of the grand ducal manufactory were included, in the year 1855, gone at some length into the subject, I need not recapitulate the details I then collected concerning the history and character of that establishment. I may, however, state that the same technical perfection which I had then occasion to praise, and the same faults, as it appeared to me, of judgment in the general design of the principal objects which I then pointed out, may still be considered to characterise the productions forwarded to the exhibition under notice.

Thus the principal object, upon which it is said that vast sums of money and very many years of labour have been lavished, the altar frontal for the Chapel of the Medici, in San Lorenzo, is, it appears to me, altogether a mistake. With extraordinary patience and skill, materials of the most precious kinds have been selected and fitted to one another with microscopical precision, in order to reproduce a picture of the "Supper at Emmaus;" and, after all, wonderfully, but not successfully. In other objects, such as a magnificent table top, in which flowers, fruit, and birds are introduced in combination with conventional ornament, a very much happier result is obtained. The best understood, however, of any of the productions of the royal manufactory, appeared to me to be the fine wardrobe in walnut wood, inlaid with panels of pietre dure, limited in design to almost entirely conventional ornament.

Private manufacturers have during the last twenty years been creeping up in excellence, as the grand ducal school has been somewhat losing its old monopoly of excellence; and we now recognise specimens forwarded from private studios of almost equal merit to those wrought at the government establishment; thus, in point of pictorial mosaic, the centre and medallions of the great table executed by Bianchini, are more effective than the *tour de force* of the royal fabric, the "Supper at Emmaus," although perhaps not quite so perfect in execution. In the centre of this table is a picture of the adoption of Giotto by Cimabue, executed with extraordinary delicacy and dexterity. Among the highly commendable specimens of this class of mosaic are also the table tops executed by Francesco Betti, and the Brothers Lattici, of Florence.

For those whose pockets are unprepared for such drafts as the purchase of any of these splendid works would necessarily make upon them, similar objects, made in scagliola, and producing an equally brilliant effect, may be obtained at greatly reduced prices. One slab, executed by Picchianti and Son, of Florence, none but the most experienced eye could detect as being an imitation instead of an original.

Of the various materials in which pietre dure slabs are inserted, none appear to me to blend with it more successfully than ebony, and this happy union could not be better exemplified than in the beautiful little casket executed by Barzanti of Florence, which, both in the excellence of the mosaic and the taste with which the object is made up, could scarcely be exceeded.

In addition to mosaics formed with natural stones and marbles, some specimens of an agreeable, though rather too brilliant effect, formed by the insertion of artificial aventurine (made in glass) into marble and metal work, were exhibited by Signori Bigaglia of Venice, and, being a novelty, appeared to be highly appreciated by the Italians.

The other branch of mosaic based upon ancient Roman and Byzantine processes, is an art which has been steadily kept up in Italy, partly through the maintenance of the great Papal manufactory at Rome, and partly through the necessity of constantly supplying workmen and materials suited for restoring the great monuments scattered throughout Italy and Sicily, embellished both within and without with this luxurious decoration. But it is only recently that an attempt has been made to organise such facilities of production as may enable private manufacturers to offer their works in this department of industry for public sale. There seems every reason to anticipate that this industry will assume large proportions, from the demand existing for such architectural accessories, not in Italy only, but in all the highly civilised countries of Europe. The best specimens were those sent by Salviati and Vincenzo Redi, of Venice, one a representation of St. Nicholas, from St. Sophia at Constantinople, evidencing a power to reproduce the ancient Byzantine processes, and the other a figure of Christ, from St. Mark's at Venice, exhibiting an equal mastery over the Græco-Italian processes employed in that cathedral. Another competitor for patronage in this department of industry was Antonio Gazetta, of Venice. In all of these works the difficulty of producing good flesh-tints and properly vitrified gold-ground mosaic, appeared to be successfully overcome.

In glass, I am sorry to say, there was but little to praise, with the exception, perhaps, of the ruby glass of Piezaro, near Orvieto, the stained glass generally being inferior to contemporary productions in France, Germany, and England; while in cut and cast glass the form and ornaments were poor and unworthy of notice. How much of the reproach of insignificance in this department might have been removed had the establishments of Murano freely contributed the results of their best exertions it is difficult to say. Let us hope that whenever the next Exhibition of the products of United Italy may take place, the descendants of those who in the old time thought it no degradation to their nobility to be masters in the craft and mystery of glass making, may successfully vindicate their forefathers' reputation. In ceramics, however, there was much to interest.

At the head of this branch of industry stood, without a rival, the Marquis Ginori, who now sustains, to his own credit no less than profit, the old factory at Doccia, founded in 1735 by one of his ancestors. In fine porcelain the productions of the establishment leave little to be desired as to the quality of the paste, but the painting is as yet unequal to the excellence of the material. The most remarkable and characteristic of Ginori's productions are the imitations of ancient majolica, for his improvements in the manufacture of which the marquis gracefully acknowledges himself indebted to the talents in chemistry of one of his *protégés* and assistants, Signor Giusto Giusti, whose death in 1858, while scarcely in the summer of his intellectual powers, may be a source of regret, not to the marquis only, but to all Italy.

Many of these imitations of ancient majolica, and more particularly of the Fontana and Zuccheri types of it, are so ably executed as to imperil inexperienced collectors, who are too apt to believe that it is possible to obtain by chance objects for ten pounds eagerly sought after by many really well informed in such matters, who would not hesitate to give ten times the sum for undoubted specimens of the works imitated. Let one and all discard such vain illusions, and beware of either too cheap or too dear *articles de vertu*, in Italy. I was happy to notice that some of the most graceful of the Doccia productions were purchased by Englishmen, and among others, one of the smallest but prettiest, by our friend Mr. Crace.

In one of the great difficulties of the potter's art, that of burning large groups in biscuit, and allowing them to cool without cracking, the Marquis Ginori has not proved altogether successful, yet the design and modelling of his principal specimen deserved a more successful treatment in firing.

Although he may be considered as without any serious rival in the production of porcelain, in some of the appliances of earthenware with enamelled glazes he meets with competitors of almost equal ability. Thus, in the revival of pavements similar to those which floor the celebrated loggie of the Vatican, made it is believed by Girolamo della Robbia, Bernardino Papi, of Sienna, proves himself a thoroughly capable manufacturer. As also in Ginori's revival of the Luca della Robbia ware, others of the Lombard potteries prove that he his not alone in his knowledge of the processes by which such objects were anciently wrought.

In ordinary terracotta, such as those suited for stoves, large garden flower pots, and architectural ornaments, Bacci of Florence, Carlo Vanni of Impruenta, near Florence, Filippo Martinez of Palermo, and Rafaelle Piegaia of Lucca, exhibit very excellent productions, thereby demonstrating how widely a knowledge of these processes of old repute in Italy is spread.

Nor is it alone in quality that the specimens forwarded by these manufacturers excel, since in price it would be difficult in any other country, I think, to match them. For example, really a graceful stove in terracotta, burnt by Furlani, and such as in this country, I believe, would not probably be procurable under £3, I had the pleasure of buying for 25 francs, or £1; a much more ambitious and larger stove, of the same kind, by Ginori, was priced 80 francs, or about £3 4*s*. It is much to be desired that the Committee of Fine Arts for the decoration of the Horticultural Society's grounds at Kensington may find English manufacturers equal to the productions of vases and other features for the embellishment of gardens at similarly reasonable rates, since not a few proprietors of more modest gardens throughout the country are craving for such objects at prices a little less extravagant than those they cannot avoid paying now if they would introduce any similar ornaments amidst their shrubs and flowers. In ordinary tiles of inlaid clays suitable for mosaic, the Cavaliere Avila Altoviti, of the Val d'Arno, reigns supreme.

Marquetry—mosaic in woods—is an art of oriental origin, communicated to and almost entirely monopolised by the Italians for several centuries of the middle ages. In the North of Italy it is still highly popular, and both at Paris, in 1855, and the present exhibition, numerous specimens were to be seen—not in all cases sufficiently quiet in colour, or well understood in application, but almost invariably well and boldly executed. The absence of Gatti, of Rome, whose ivory and other inlay was so highly admired at Paris, is greatly to be regretted, as nothing in this Exhibition is equal to the small cabinet he there exhibited in 1855.

The best specimen of inlay, and probably one of the best of furniture in the whole Exhibition, is presented to us in the table for a grand saloon, made by Guiseppe Fontana, of Pisa. This piece of furniture is in fine old Siennese style (that which shortly preceded the year 1500), and leaves little to be desired. The remaining furniture in the Exhibition is of good average quality, requiring no particular remark, if we except the good lac-work, in imitation of Chinese, of Luigi Zampini of Florence.

Some buhl-work was sent from Genoa, by Jacinto Grosso. In a carved picture-frame, by Lorenzo Papi, of Florence, I observed a particularly pleasing effect produced by placing walnut wood carved in open work over a gold ground. I need scarcely note how good and cheap, and how well gilt and burnished the ordinary carved picture-frames of Florence now are.

The class of silk fabrics will no doubt, be so ably noticed by my friend, your vice-president, Mr. Winkworth, that I need do no more with respect to it and other textile fabrics than remark that as far as my powers of observation extend, in none, with the exceptions of the embroiderer's art, was there any great evidence of able design in connection with their production.

In carpets the Italians are altogether behind-hand; but some of their silks and velvets for upholstery, particularly the latter, are by no means bad. I did not notice any good lace in the Exhibition, but both at Venice and Genoa I have seen modern nearly equal to the old. Some of the fine thread needlework on cambric was exquisite.

In book production and decoration, although the glories of the classic printers of Italy—the Aldi, Giuntus, Giolitos, and Bodonis—were not perhaps fully sustained, there were many evidences of excellent capability. In bookbinding, particularly, the houses of Vezzosi of Turin, and Binda of Milan, took very high places, both for excellence of work and taste in the application of ornamental design to the requirements of their special branch of industry.

We have already noticed the perfection attained by the Italians in engraving and chromo-lithography, arts now all but indispensable to the perfection of luxurious typography. It remains only to say a word or two in vindication of the national powers in the art of engraving on wood. I observed scarcely any specimens in the Exhibition, but in contemporary publications, and more particularly in the *Giornale dell' Esposizione Italiana*, I noticed many examples of fair average excellence.

Such are a few observations which occur to me in respect to the present Italian industry, as exemplified by the products displayed in the Exhibition at Florence, and with your permission I will now proceed to add a few remarks touching the even more important question of the possible Italian Art-Industrial future, as now foreshadowed.

As there can be no fire without fuel, so there can be no fruitful production without education; and it is from the withdrawal of the restrictions which have hitherto tended to discourage every class of practical instruction, throughout most of the States into which Italy has been divided, that the probably most prolific source of future benefit is to be anticipated. Thus in the fine arts, although many costly literary works—such as the "History of Painting," by the late Professor Rossini, of Pisa; the "Illustrations of the Certosa of Pavia," by Durelli; of Milan by Cassina; of Venice by Cicognara; of Ancient Art by Canina; of the Museo Borbonico, by the Neapolitan Government; and of the Florentine and other academies—have been produced, mainly in answer to a foreign demand, there is an almost entire blank in the contemporaneous supply of what may be understood as school books of art fit to place in the hands of workmen and students. Since the days of Mengs, Algarotti, and Visconti, but few Italian writers have followed closely those theories of æsthetics which have largely engaged public attention in Germany, France, and England, and still fewer have endeavoured to methodise and popularise those texts for the practical instruction of the student. Gioberti's eloquent and learned essays, "Del Buono," and "Del Bello," are far too ethereal to be palatable to the general reader; while the master mind of Nicolini, the early bent of which inclined strongly towards the solution of art questions—as evidenced in his excellent discourses on Orcagna, Michael Angelo, Leon Battista Alberti, on "The Connection between Poetry and Painting," and on "The Influence of the arts on Social Life"—became subsequently engrossed by political, literary, and educational questions, of even more serious import to Italy.

Among modern writers on the subject of the fine arts, the Count Salvatico, the Marchese Ricci, and the Marchese Roberto D'Azeglio, may be considered as having effected the largest amount of good; but there is still much to be hoped for, now that it is possible for the books published in one part of Italy to be read in others, besides those in which, having eluded the Scylla of state censure, they were imperilled and imprisoned by the Charybdis of heavy and almost impassable barriers of state dues and inquisitorial police.

To the workman, however, there are practical sources of instruction even more valuable than the text books of his art. These are to be recognised in the works of his contemporaries. What can be imagined more instructive for an apprentice than to have placed under his eyes the best performances of his master contrasted with those of other manufacturers? What more beneficial than to be able to examine the productions of those who in any special branch of industry are superior even to the master he has been accustomed to recognise as to him its practical head? Such instruction is to be derived from Exhibitions such as that under notice; and it is to be hoped that the present may be but the first of a long series in which from year to year, and in different localities, the Italians may take stock of their own advancement, and from time to time enjoy opportunities of comparing their own productions with those of other, and perhaps in a commercial sense more advanced, nations of Europe. The tendency and ultimate result of such comparisons and such stimulants will no doubt be in Italy, as their action has already frequently proved in other countries, to convert exceptional into staple productions; and to lead to the confirmation of a manufacturer, treading with hesitating steps the path of novelty, in branches of industry ultimately destined to confer riches and honour on the land in which they may be originated. There is, too, in these Exhibitions a species of combination and subordination of means to a common end, the moral effect of which, for the Italians especially, cannot but be most excellent; and may tend strongly to correct, by a system of aggregation, the tendency to isolation so largely developed, even among the working classes, by antecedent social and political restrictions.

It is difficult for any traveller in Italy now, who may be at all acquainted with the great founts of Della Cruscan literature, not to recognise the deterioration which has befallen the noble Italian language, a deterioration commencing, perhaps, with the redundant epithets of Marini, and continued through the inanities of the "Compagnia famosissima della lesina," and of the still more celebrated Arcadian academy, to the present comparative decrepitude of once vigorous speech. Owing to a want of unrestrained communication, and of freedom of discussion, oral or written, on any but the most trivial subjects, there have been developed of late years tendencies—to cling to defective *patois* by way of concealing convictions on the one hand, and to verbosity, as a means of disguising ignorance, on the other hand—which have nourished the weeds of both Italian thought and Italian language, to the choking up of the flowers which were wont to spring so spontaneously from that ancient hod-bed of civilisation. This will, no doubt, be speedily rectified by a free press, and that facility of intercommunication by means of railways, which will ultimately obliterate the provincialisms complained of.

The same general principles of repression that checked the development of thought, that enfeebled the language, and barred the practical usefulness of the middle classes in Italy, condemned almost as conspiracy any attempts in the lower classes to remedy by combination the evils incident to their being left, as it were, without those natural leaders in art and industry which the middle classes in free countries invariably supply to the artizan.

Another unquestionable source of probable benefit to the arts in Italy must be recognised in the development of principles approaching to those of free trade, as opposed to old obnoxious tariffs, and in the increase of commerce and the profits arising from trade and manufactures to be thereby induced; for we cannot forget that it was out of the fulness of business profits, rather than any other source, that the funds were supplied in old times which led to the creation of those noble monuments which gave to the Italy of the fifteenth century its pre-eminent position in the history of art and art industry.

While it is true that a high development of industrial art is not an inevitable attendant on the existence in any state of a high degree of social and political liberty, in cases where the genius of the people is not bent in that direction, it is certain that where the tendency of a population is so strongly set as to have maintained during ages of repression, and under circumstances of the most antagonistic description, such an amount of capability as is now manifested by the Italians, those germs—dormant, or nearly so, during periods such as those referred to—will fructify a hundredfold under institutions calculated to develope personal independence and free action in that direction towards which the sympathies and aspirations of an enthusiastic people congenitally tend.

A comparison of the past with the present, and a correct appreciation of the phenomena of each, may certainly justify what has been predicted of the future of Italian art industry; but there exists yet another source from which as much fruit may be probably anticipated as from any of the reliable conducing causes to which allusion has been made. Such a source is to be found in what is commonly called "the chapter of accidents." As perhaps the brightest, though most sadly tarnished, American genius, Edgar Poe, acutely remarks—"The history of human knowledge has so uninterruptedly shown that to collateral, or incidental, or accidental events, we are indebted for the most numerous and most valuable discoveries, that it has at length become necessary, in any prospective views of improvement, to make not only large, but the largest allowances for inventions that shall arise by chance, and quite out of the range of ordinary expectation. It is no longer philosophical to base upon what has been, a vision of what is to be. Accident is admitted as a portion of the substructure. We make chance a matter of absolute calculation." Without going so far as this writer, we may yet carry a large sum to the credit side of our account from what mathematicians have designated "the doctrine of probabilities."

Thus, then, it is with a hope almost approaching to certain anticipation, and in serious though rather than glowing sympathy, that I venture to augur, from the combination of the excellence already attained, with the facilities for progress opened by its new political constitution, a future for the arts and industries of Italy such as may place them on a level with, if not in advance of, the most successful worshippers at the shrine of beauty in any other country of Europe.

It remains for us now, in the last section of this essay, only to endeavour to derive practically the largest amount of benefit we can from the past experiences of the Italians, and from the lessons which their productions past and present may teach us in the present day. The most important of these, it appears to me, is to recognise how, under all circumstances, the Italian demands art, not as a luxury, but as a necessity. If he cannot have it in good material he will have it in bad; but in some shape or other his eyes must be gratified with that without which vision would be to him but comparative blindness. If, for instance, the view from one of his saloons is terminated by a blank wall, as is the fate of many of those who dwell in our London houses, rather than let that wall remain a blank he will employ an artist to make him a design of an architectural or pictorial character. That design, if his means permit him to execute in marble, no material will be too costly for him to employ; if he cannot have it in marble he will have it in stone; if he cannot afford it in stone it will be in stucco; if he cannot afford it in stucco he will have it painted; if he cannot afford to pay anybody to paint it he will endeavour to do it himself; if he cannot paint it himself, or afford to pay for its being done, he will cover it with creepers—but supply his craving he most assuredly will. If we could feel the same active want, it is unquestionable that our greater amount of vital energy and greater wealth would lead us even better to supply our cravings than the Italian is enabled to gratify his. What then is most wanting in us is an ardent desire for the beautiful. I am far from saying that this desire does not exist in a large and rapidly increasing percentage of the English people, but with us it is so interjectional a sensation as to lead to comparatively little practical result. The rich man who sees a picture or statue which pleases him, will buy one or other, or both, but how seldom with the least consideration of special fitness for supplying any particular want—much thought of, long cherished, and carefully determined upon. The nature of such a want, and the best mode of supplying it, will occupy the earnest thoughts of the Italian, but with an Englishman, in a general way, the inclination will be but desultory, and if not supplied at a moment when strongly felt it will pass away, and perhaps never meet with realisation at all.

Another lesson of great importance to us may be derived from the fact that, both in the past and in the present the Italians have never been in the habit of looking at any one art as perfect in a condition of isolation from others. To produce for them the effect of beauty or nobleness all must contribute. Colour is just as essential as sculpturesque form, and both must be held in subordination by the symmetrical conditions of architectonic disposition of lines and spaces.

We, unfortunately, now see too many of the great monuments of Italian art stripped of half their furniture; but if, from the relics of perishable objects preserved in museums, such as that at South Kensington, we attempt to restore to those denuded monuments, to those ransacked palaces, "those banquet halls deserted," the embellishments we recognise as having formerly belonged to them, we shall at once see that the attainment of a really perfect effect in monuments, the beauty of which was dependent upon the combination of the fine arts, could only, in Italian eyes, be properly effected by superadding with profusion all that the industry and ingenuity of the most skilful workman could produce in the industrial arts.

To this union of all the fine arts among themselves, with the industrial arts attending as their handmaids, we must look as the most important element in all magnificence; and if we would emulate the Italians, we must not rest until we have learned to blend all cognate arts and industries in harmony.

The third great merit in the best Italian production, whether in a small article of industry or in the most magnificent monument, is nobility of inclination.

The mistake, for instance, of building the front of a palace in stone, and suddenly dropping off, the instant the corner is turned, into brick, might occur to even a millionaire in this economical age, but would scarcely have presented itself to a Medici, or a Farnese, in the old days of Italian magnificence. Not that the wealth, or the inclination to do what is handsome, might be less in the one case than in the other, but that public opinion and system would keep the patrons of old straight, and allow those of to-day to fall into what cannot but be regarded as an architectural meanness.

It would be, of course, too hard to point to any particular cases where hundreds are almost daily guilty of committing similar solecisms in taste, but unless we are to look for the exemplification of nobility of structure to those whose means place it within their power, how can we expect it from those to whom an increased expenditure might be a really important consideration?

Nobility of material lavishly used, ample space, solidity of structure, and the gift to the eye of something obviously designed rather to please than to pay, together with the effect that such departures from rigid utilitarianism produce instinctively on the spectator—sources of effect lavishly indulged in in Italy at every period of her history—are only beginning to be appreciated amongst us in the present day.

At the times when architects, such as Inigo Jones, Wren, Gibbs, and Chambers, endeavoured to maintain in this country the principles of grand Italian architecture, founded upon the universal practice during the best classical and mediæval periods, marble, oak, and stone were freely used. Cortiles and loggias, colonnades and arcades, were not banished as profligate waste of ground and money. Carving, and the elaborate working out of ornamental features in true and just proportions, were considered to be essential to fine effects. Paintings were not to be hung as by accident against walls—here a Madonna, and there a set of boors drinking—but allotted places were provided for them, in the vaults and on the walls of the principal apartments. Sculpture, too, found its niches, and when English talent failed to supply it, the services of foreigners, in despite of strong insular prejudices, were freely enlisted. And it was precisely when the public taste adopted a meaner class of building materials, a grudging spirit in the distribution of space, and a lower kind of internal decoration, that the arts of design in this country, with some few honourable exceptions, fell to zero. From that pitch (if I may use the expression) of degradation and disintegration, they are now happily rising into a concrete and perfect form, with a reaction the vigour of which is scarcely to be paralleled in the world's history. We are beginning to do better in each separate department of production, we are beginning to recognise that excellence in one must necessarily be combined with excellence in others, and we are beginning, in fact, to learn and practice the very system still lingering in the hearts and habits of the Italians. May we advance with them, and they with us—for it is one of the happiest conditions of all true art, that if it be worthily carried to perfection, its universality must breed honourable emulation, but never envy or jealousy.

ON SOME RECENTLY EXECUTED DEEP WELLS AND BORINGS.

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

(*Concluded from page* 78.)

It may be worth while to call attention to the mechanical means adopted by M. Kind in sinking a boring of the large diameter of 2 ft. 4 in. to the enormous depth of nearly 2000 feet from the surface. The work was commenced by a shaft, as usually is the case, and after it had been sunk to a depth of about 50 feet the boring commenced, and was continued with as nearly as possible the same diameter to the bottom. M. Kind employed for this purpose what may be called rods with releasing joints, very closely resembling the joints introduced by Œuyenhausen, which allowed the cutting portion of the tool to be raised a certain height and then to be released automatically; this arrangement was adopted in order to avoid the lashing of the sides of the bore by the long rods, and to regulate the force of the blow. The cutting tool used by M. Kind also differed from the tools generally employed, for it consisted of a single or a double trepan, according to the nature of the ground, instead of the ordinary chisels and augurs. A patent was taken out for these tools by M. Kind, No 13,478 of the year 1854, the specification of which contains a series of engravings of the various modifications proposed for the various kinds of rock; in the *Annuare Scientifique* for 1861 illustrations will also be found of the ordinary trepans and of the slide joints. M. Kind is able, by these combinations, to strike as many as twenty blows in a minute with the greatest regularity at a depth of 2000 feet. The patent of 1854 specifies also certain methods of lining the sides of the borings; but it must be confessed that they do not seem to me to possess any great merit, and indeed M. Kind had more difficulties to encounter at Passy from the collapsing of his tubes than from any other cause. It is a common error of well-borers to undervalue the effort exerted by clays swelling when charged with water; and the great delays encountered in sinking the Passy well were precisely caused by the false economy introduced in the execution of the tube linings. The time actually employed in sinking the Passy well was nearly the same as that employed at Grenelle; in the former instance it was 6 years 275 days, in the latter it was 7 years 90 days. The cost of the Grenelle well, as above stated, was £14,000; that of the well at Passy was £40,000, but it must be observed that the quantity of water, delivered at the same height in the two cases, is ten times greater at Passy than it is at Grenelle; the rates of delivery are, in fact, nearly in the direct ratios of the diameters.

I have not been able to learn whether the artesian wells of Elbœuf and of Rouen have been effected by the completion of the new well at Passy, and at present I am inclined to believe that they may escape this action, on account of their proximity to the entering ground of the lower green sands, on the western margin of the cretaceous basin. At Tours, however, so many wells have lately been sunk (in an early edition of M. Degoussé's excellent 'Guide du Sondeur,' that gentleman mentions that he himself had executed no less than sixteen of them), that the subterranean supply is becoming exhausted, and, as in the case of the wells supplied by the basement beds of the London clay, the lower green sand wells are gradually losing their artesian character. In two wells also, at Evres and Ferrières, the subcretaceous formations yielded no water; and in the latter the bore was even carried to a depth of 30 feet in the great oolitic, or Jura limestone series, without obtaining a supply. I call especial attention to this fact, because it illustrates again the uncertainty at all times overshadowing the execution of the first deep wells in a particular district, and that the stratum which yields water in one locality is likely to be unable to do so in another. The enterprising gentlemen who are engaged at the Hastings well should bear this fact in mind; and though I believe that after they shall have traversed the lower members of the Wealden series, they are more than likely to find the upper or Portland oolite, which is of sufficient water-bearing power to insure them a good supply of water, they must also be prepared for disappointment. The Hastings well is already 553 feet deep, still in the Hastings beds, and as these have never yet been traversed, it is impossible to say whether they will be found to be seven or seventeen hundred feet thick. Most probably the former guess will be found to be the more correct, because the town of Hastings is situated at a low horizon in the series of Weald beds; but all operations of this description at Hastings must for the present be conducted in doubt as to the ultimate result, however strong may be the hopes of success. The character of the strata already traversed, and of those likely to be met with at Hastings, leads me to believe that M. Kind's processes would be particularly applicable there, but the success of such an operation would still be a mere matter of speculation, such as ought to be left to private enterprise.

I dwell a little on this point, because the Board of Guardians of Brighton are engaged upon a similar experiment, at a place called the Warren Farm, near that town. It is not my place to criticise the mode of execution adopted in carrying on this work, but I cannot refrain from saying that there are many things about it which seem to me to be in opposition to the opinions now entertained by scientific engineers; and I gravely suspect that, even if water from the subcretaceous formations should be obtained at this well, it cannot by any possible chance rise near the surface, which, at the Warren Farm, is not less than 410 feet above the mean tide level. It is inexplicable to me also, that this well should be continued by means of a shaft at the great depth already reached, instead of by means of boring; and I regret bitterly to see an experiment, which has been carried on hitherto with so much spirit, compromised by what I consider the mistaken course latterly adopted. At Brighton, nevertheless, the only chance of securing a supply in the parts of the chalk basin lying beyond the influence of the faults or "cross throws," which have, for instance, enabled the Water Works Company to obtain, as is said, one million gallons per day, is to penetrate the chalk to the lower green sand. Notwithstanding the cost of the previous experimental borings in the surrounding counties, I am convinced that the cheapest manner of effecting this object would have been to have bored, rather than to have sunk a shaft, and even now the Guardians would do wisely to adopt this course, especially as theirs is really the first experimental shaft or boring on the east bank of the Arun. It is, however, a sad peculiarity of the municipal bodies of England, that they are always disposed to listen to those whom it is the fashion to call "practical," in contradistinction to "scientific" men, as though the mere fact of working "by rule of thumb" gave men truer insights into the laws of nature than long study and careful observation. At Brighton this seems emphatically to have been the case, and in a report addressed to, and received by, the Board of Guardians, the opinions of three practical well-borers are quoted as to the probable cost of continuing the well at Warren Farm, but no opinion seems to have been asked from such men as Mr. Hawksley, Mr. Mylne, or Mr. Homersham, who have brought great experience and deep study to bear on the hydrographical conditions of this district on other occasions. It is one of the fashionable theories of the day that a scientific education incapacitates a man for the exercise of a profession, and that the most able men in any branch of art or science are those who have not been brought up to pursue it. Under these circumstances it may not be surprising, however unfortunate it may be, to find empiricism preferred to science, or that the Brighton Guardians should avoid taking the opinions of really eminent engineers.

In stating, in the previous part of this paper that I should return to the question of the abnormal beds met with at Highgate, I had especially before my mind's eye the cases of the well sunk under my own orders at Warnham Court, near Horsham; and at Red Hill, by my friend Mr. Docwra. In the former case, the boring, after it had been carried through the sandstones, clays, and shales of the upper Wealden deposits, passed at a depth of 142 feet from the surface into a bed of red clay and sandstone intermixed. At first, I believed, from the external characters of the materials, that they were of the same nature as the beds found at the bottom of the Kentish Town well, and I was supported in this opinion by several distinguished geologists to whom I showed the samples. As the Kentish Town beds were, at the time I refer to (about five years since), universally considered to be members of the new red sandstone series, of course I regarded the Warnham bed as one of the same range. But Mr. Docwra, at Red Hill, after he had traversed the sands and loams of the subcretaceous series to a depth of 438 feet, passed into a bed composed of red clays and particles of red sandstone, which were identical with the Warnham beds, and with some members of the Wealden series. It seems therefore to me to be very probable that the Kentish Town beds may be members of the Wealden series, but the solution of this question has simply a geological interest, for alike, the Weald clays and the new red sandstone clays, are without water; and, under these circumstances, the wisest course to be adopted was to stop the further progress of the works in all such cases as Warnham and Red Hill, unless they were carried on distinctly as philosophical experiments.

The well at Rugby, though it has proved to be, no doubt, a source of annoyance and disappointment, may eventually turn out to be of importance to the commercial interests of the locality. It was commenced with the hope of finding in the new red sandstone series under the lias, some water-bearing strata which might be able to furnish a supply to compensate for the deficiency under which the town of Rugby was suffering, after it had been put to the expense of carrying out the absurd crotchet of the so-called "gathering grounds" system. A boring has here been carried down to a great depth in the new red sandstones of the triassic group, which, at Liverpool and Birkenhead for instance, frequently supply large quantities of water. At Rugby, however, the boring at present has only yielded a brackish water, and I suspect that now all hopes of securing the result desired by the Local Board of Health by this well must be abandoned, unless the Board determine upon tubing the bore-hole throughout its length, and upon continuing to sink to a much greater depth. It is possible that, within a moderate distance from the bottom of the present well, stronger brine springs than those now brought to the surface may be found, which it would be possible to evaporate economically for the purpose of salt making; but a very careful comparison between the strata of this locality, and of those near Derby or Droitwich, would be required before any decided opinions could be formed as to the probability of finding soft water within a reasonable distance from the surface at Rugby.

The well at Great Yarmouth, executed by Sir E. Lacon and Co., is of interest, on account of its showing the great depth attained by the tertiary strata on the east of England; but, unfortunately for the spirited proprietors, the results, so far as water supply is concerned, have been "negative." The depth of the tertiaries here was found to be 527 feet, and the first 170 feet of this thickness were composed of recent estuarine and blown sand, deposits of very recent formation. At Norwich, Messrs. Colman are steadily pursuing an experimental boring, which has already passed through the chalk to a depth of 1158 feet, the upper green sand to a depth of 8 feet, and the gault to a depth of 30 feet; the works have been suspended in this formation on account of some accident to the machinery, but when this shall have been repaired they will, no doubt, be resumed. It may be necessary to descend 150 feet lower before reaching the water-bearing stratum, but the comparative success of Mr. Lankester Webb's well, at Stowmarket, affords good reason to hope that Messrs. Colman's perseverance will ultimately be rewarded. I do not anticipate, however, that the water will overflow the surface, because the lower green sand is traversed by one of the affluents of the Ouse, near Downham Market, at a comparatively low level.

In a paper which I had the honour of reading in this room last year, I alluded to the very successful borings made by the Kent Water Works Company, in the Ravensbourne Valley, and this evening I am enabled to lay before you a section showing the strata they traversed. One reason for my doing so is, because I have heard that some parties propose, as I said in the opening paragraph of this paper, to sink artesian wells near London for the supply of the metropolis; and I think it desirable to state for their guidance, that unless they meet with the peculiar conditions of the faults of the Ravensbourne Valley, they are not likely to obtain a large supply of water from the chalk on the north side of the Thames, whilst there is no chance whatever of their finding water below the chalk. There are, no doubt, copious and beautiful springs given off from the head valley of the Lea and the Coln, both of which rise in, and are fed by, the chalk; but those springs may, in almost all cases, be shown to be connected with some geological disturbance of the strata: and the only locality near London where there seems to me to be any chance of obtaining a large quantity of water from the chalk, would be on the left bank (or the west) of the river Lea, somewhat to the north-east of Stratford, because there is about that district a line of disturbance in the chalk parallel to the great fault which brings to the surface the springs lately tapped near New Cross, and those of Grays in Essex.

Finally, it must be evident to anyone who reads attentively the records of the success and of the failure of the attempts abovementioned, that the execution of artesian wells is an operation which should only be entrusted to skilful and well-tried men, acquainted with the theory and practice of their art. No such work should be commenced without a careful preliminary survey of the geological and hydrographical conditions of the country extending over a very wide range. This is seldom done, because public bodies, in England at least, do not seem to object to pay for engineers' blunders and miscalculations, but they do object to pay for their study; and it is at once assumed that because artesian wells have succeeded in one case they must succeed in all. But even when the greatest amount of skill and science have been brought to bear on the preliminary investigations for the establishment of an artesian well, it is impossible to predict with any certainty what the result of sinking a shaft or a boring may be in a stratum hitherto untried. Moreover, every artesian source of supply is limited in amount, and even in the case of the Paris basin it would be desirable to watch the effects of the increased draught upon the lower green sand during a dry summer, especially before commencing, as has been proposed, the execution of a large number of wells like those of Passy and of Grenelle.

The student who may desire to obtain a complete view of the subject thus briefly referred to, would do well to consult the works of Messrs. Prestwich, Mylne, Clutterbuck, Homersham, Degoussée, Burat, Hericart de Thury, Garnier, &c., the Transactions of the Institution of Civil Engineers, the Comptes Rendus of the Académie des Sciences, and of Les Ingénieurs Civils of France. I am myself under great obligations to Messrs. Hawksley, Lockwood, Wells, Chamberlain, Docwra, Prestwich, Morris, Snider, and others, for the sections and information so liberally supplied to me.

I may here add that in the number of *La Presse Scientifique*, for the 16th January of this year, I find a notice of a well lately sunk at Columbus, Ohio, U. S., which is not less than 2575 feet deep. The thermometer (on the system invented by Mr. Walferdin) registered a temperature of 88°; this would seem to show that the law of the increase of temperature is rather slower in Ohio than it is near Paris. No particulars are, however, given of this important boring.

THE OFFICIAL PROGRAMME FOR THE DESIGN OF THE PARIS OPERA HOUSE.*

Second Division.—The Stage.

39. It is not necessary for the stage (*la scène*) to be deep—it is by the illusions of perspective that distant horizons are produced. A depth of 30 metres (98 feet) between the proscenium and the back of the stage suffices for all scenic requirements. A greater depth would present more disadvantages than advantages. The stage ought not, however, to be too wide. The opening of the scene would be satisfactorily fixed at 15 metres (49 feet), as at La Scala. At the (present) opera house it is 13·20 metres (42 ft. 6 in.)

40. The space occupied by the wings (*coulisses*) on either side of the stage ought to be extended as far as possible; first, with the view of being able, where necessary, to open oblique vistas, and second, in order to prolong the curtains and front framing sufficiently to intercept the visual lines from the nearest side boxes, without the help of those oblique screens (*brisures*) which generally have to be added to most flat scenes, in order to screen the openings (*découvertes*),—unsightly additions, which encumber the entrances, to the detriment of the *mise en scène*, and interrupt the perspectives of the front scenes. To get rid of this disadvantage entirely, it would be requisite to widen the stage disproportionately, but the wider the wings are made the more will it be diminished.

41. The present width of the wings between the side boundaries of the stage and the margins of the opening of the scene is equal to one-half that opening: at least two-thirds are requisite, which, for an opening of 15 metres, would give a total width of 35 metres.

42. There are also required on each side of the stage, between the scene, properly so called, and the scenery stores (*cases à décors*) which will be described further on, galleries three or four metres wide, in which the chorus can be grouped, and the evolutions of large bodies of persons can be prepared for, things which are now extremely difficult, if not impracticable, for lack of room.

43. These galleries will be connected at their further end with another gallery of the same width running behind the back wall of the stage, and into which the doors for entrance on to the stage will open. These doors must be very wide openings in the masonry, but may, however, be reduced by moveable panels to such a size as is necessary for ordinary requirements.

* Continued from page 67.

Scenery Department.

44. A gay and good-humoured critic lately said of the machines at the opera, that "they have in two centuries lost nothing of their charm and their force." This is quite true—the machinery at the opera still remains what it was at the time of the Marquis of Sourdéac. Since 1672 it has, indeed, lost little or nothing, but it has not made the slightest advance. As matters now are, it is necessary to seek out in the scene room, move, set, and fix by manual labour the whole of the scenery required for each performance, and their repeated handling damages the scenes so rapidly, that they are almost always tarnished before the first performance, and sometimes are worn out before the piece for which they were prepared has run through its success. At each act difficult and dangerous manœuvres have to be afresh commenced, with the object of fixing the framed scenes (*châssis*) which during the day have been laboriously accumulated, in what is termed the "groups" (*les tas.*) The whole thing is one perpetual demolition and reconstruction, and in spite of the exertions of a hundred scene-shifters it is no uncommon thing for half an hour, sometimes even more, to pass between the acts, to the great detriment of the works performed, the success of which is endangered by the impatience which these delays arouse in the audience.

45. It will be understood that such a system renders it impossible, if some unforseen accident interferes with the arrangements of the manager, to change on the day of representation the play announced and prepared the previous day; and often there is no resource than to close the theatre, and have no performance.

46. With the present machinery of the opera many scenic effects have to be given up, because the shifting the scenes would require whole hours of work.

47. At the same time, nothing would be more easy than to perform within a few minutes the most complicated changes of scenery by the aid of a few mechanical contrivances of a nature more simple than those daily in use in the smallest workshops.

48. The whole problem consists in causing the framed side scenes, which, together with the scene at the back, constitute a complete scene, to advance or recede by a to-and-fro motion of the simplest nature. These framed scenes—and we include under the term set scenes (*fermes*) which are only framed scenes which fill the entire width of the stage—are very difficult to move under the present system, but more on account of their flexibility than their weight; they could on the other hand be moved with the greatest ease if, instead of being moved by main force and from the bottom, they were suspended and slid along a system of rails suitably fixed above, and continued on right into the scenery stores, which would be formed at the sides of the stage. Thus adjusted, the most simple motive power—such for example as a windlass—would suffice to set them in motion, and cause them to advance or recede at pleasure upon a signal from the stage manager, means being also adopted, in cases when they have reached their position, but are not to be seen full in front, for causing them to perform a very simple rotary motion round the centre from which they would be suspended, which motion might be done by hand labour, for we have no intention of depriving ourselves of a recourse to intelligent manual labour, but only of limiting it to the detail of the working.

49. We require that these scenery stores should be each one of a width equal to half that of the scene. If this be the case, it would be possible to dispense with many stories in the basement; for the largest scenes, the set scenes, could be moved sideways in place of being extracted from abysses into which they have been with much difficulty introduced during the day, only to draw them out at night by the not unfrequently dangerous action of the ill-restrained power of balance-weights.

50. If, however, the lack of room prevented such a width being given to them, the management of the scenery would be something more complicated and a little slower, but would not be much more difficult. It would be only necessary to divide those framed or set scenes which when extended would exceed the width of the store, into several folds. But this would require to be avoided as much as possible, for nothing wears out scenery more than the creases which such divisions render necessary.

51. For the same reason it is requisite that the height between the top of the proscenium and the roof should be sufficient to permit drop scenes to be drawn up entire and without folds, as is the case in the Dresden theatre.

52. These scenery stores would be further equipped with moveable fronts, closely shut during the performance, and only open in

the interludes for a few moments to allow the passage of such scenes as the scene shifters would have to prepare during the progress of the piece. Such a thing is at the present day impossible, for the whole is put together piecemeal on the stage, with loud blows of the mallet, and noisy struggles.

53. Nor would reforms be limited to scenery strictly so called; they would include those monstrous piles of timber by the aid of which staircases and mountains are made, and in fact everything designated so inappropriately as "practicable." For the most part, the mountains of the opera, like those of the earth, might be formed by a mere elevation of the ground, if the boarding of the stage was formed of moveable portions lifted by standards with cogs (*epoutilles a crémaillère*).

54. The system of suspended scenes would be also of assistance in another respect; by superseding the use of all the channels which under the present system furrow the stage, it would allow the substitution of a level and tongued floor, for the openwork which now constitutes the floor of the stage. And as one improvement leads to another, this step would destroy the source of the most injurious of the cold draughts to which the performers are exposed.

55. By these means the most complicated alterations of scenery would be brought down to the limits of the simplest shifting of scenes; as long as the piece stood upon the list, its scenery once prepared would be all ready to be brought forward at the signal of the head machinist, who would not require more than two hours' notice. Consequently there would be an end to blank nights, so hostile to the treasury: the scenes might be preserved for an unlimited time; the pauses between the acts could be of just the length thought best; and a saving of labour and materials would accrue, for twenty men would suffice to perform the work which now employs one hundred. What advances might it not be possible for the scene painter's art to accomplish, if simple and ready methods existed of realising within a few minutes, effects such as now cannot be attempted, or which are practicable at the present day only by main force and at great expense, and with endless delays!

56. For the reason above given, we consider that the scenery should necessarily be stored at the sides of the stage and not elsewhere, and that the following suggestions relative to the width of the scene and its lateral appendages ought to be adopted :—

				ft	in.
The opening of the scene taken as the unit of measurement...	1·	or, in metres	15 =	49	0
The distance between the sides of this opening and the lateral boundaries of the stage, should be for each side 0·66, or for both	1·32	,, ,,	20 =	65	6
The scenery stores will each one have a width equal to $\frac{1+1\cdot32}{2}$, and together	2·32	,, ,,	35 =	114	6
Corridors of communication and working each (at the least) 0·20, and together	0·40	,, ,,	6 =	19	8
		Total in metres	76 =	248	8

We are not increasing by much the space allotted to scenery stores. At the present opera it is about five-sixths of the area of the stage, and is notoriously insufficient.

Stage	24·00 × 25·00	= 600 metres.
Scenery	{ 168·00 / 351 }	= 519 ,,

What we require is an area equal to that of the stage.

Various departments connected with the Scenery, Accessories, and Properties.

57. Like the scenery, the accessories and properties ought to be readily and easily transported on to the stage. This requires an adjoining depôt, but it is not essential that this depôt should be the general store of accessories; all that is requisite is for it to be sufficient to contain those belonging to ten or twelve pieces out of the list. The store appropriated to this department in the opera house covers an area of 170 square metres, and is sufficiently large. This area, like that of the stores and ware-rooms which will be mentioned below, is given with relation to an average height of story; but in many cases surface may be set against height, and *vice versâ*. These directions, moreover, are not in any sense invariable, they are merely average data, which may be altered to suit the arrangements of the plan. With this depôt should be connected)—(1) A small work-shop for the maintenance of properties, inclusive of minor carpentering works turning, smith's and tinman's work, painting, gilding, papering, needlework, &c., all however done by the property-man and his assistant, and by one seamstress, three persons in all. (2) A dressing room, and the wardrobe of those attendants who will have to appear on the stage, about eight men. The general store of properties may be placed in the roof, provided that it be reachable by a convenient staircase. An area of from 200 to 300 metres is required for the minor properties, and another of equal or smaller size for the more bulky ones. Properties now occupy at the opera house

One store and several appendages cover together	192 metres.
One store above the public saloon about	200 ,,
	392

And in addition, all the roof round the cupola, and a large number of closets or garrets in various parts of the house and stage. This however is not enough: there is confusion, the work is badly done, things get worn out, and good order is out of the question; many articles moreover have been destroyed which it was found impossible to take care of for want of room.

58. The store of the stage upholsterer ought to be similarly arranged, and to include—(1) A store near the stage, 50 to 60 square metres. (2) A small, well ventilated shop, lighted by daylight, and if possible opening into a little court-yard, for two or three men and as many workwomen, (15 to 20 metres). (3) A reserve, store which may be placed in the roof, but easily accessible (about 100 to 150 square metres).

59. The plumber's store, to contain also the hydraulic machinery belonging to the scenery, ought also to be contiguous to the stage, and preferably below than above it. It is probable that with a well contrived hydraulic system it will in the future theatre be possible to secure effects which it is impossible to produce at the present day, and the plumber's stores will be augmented. A moderately large store however, which will be better long and narrow than square, so as to allow pipes to be stowed there, (say 8 or 10 metres long by 3 metres wide) ought to be under any circumstances sufficient for all requirements.

60. Two compartments, one at each side, for stowage of articles belonging to the lighting, bearers, side lights, chandeliers, pipes, &c. These stores should have high ceilings, as most of these articles will require to be placed vertically; but a large area is not required for them, 10 to 12 metres are enough for each, with the provision of a large store-room in an upper story or in the basement (but in either case secured from damp) for articles kept in stock.

61. The workshop of the fire-work maker, and stowage for his tools, and stores (about 20 square metres). This shop should be near the stage, in order to reduce the danger attendant upon the transport of inflammable articles and of fireworks and their remains through passages. It should be as much as possible sheltered from fire, and so placed that, should an accident occur, the effects of the explosion would expend themselves outside the building.

62. The laboratory of the *physicien*—qy. electrician ?—which may be placed in the roof, to facilitate the escape of noxious fumes from the acids, but as far as practicable near the stage, to shorten the length of the electric wires. This laboratory comprises—(1) a main room of fifteen or twenty square metres for the battery, and the necessary work connected with it; (2) a small room for the *physicien* and for the stowage of his instruments, containing about from ten to twelve square metres; (3) a small, easily accessible store for acids, metals, charcoal, &c.

63. The head machinist must have his office near the stage, but easily accessible from without. He ought to have near him—

64. The under machinist;

65. The head gasfitter (*chef de l'éclairage*); each of whom will have a small office.

66. Among the adjuncts to the stage, and as far as possible at heights corresponding to their respective positions, should be the rooms of the foremen machinists aloft (*du cintre*) of the stage, and of the basement (*les dessous*); a rational division, and one that will always be preserved, whatever system be adopted. For the working scene-shifters, about sixty in number, a common room will be required, with a locker for each man; a separate room in the upper stories for the carpenters of the stage and aloft, and another in the lower stories for those belonging to the basement.

67. The gas-fitters will have a place assigned to them near the

store for their department, which we shall have occasion to mention further on (see No. 99).

The Departments of the Stage and the Management.—Manager's Court.

68. In the midst of the buildings intended for the management there must be a court, with a covered gallery in front of one of the façades, or, what would be preferable, round three or all four of the sides, and forming a covered way leading to the street.

69. A single entrance, divided, however, into carriage gates and a gate for foot passengers, will give access to this court-yard from the street. It ought not to be possible for any person to enter or leave this court without passing under the eye of the door-keeper, whose lodge will adjoin this gate.

70. Under the corridor of this court there will be three entrances: one for the manager's department and the offices; one admitting to the theatre for the chorus, scene-shifters, and supernumeraries; and one for the principal performers (*artistes*) in the opera and ballet. Before the latter there will be a porch to facilitate their entering and leaving their carriages in security from the weather. Too much precaution cannot be taken to protect singers from the injurious effects of the outer air, when, weakened by the labours of a performance, they leave the building in the middle of a cold, damp, winter's night.

71. Near the manager's court there must be a shed for carriages, to the number of five or six, in waiting for the principal performers, as they leave.

72. A low hall, or species of external gallery, must be provided, opening directly on to the high road, near the porter's lodge, and communicating with the portions of the building appropriated to the stage department, by a door not to be opened till the right moment: here, an hour before the commencement, the extra supernumeraries and any additional workmen of all classes required may assemble and wait till they are wanted by their superiors. None of these men ought to be able to enter the theatre before he has been called by name. This hall should be capable of containing one hundred persons, sometimes it receives more, but only under exceptional circumstances, which are not of frequent occurrence.

Stage Manager.

73. The stage manager's department is the centre round which are grouped those other departments which are all more or less dependent on the direction of the stage. It should be in easy communication with the scene and its adjuncts, with the green room, with the wardrobes (*magasins des costumes*), and within reach of the manager's office, with which it is frequently in communication, and whither the various superintendents require to proceed with despatch when they are called for. It must also have a ready communication with the exterior. The stage manager's department comprises—(1) an ante chamber, where the call-boys (*avertisseurs*) wait; (2) the stage manager's room; (3) the office of the superintendent of the chorus (two persons); (4) the office of the superintendent of the ballet (two persons); (5) a station for the inspectors of the stage (3 persons).

Performers' Dressing-rooms (Loges des Artistes).

74. The division of the dependencies of the stage into two sections, appropriated to the two kinds of performers, singers and dancers, which the nature of the case seems to point out, cannot be as rigidly carried out as might be thought. Many important departments are connected alike with both sections; further, the opera and the ballet are not conducted under the same circumstances; the individuals belonging to each section have not the same requirements, and are differently grouped (*organisé*); consequently the idea, natural enough upon the first blush, of appropriating one of the sides of the scene to each division, is difficult to put in practice, and corresponds ill with working requirements. The dressing-rooms of the vocal performers ought to be as near the stage as possible, and at least those of the principal performers ought to be on the same level. There is, on the other hand, no disadvantage in placing the ballet department further from the stage, and on a different level. So that, instead of a division into two departments on plan, a division into different stories appears to be the preferable one. But it is suitable, and corresponds with working requirements, that one side should be appropriated to men, and the other to women, on each story.

75. Each principal performer's dressing-room (*loge d'artiste*) ought to include—(1) a lobby, to cut it off from the common corridor; (2) the dressing-room itself, of ten or twelve square metres, rather more for the principals (*premiers sujets*), especially the principal dancers, who practice in their rooms; (3) a closet for dresses. The principal dressing-rooms should be large enough to allow a performer to see herself all over in a mirror fixed against one of the walls, so as to be able to judge of the effect of her dresses and her attitudes. It would be desirable for the dressing-rooms of the principals each one to have a separate closet (w. c.) The means should be provided of readily warming each room to the very variable temperature which each artist prefers, either by a fire-place, or whichever heating apparatus (gas, hot water, steam, &c.) is admitted to be the best.

76. The following, taken in connection with what has just been said, are the requirements of the various departments belonging to the stage.

Section I.—Opera.

PRINCIPAL MALE PERFORMERS.

(1) Principals (*premiers sujets*), twelve dressing rooms.

(2) Substitutes and seconds (*remplacants et doubles*), twelve ditto.

(3) A store for dresses (about twenty-five to thirty square metres) in the midst of these rooms, and communicating easily with the central wardrobe.

(4) A station for dressers (four or five men) should adjoin this store.

(5) Accommodation for the hair-dresser, with a closet for his wigs.

PRINCIPAL FEMALE PERFORMERS.

(6) The same arrangement as for the men.

LEADERS.

(7) The room of the principal singing masters (*chef de chant.*)

(8) One for the second singing-master and the rehearser (*répétiteur*). Each of these rooms will be of the size of a small dressing-room. An upright piano, a small bureau, and a few chairs, form the sole furniture.

CHORUS.

(9) The room of the chorus-master.

(9*a*) One for the second chorus-master and the rehearser, the same dimensions as those of the other singing-masters.

MALE CHORUS SINGERS

(10) One large dressing room, or two or three, for the accommodation of 60 regular (*titulaires*) chorists. Each chorist ought to have for dressing and hanging up his dresses a dressing box or stall of about one metre in depth by a nearly equal width. The best arrangement for working would consist of two large rooms adjoining one another, communicating by a wide opening, each having a separate entrance, and being divided by low wooden partitions into dressing boxes of the required size. The passages between these boxes ought to be wide and roomy, and the clear space should be sufficient to allow the chorists to feel comfortably at ease between the acts. This requires for 60 chorists an area of about 200 metres. In the opera house, where the singers' dressing boxes are much too narrow, 2·70 metres is allowed for each occupant.

(11) Two dressing rooms for principal chorus singers (*choryphées*), each for two or three persons.

(12) A room for ten choir boys.

(13) A store for dresses, as near as possible to the large chorists' room, and communicating easily with the central wardrobe (of 30 or 40 square metres according to its height).

(14) A large dressing room, or room for 30 additional singers, accommodation required on special occasions and conditionally, and consequently admitting a position more removed from the stage, and more limited arrangements than that for the ordinary working.

FEMALE CHORUS SINGERS.

(15) One, two, or three dressing rooms for 50 chorists.

(16) Two rooms for leading chorus singers (*choryphées*), each for two or three ladies.

(17) A store for dresses (30 to 40 square metres) adjoining the large dressing room, or very near to it, and communicating easily with the central wardrobe. The rooms of the female chorus singers should be arranged like those for the men, and similarly divided by wooden partitions into stalls or separate compartments, only it will be convenient that for the women these compartments should be wider than those of the men, say 1·20 metres in place of 1 metre.

(*To be continued.*)

LECTURES ON ARCHITECTURE AT THE ROYAL ACADEMY.

By Sydney Smirke, R.A.

Lecture II.*

I must not pursue the subject of chimneys further than just again to remind you of the æsthetic advantages afforded by the old mode of treating the chimney hearth. The contemptible little pinched-up compositions of thin, flat, marble slabs, which now usually decorate this social centre of domestic hospitality, contrast most painfully with the large and generous treatment of the fireplace, and with the sculpture and painting which were lavished during the period to which I am adverting on this place of honour in the halls of former days.

Although time has left us but few illustrative examples of these fireplaces in England, we have but to visit Nuremberg, or any of the older cities of the Netherlands, to find noble examples still surviving the wreck of time. Even the great hall in the Hotel de Ville, in Paris, probably familiar to you all, which is of the time probably of Francis I., affords a remarkable example, sufficient to dwarf down into insignificance every similar object I have met with in England, although I am aware there are examples of the time of Henry VIII., of Elizabeth, and of Charles I., of no mean character.

At the magnificent Chateaux of Blois and Gaillon, the most remarkable features are their gardens. They are, of course, laid out in the formal artificial manner usual in the gardens of the early period to which these examples belong. In the centre of both these gardens is a fountain of much elegance of design, although the jets of water issue from sources not altogether unobjectionable. The practice of throwing the water from the mouths of human masks cannot be defended, although it is a very common expedient. It was suggested probably by the gargoyles of Mediæval times, when monsters, often of the most preposterous design, were made to emit water, both in fountains and at the eaves of roofs; but these, also, may claim a far more ancient origin. We know how commonly the rainwater which fell on the roofs of Greek temples was made to issue from the mouths of lions carved on the cyma of the cornice: they were, in fact, the true gargoyles of the Greeks. The practice may perhaps be partly due to æsthetic causes; for there are few subjects more captivating to the sculptor than the lion's head, so admirably sculpturesque in the breadth and even in the grandeur of its details. But still another and remoter origin may be assigned to the practice. The overflowing of the Nile, which, as you know, annually reanimates that arid country, and gives occasion to so much periodical rejoicing, occurs when the sun is in Leo,—a coincidence quite sufficient to lead the Egyptians to adopt the lion's mouth as the source from whence their liquid treasures were made to issue. At the fountains of the Chateau d'Anet jets of water are seen issuing from Diana's bow, and from the horns of her accompanying stag. I am, indeed, bound to admit that the rude artists of this not highly-polished nor very fastidious age caused jets to flow from still more exceptional, although perhaps more natural sources.

These devices are common enough at the period of which we are speaking, and can only be excused on the ground of the extreme difficulty (which all must have felt who have tried their hands at designing fountains) of devising any perfectly unobjectionable and yet ornamental mode of emitting the water. But perhaps the most notable feature in these early French gardens is the arcade, or covered way, which incloses the whole area. As a gallery offering a sheltered walk at all seasons of the year, whether too hot or too wet for out-of-door exercise, these covered walks must always have been a welcome refuge. The luxury was probably borrowed from the Italians, with whom these arcades or colonnades had already become a favourate adjunct to the villa. They also, in their turn, may claim a classic origin. Those who have read Pliny's description of his Villa Laurentina will remember how he dwells on the crypto-porticus as one of the luxuries of his favourite retreat—a luxury which, though preserved in the cloisters of the Middle Ages, seems to have been, without good reason, overlooked and neglected in modern gardening. In these French gardens I also perceive indications of the pergola, or trellissed walk, which forms so elegant as well as so commodious a part of almost every well-appointed Italian garden.

*Concluded from page 83.

I will not further detain you by dwelling on the other beautiful chateaux represented in these volumes, although they present to us most attractive objects, such as Chateau Chenonceau, one of the most theatrically-picturesque buildings that can be imagined,—Chateau Chantilli, perfectly Mediæval in its general design, although in its details savouring strongly of the more modern style that Catherine de Medicis encouraged, and had, in fact, introduced into France,—Chateau d'Anet, less Gothic, but equally varied, original, and picturesque.

Such are the contents of these curious and valuable volumes. A careful and critical examination of them will satisfy any impartial mind, that they take a very narrow view of the subject who fancy that all architecture necessarily divides itself into the Classic and the Gothic schools. and that therefore, if we reject the one, we must necessarily adopt the other. Such, happily, is by no means the case. I have on a former occasion endeavoured to show that such was not the case when the quatro centists of Italy put away Mediævalism in art, with the casque and gauntlet which they had outgrown. They were too good artists and too sensible men not to perceive that modern civilisation required something more than a return to columns and pediments, and they accordingly struck out a style of design perfectly original, and in many respects more beautiful than anything that had preceded it. In the same way we find that when, a little later, the artistic and inventive genius of France was directed to the production of designs in the Renaissant style, it never occurred to their fertile minds that it was incumbent on them to plunge into a purblind system of copying the works of former times. On the contrary, we see in these buildings of the time of Catherine that a style of great beauty and force was possible, which yet was equally remote both from Greek and Gothic. True art is ever young and productive; it needs only adequate incentives and encouragement to warm it into life. A well-stored portfolio of photographs would turn any man, however uneducated in art, into an architect, if the careful repetition of old forms be all that is required of him.

As I have devoted this evening to looking into a few books, I must be excused if, in closing one volume and opening another, I find myself following a somewhat desultory course. It does not, however, appear to me to be necessary to observe any especial historical sequence. The book which next comes to hand is a splendid volume, of earlier date than that to which we last adverted, and is not without a certain amount of romance in its history, for it consists of verses composed by the Duke of Orleans after his capture at the battle of Agincourt, and with which composition he beguiled the tedium of his imprisonment in England. The illustrations are beautifully executed miniatures, and of great interest as explanatory of the buildings, habits, and costume of the period. One of these illustrations is of special interest, as it presents a view of London in the fifteenth century. It is taken on the banks of the Thames, and represents the Tower in the foreground, and the bridge in the middle distance. The very rapid shoot of the current at the bridge is plainly indicated. At a short distance from the Tower is seen the creek of "Bellyne's gate," on the banks of which creek and below bridge is a considerable building, probably the Custom-house. The architecture of this building is portrayed with great minuteness, and is manifestly drawn from the actual objects, not conventionally, but with considerable effort at correctness of representation. It is worthy of observation that the lowest story consists of an arcade of perfectly Renaissance character, the arches being circular or nearly so, springing from ordinary columns, apparently very much like Roman Doric. The superstructure, however, is of quite Mediæval character, presenting a series of steep gables of dissimilar designs, and with the windows apparently mullioned. The perfectly Italian aspect of the lower part of the building seems to me to be conclusive evidence of the existence of the style of the Renaissance in England very much earlier than is usually supposed. The Porta Honori at Cambridge is generally pointed to as one of the earliest, if not the earliest, example in England of the quasi-Classic style. This gateway, however, must be nearly 150 years later than the building near Old London-bridge, so carefully delineated in this illumination

Now that I am touching on the subject of illustrated manuscripts, I need not omit allusion to the remarkable book known as the 'Codex Aureus.' It forms part of the Royal Library collected by George III., and is certainly one of the gems of that collection. It has many claims on our attention, inasmuch as it appears to be beyond a doubt that it was executed for Charlemagne. It is enriched with magnificent illustrations, which may be fairly presumed to be specimens of the highest art which Europe in the beginning of the ninth century was capable of producing, and is moreover, considering its great age, in excellent preservation. The prevailing character of the architectural features is manifestly what it is usual to designate as Romanesque. Each page represents one arch divided into three subordinate compartments by slender pillars carrying three arches. This arrangement of arches seems to have taken its rise somewhere about the period in the history of architecture with which this volume is contemporaneous; perhaps, indeed, even earlier.

The practice of building small arches in a continuous series, springing from the capitals of small pillars, bears a far earlier date. We find them in abundance at the Palace of Diocletian. Such small arcades occur, too, at the building near Ravenna called Theodoric's Palace, and a continuous range of them originally encircled the multangular tomb of that monarch. These small arcades, arranged in successive superimposed orders, came to be used to excess, as you, no doubt, well know, and covered the towers and gables of the Lombardic and subsequent ages. I may add that in paintings and mosaics of so early a date as the fourth century, represented in Seroux d'Agincourt's great work, these arcades abound.

But in the illustrations of a manuscript preserved in the Laurentian Library, at Florence, to which the date of the fourth century is assigned, a more distinct foreshadowing occurs of the Gothic mullioned window. It represents a large semicircular arch, comprising within its span four minor arches, thus dividing it into four narrow openings. It is true the head of the large comprising arch is blanked: there is shown on it a circle, probably decorative only, and not perforated; but the transition from this to an ordinary four-light Gothic window is easy and natural. In the 'Codex Aureus,' to which I have been referring, we have very plainly this germ of the Gothic window, and we have it even more distinctly developed in MSS. of the ninth century, of which representations are given by D'Agincourt. But not only were these small arcades the putative parents of mullioned windows; to them also, it can hardly be doubted, we owe the triforium of our ecclesiastical architecture. I cannot refrain from here reminding you of the analagous use of these subordinate arcades in the Westminster Hall, as built by our William Rufus. In the twenty-sixth volume of the 'Archæologia' you will find the representation of that triforium story forming an open arcaded passage way, obtained in the thickness of the wall. This curious feature in the domestic architecture of the twelfth century I had the pleasure of being the first to explore and delineate, when the interior of the walls of Westminster Hall was opened out and exposed to view, under my brother, Sir Robert's directions, with a view to the reface of the masonry of those walls in 1837.

I have, perhaps, detained you too long in thus tracing the pedigree of these mural arcades, but they are of some importance in the history of architecture. It may be difficult to point to any feature more strongly characteristic of Mediæval architecture, or more definitely distinguishing it from strictly Classic art.

In the singular works of early Christian architecture to which I have been adverting it is impossible not at once to recognise a strong savour of Byzantine art. There is, for example, in the Codex Aureus an almost infinite variety of frets and friezes introduced of a quasi-Classic character, all most carefully and elaborately executed, and with a manual dexterity and preicsion which seem to imply great practice in such works. The Greek labyrinth fret occurs in utmost variety, and those interlacing patterns, that stamp a peculiar character on the art of ornamental design in this Byzantine style, occur in these illuminations in utmost profusion. Whether accompanying Runic inscriptions in Ireland, in Norway, or elsewhere, or whether seen carved in stone in the earliest Christian buildings of Lombardy, or worked in mosaic on the walls of Greek churches, or depicted upon vellum in these beautiful manuscripts now under our consideration, there is a similarity of design and a general agreement in the manner of treatment which is certainly well worthy of observation. What adds especial interest to this curious kind of ornament is that it was not, apparently, derived from or suggested by any similar ornament in the preceding Classic school. Could it have been traced back to ancient Rome, we should not have been surprised at its occurrence in localities so widely apart, and in styles of design so widely differing; but nothing, as far as I know, occurs in Roman art from whence these intricate interlacings could have been derived—unless, indeed, we may suppose that the guilloche was the parent of this ornament, which would, in that case, take back the idea to Athens itself, and to how much remoter a period I know not. Even Assyrian art is not without traces of it. Whether so derived, or whether it was the original product of a Teutonic or a Byzantine mind, certainly its wide prevalence is remarkable. It seems not unlikely that the facilities which these interlaced ornaments afforded of producing the device of a knot having no ends, would recommend it to the favour of the early Christian artists as an emblem of eternity, as well as of brotherhood. But whatever its origin, the idea was certainly most prolific. Besides being productive of a variety of mere ornaments, such as we see on this MS. of the time of Charlemagne, it suggested no doubt the monsters devouring their own tails, which we see so commonly portrayed in Mediæval sculpture; and the true lovers' knots depicted in a thousand familiar although unmeaning shapes, on our walls and ceilings, down to the time of Elizabeth, and, for aught I know, to the present day.

That warns me that I must not now introduce to your notice any more of the literary and artistic treasures stored up in our magnificent national collection. I am well aware of the superficial nature of these few slight notices: they present to you but the faintest glimpse of the almost endless stores that the liberality of the country has been enabled to accumulate under the guidance and with the assistance of her best scholars. In calling your attention to the few books which I named, I am, I fear, subjecting myself to the sarcasm of the old Greek author, who tells us of a certain "Scholastic," who, being desirous of recommending a house to the favour of his friends, carried about with him a brick or two by way of specimen of the entire mansion. Yet scanty and very inadequate as the samples may be which I have this evening laid before you, I feel sanguine in the belief that my few remarks and criticisms will not have been made in vain if they have produced in your mind a desire to seek for further satisfaction at the fountain-heads; to consult them for yourselves, and to liberalise and enlarge your studies by a wider field of investigation.

A careful contemplative study of the causes of the almost awful sublimity of the Coliseum, for example, is calculated perhaps to encourage and even to generate a greatness of manner, and to elevate the artistic tendencies of the mind; and to teach us that the grandest effects, in our art, are far more readily attainable by simple general forms than by resorting to that excessive elaboration and subdivision of details which (perhaps I may be permitted to say) is one of the least commendable tendencies of the present day, and against which it would be well that you should be on your guard.

Then, again, a critical examination of the interesting production of the age of the Renaissance in France—an examination so greatly facilitated by the two beautiful volumes of Catherine de Medicis which I have been adverting to, is well calculated to fertilise the mind of a young architect, and to show to him how the combination of two very different kinds of beauty is capable, in the alembic of genius, of being made to produce still another beauty—a *tertium quid*—differing very materially from its two components, yet partaking of the merits of both.

Such an examination would, furthermore, satisfy him that it was no mere love of innovation, no mere freak of fashion, that led our forefathers to lay aside in their architecture the stern and rigid air of Mediævalism. They abandoned mullions and tracery in their windows, and made them wide, and square, and open, not in sport and for the sake of a frivolous change, but because they were beginning to learn to appreciate more fully the value of light and air, and because they began to perceive that there were other means of excluding an enemy, and securing their personal safety and an inviolate hearth, besides loopholing and crennelating their dwellings. An inquiry into these great changes in their habits of building is a curious and not unprofitable inquiry. It is common enough to hear it said that the revival of a taste for classical literature led to the study and subsequent adoption of classical architecture. Whereas the two rivals were, in truth, strictly contemporaneous; and it is by no means improbable that they may be regarded, not as one being consequent on the other, but that both were necessary results of a common cause—namely, the advance of civilisation, involving the acquirement of new habits and new wants.

The other volumes of which I have this evening made mention have an antiquarian rather than a practical value, and to that extent are, no doubt, less suitable subjects for me to urge on your attention here. Yet those manuscripts are samples of a great store of similar works which our national Museum may be justly proud to possess, and which, whilst they are of the highest literary and historical value, must ever be precious also in the eyes of artists, inasmuch as the illuminations which adorn their pages represent faithfully the condition of the fine arts during the Mediæval period, and are, as it were, the golden link that connected the ancient with the modern schools of painting and design.

INSTITUTION OF CIVIL ENGINEERS.

JOHN HAWKSHAW, Esq., President, in the chair.

Jan. 28.—The paper read was "*On the Form and Materials for Iron-Plated Ships, and the Points requiring attention in their Construction.*" By JOSEPH d' A. SAMUDA.

The author stated that, iron-plated ships having now become a necessity, it was important to ascertain, first, the best description of construction of ship and and armour, and secondly, the best form and dimensions of vessel. To effect these objects, there were four indispensable conditions: first, these vessels must be of such dimensions and power, and be built on such lines, that they should always command a superiority in speed over the best timber-built frigates afloat; secondly, they must be protected with armour over their entire length; thirdly, the armour must be so applied as to be capable of rapid replacement or repair; and fourthly, the armour should enter into the construction of the ship, and thus give strength to the whole fabric, as well as protect it from an enemy's fire. These conditions had only been partially attained in the vessels already constructed, or proposed to be constructed; for the Warrior" class obtained speed alone, the "Defence" class failed in all, the "Valiant" class only approached the second condition, and the three new ships of 6700 tons burthen, recently contracted for, at a cost with their engines of £400,000 each, would probably possess the first and second, but not the third and fourth conditions.

Although the "Warrior" was highly creditable as a first effort and was not defective in strength, yet it was a complicated and costly construction, and its character should not, therefore, become stereotyped, as incapable of further improvement, or as if it were not desirable to seek for it.

The author proposed that the framework of the hull should be built as in an ordinary first-class steamer of the same size; and that outside the frame-work, and rivetted to it, there should be five longitudinal ribs, at intervals of 5 feet, reaching 20 feet below the gunwale. These longitudinal ribs should be of bars of rolled iron, 2½ inches in thickness and 16 inches wide, the outer 4 inches on each side being recessed 1 inch. The ordinary skin plates, 1 inch thick, were then to be rivetted in these recesses, so as to form a flat surface for the reception of the armour, each strake of which was to be made to correspond with the distance from centre to centre of the longitudinal ribs. The edges of the armour plates, 5 inches in thickness, were then to be bolted or rivetted through the ribs longitudinally, the vertical butt joints of each plate, made to break joint with the skin plates, being rivetted to corresponding ribs 2½ inches in thickness, placed between the longitudinal ribs, and attached to them with fish plates. It had been determined by experiment that this thickness of rib would be sufficient to render the edges of the armour plates, when weakened by the rivet holes, equal in strength to the central body of the plates. By this arrangement, a perfect ship without armour was first made; then a complete armour case was attached through the longitudinal ribs, without interfering with the joints or fastenings of the ordinary skin of the vessel. Indeed the skin would be so distinct from the armour that, in time of peace, the armour could be removed, and the vessel be used as a transport if desired. By these means the armour could be rapidly repaired at any point, and there would be no necessity for tongueing and grooving the plates, adopted as an expedient by the Admiralty to remedy the bending up of the edges, which the present imperfect mode of fastening rendered them liable to.

Thus protection would be obtained over the entire length of the vessel, by the armour admitting of rapid replacement, and entering into the construction of the ship. It remained only to show what dimensions and power were necessary to secure speed. For a 32-gun frigate constructed as described the best dimensions would be 382 feet long, 55 feet beam, and 31½ deep to the main deck; 5600 tons burthen, and fitted with engines of 1200 H.P., by which a speed of 15 knots an hour could be obtained, with the armament, ammunition, and coal on board, and with the port sills 9 feet above the water line. Such a vessel would have even greater speed than the "Warrior," and be wholly protected over the entire length of the sides.

As the importance of complete protection had now been recognised by the Admiralty, it was desirable to compare this armour-skin vessel of 5600 tons burthen with those now building. The Admiralty vessels were to be 6700 tons burthen and 1250 H.P., but they would not be able to carry a heavier armament, or possess a higher speed than the proposed vessel. They would be less manageable, form larger objects to fire at, and cost £400,000 each instead of £340,000, or in a fleet of twenty-four such frigates, one million and a half pounds sterling more.

For coast defences vessels might be built protected from stem to stern, having a length of 200 feet, beam of 48½ feet, depth of 25 feet, burthen of 2,200 tons, and engines of 350 H.P., pierced for thirty-two 68-pounder guns but carrying only sixteen, with a draft of water of 16 feet when the guns, ammunition, and coal were on board, and capable of attaining a speed of 11 knots an hour.

In conclusion, the author thought that the time had arrived when the Admiralty should see the propriety and the advantage to the public service of abandoning the monopoly of restricting all advance in the construction of mail-clad vessels to plans and systems emanating from themselves; and that it would be far better to trust to the engineering skill of this country, leaving it free to take the initiative in improving this branch of National Defence, and the Admiralty only exercising a veto within such limits as experience fitted them to form a judgment upon.

March 4.—The first paper read was "*Description of the Loch Ken Viaduct, Portpatrick Railway.*" By E. L. J. BLYTH, M. Inst. C.E.

This viaduct was situated on a curve of half a mile radius, and carried a single line of railway over the loch at an oblique angle, so that the width of the waterway was increased from 265 feet to 360 feet, the depth of the water at the point of crossing being 29 feet in summer. It consisted of seven openings,—three of 130 feet each in the centre, spanned by wrought iron girders of the bow-and-string form; two semicircular arches of masonry, of 20 feet span, in the abutments; and two openings of 20 feet each at the ends, provided with flat cast-iron girders. Owing to there being scarcely any current, it was not deemed necessary to set the piers in the line of the loch, but they were placed at right angles to the viaduct, and each pair of girders was at a slight angle to the adjacent ones.

The foundations consisted of strong gravel, except in the case of the east abutment of the main openings, where a running sand was met with, and in this instance the lower courses of the masonry were laid on a bed of hydraulic lime concrete 2 feet in thickness. The two deep-water piers were each formed of two towers, 8 feet in diameter, placed 8 feet apart, and connected above the water level by semicircular arches of masonry. For each tower of the piers a cast-iron tube 8 feet in diameter, in six pieces, was sunk, the tubes being 36 feet and 42 feet in length for the east and west piers respectively. When the masonry was brought up to the surface, the upper castings of the tubes were removed. Around the piers 4000 cubic yards of loose rubble stones were deposited, so as to produce an artificially deeper foundation. The tubes, when placed in position, sank from 1 foot to 2 feet by their own weight, until they reached the gravel and sand, where they remained quite firm. This formed a good test of the sufficiency of the foundation, as the weight of the tubes on their narrow edges was equal to from 8 to 9½ tons per square foot, while the total weight on the foundations of the finished structure, including the moving load, was only about 6¼ tons per square foot.

The method adopted in sinking the tubes was that of ordinary well sinking. Two plate-iron screw pans, of an inverted cone shape were employed; one 2 feet in diameter at the top and 1 foot deep, and the other, which was only used for the harder portions of the excavation, 1 foot in diameter at the top and 1 foot deep. There were openings in the sides, covered with leather flaps, to prevent the material from escaping when the pans were filled. Three arms of round iron projected through the sides of the pans, and, being connected to a long rod with a cross handle at the upper end, the screw pans were worked by four men, and when full were raised by tackle. The larger pan raised about 1 cubic foot of material each time, and the smaller one about one-fourth of that quantity. By these means the tubes were sunk in some instances as much as 18 inches in one day, the minimum being 2 inches per day in the case of the north tube of the west pier, where large boulder stones were encountered rendering necessary the use of a screw pick. When the tubes had been lowered the desired depth, concrete was deposited within them, varying from 12 feet to 18 feet in depth in each tube. On this concrete, ashlar masonry was laid, the cordon course being of granite in large blocks, for receiving the ends of the girders, which rested on wrought-iron plates, laid on thick sheets of vulcanised india-rubber to lessen the effect of vibration.

The bow-and-string girders were each 136 feet 8 inches in length, and were segmental in form, the rise being 17 feet 6 inches, so that the segment was almost identical with a catenary curve, or the true curve of equal pressure. The sections of the upper and the under booms were identical. They consisted of a main plate, 24 inches broad and ¾ of an inch thick, and of two channel irons, each 8 inches by 4 inches in section and ½ an inch thick, placed at a distance of 8 inches apart, between and to which the struts and ties, of the same section of channel iron, were rivetted. The transverse girders for carrying the roadway were 6 inches in depth at the ends where they rested on the channel irons of the under booms, and 15 inches deep in the centre. The middle web of these girders was ½ of an inch in thickness, and there were angle irons, 3 inches by 3 inches by ½ an inch in section, at the top and the bottom of the web on each side. Every alternate girder projected 2 feet, from which T iron struts were carried up to the crossings of the diagonal bracing. The weight of the girders and roadway between the points of support was 88 tons, and of the ballast (2 inches in depth) 14 tons, making a total dead load of 102 tons; and taking the rolling load at 1 ton per lineal foot, the total load on one span would be 232 tons. The area of the upper boom was 33 inches, and of the under boom, exclusive of rivets, 27·04 inches. The distance between the centres of gravity of the upper and the under booms was 17·04 inches. The tensile strain on the under boom amounted to 4·04 tons per inch, and the compressive strain on the upper boom to 3·35 tons per inch. When the whole of the load was upon the girders there was no compressive strain on any of the diagonals, but there were tensile strains varying from 3·4 tons to 7·5 tons, or equal respectively to 9 cwt. and 1 ton per square inch of section.

The author considered that the bow-and-string girder posessed advantages over the Warren or other lattice girders, with parallel top and bottom members; as in the latter class it was not possible to make the top and bottom members theoretically correct, without great labour and waste of material, and as owing to the great variation in the strains on the diagonals, it was necessary that they should be of varying dimensions, involving in some cases even different sections of iron.

The girders were built in position on staging, and the greatest amount of deflection of any one girder from its own weight was ⅜ths of an inch. Subsequently, when a locomotive engine, weighing 34 tons, was placed in the centre of each span, and afterwards was run over, first at 10 miles an hour, and then at 25 miles, the deflection amounted to from $\frac{3}{16}$ to ¼ of an inch in each girder, there being no perceptible difference in either case. Finally, when four engines were coupled together, so as to give a load equal to 1 ton per lineal foot, the deflection only amounted to from ¼ to ⅜ths of an inch.

It was stated, that the total cost of this viaduct had amounted to about £13,000.

The second paper read was "*Description of the Centre Pier of the Bridge across the River Tamar at Saltash, on the Cornwall Railway, and of the means employed for its construction.*" By R. P. Brereton, M. Inst. C.E.

This communication embraced, in a narrative form a detailed account of the preliminaries connected with the Albert Bridge, which crossed the river Tamar where it was only 1100 feet wide, with precipitous banks and a depth of water to the surface of the mud of 70 feet. A dyke of greenstone trap intersected the clay slate formation at this point, and cropped out to the surface above the water on the western bank of the river. It was ascertained by borings made in the bed of the river that rock extended from the eastern side to beyond the middle of the stream, covered with mud or silt to a depth of from 3 feet to 16 feet. Subsequently, a thorough examination of the bed of the river where a centre pier would probably be built, by means of 175 borings made within a cylinder at thirty-five different places, over an area of 50 feet square, enabled an exact model of the surface of the rock to be prepared showing the irregularities and fissures that might be expected. Eventually it was decided, from the information thus obtained, to erect one pier only in the deep water, instead of three, as would have been necessary for the spans required by the Admiralty; and when it was determined to proceed with the construction of the bridge, in 1852, it was decided that there should be two spans of 455 feet, two of 93 feet, two of 83 feet 6 inches, two of 78 feet, two of 72 feet 6 inches, and nine of 69 feet 6 inches; the total length, including the adjoining land openings, being 2200 feet.

The centre, or deep water pier, intended to carry the weight of one-half of each of the two main spans, consisted of a column, or circular pillar, of solid masonry, 35 feet diameter and 96 feet high, carried up from the rock foundation to above high-water mark. Upon this were placed four octagonal columns of cast iron, 10 feet diameter, carried up to the level of the roadway, which was 100 feet above high water mark. Upon the tops of the columns, cast iron standards were fixed to receive the ends of the tubes and chains which constituted the trusses of the bridge. The weight at the the bottom of the masonry foundations was about 9½ tons per square foot, increased, when the bridge was loaded by passing trains, to about 10 tons per square foot.

In the construction of the masonry pier, a wrought iron cylinder, of boiler plates, 37 feet in diameter and 90 feet in length, and open at the top and the bottom, was sunk through the mud of the bed of the river to the rock. The water was then pumped out, and the mud excavated, the masonry being built up inside, and the cylinder above the ground afterwards removed. It was expected that, by forming a bank round the cylinder after being sunk to the rock, sufficient water-tightness would be ensured for getting in the masonry. To provide, however, for the contingency of excessive leakage, the cylinder was so constructed as to admit of the application of air pressure. As the surface of the rock, although very irregular and ragged, had a general dip to the south-west, the bottom of the cylinder was formed with a corresponding bevel, one side being 6 feet longer than the other. A dome, or lower deck, was constructed inside, at the level of the mud, and an internal cylinder, 10 feet in diameter, open at the top and the bottom, connected the lower with the upper deck of the cylinder. The 6 feet cylinder, previously used for the borings, was fixed eccentrically inside the other, and an air jacket or gallery, making an inner skin round the bottom edge below the dome, was formed, about 4 feet in width, divided into eleven compartments, and connected with the bottom of the 6 feet cylinder by an air passage below the dome.

Details were then given of the construction of the larger cylinder, and of the mode of launching and floating it to its position. When accurately adjusted over the intended site, water was gradually let in until the cylinder penetrated through the mud about 13 feet, and rested on some irregularities upon the rock, which caused it to heel over towards the east about 7 feet 6 inches. By letting water in upon the dome or lower deck, and loading the higher side with iron ballast, the cylinder forced its way through the obstructions at the bottom edge, and took a nearly vertical position. The air and water pumps were then set to work, and the greater part of the mud and oyster shells, which filled the compartments of the air-jacket at the bottom, was cleared out, and the irregular surface of the rock excavated; the bottom of the cylinder being now 82 feet below high-water. Subsequently, a leak having broken out through a fissure in the rock on the north-east, or higher edge, considerable difficulty was experienced in maintaining sufficient pressure with the air pumps to keep the water down and the bottom dry. The leak was at length reduced, by driving close sheet piling into the fissure. When at its full depth, the cylinder was 87 feet 6 inches below high-water at the lowest place, and then a hemp gasket was worked under the edge of the cylinder, all round the outside, to assist its water-tightness. A ring of granite ashlar, 4 feet in width and about 7 feet in height, was then built in the air jacket; and a bank of clay and sand was deposited round the outside of the cylinder to compress the mud. When the water was pumped out of the body of the cylinder below the dome, and the excavation of the mud was being proceeded with, a leak broke out, and the water overpowered the pumps. Additional engines and pumps were provided, and efforts were made to diminish the leakage, with varying success; but as it required four pumps to keep the water down to 54 feet, recourse to air pressure in the body of the cylinder below the dome became imminent, and preparations for its application were made. To provide against the buoyancy, or upward pressure against dome and cover, the 37 feet cylinder was loaded with 750 tons of ballast, in addition to its own weight of 290 tons. The pumps were then got into good order, and, by continued pumping, succeeded in keeping the water down. The mud was excavated, the cylinder below the dome securely shored across, and the rock levelled, when the masonry in thin courses of granite ashlar in cement, in the body of the cylinder was commenced. As soon as the masonry reached the level of the air jacket ring, it was thoroughly bonded, the plates of the air-jacket being cut out as it proceeded. Upon the top of the bonding course, two courses of hard brick-work in cement were laid, making a perfectly water-tight floor over the whole diameter of the column. Meanwhile, the masonry of the air jacket, where the leak occurred, was taken down, and the leak was diminished by additional sheet piling. The leak was discovered to have broken out at the same fissure as before, and had torn away the rock underneath the masonry of the air jacket and bottom edge of the cylinder, but the masonry itself was undisturbed.

The next operation was to draw off the water above the dome and remove the ballast, to allow the masonry to be proceeded with, which it eventually did at the rate of from 5 feet to 7 feet in height per week. When it was 46 feet in height the influx of water was entirely stopped. After the masonry had been completed to the level of the plinth, the upper part of the cylinder was unbolted at the separate joints, and floated to the shore.

March 11.—The paper read was "*Description of the Delta of the Danube, and of the Works recently executed at the Sulina Mouth.*" By C. A. Hartley, Assoc. Inst. C.E.

In the autumn of 1856, by virtue of the Treaty of Paris, the European Commission of the Danube, consisting of representatives from each of the seven contracting powers, was charged to execute the works necessary below Isakcha, to clear the mouths of the river as well as the adjacent parts of the sea, of the impediments which obstructed navigation. This Commission, to which the author had acted as chief engineer, was authorised to levy rates to cover the expense of such works, on the express condition that the flags of all nations should be on a footing of perfect equality.

In the preliminary studies of the three principal branches and mouths of the Danube, advantage was taken of the charts made by Captain Spratt, R.N., C.B.; and aided by these, and by the author's own surveys and personal investigations, a brief description was given of the chief characteristics of the progress of the river through its delta. The Danube, after a course of 1700 miles, during which it received more than four hundred tributaries, and drained upwards of 300,000 square miles, passed in a single channel 1700 feet wide and 50 feet deep, the Bulgarian town of Isakcha, situated on the right bank, at 30 and 40 English miles respectively below the large corn-exporting ports of Galatz and Ibraila. Isakcha was 76, 78, and 90 miles from the sea, following the courses of the Kilia, the Sulina, and the St. George branches, and 58 miles in a straight line. The head of the delta was reached, at Ismail Chatal, or Fork, 15 miles lower down, and here the fresh waters divided, never to reunite; seventeen twenty-sevenths of their volume passing in an easterly direction by the Kilia branch, and the remaining ten twenty-sevenths in a south-easterly direction by the Toultcha branch. At 11 miles below Ismail Chatal, this latter branch separated into two channels, the St. George and the Sulina, discharging respectively eight twenty-sevenths and two twenty-sevenths of the whole volume of the main river.

A short account was then given of the three channels, from which it appeared that the waters of the Kilia were delivered to the sea by twelve distinct mouths, only navigable for fishing vessels; that the river portion of the St. George offered no real obstacles, having an average width of 1200 feet, and a minimum depth of navigable channel of 16 feet, at seasons of extreme low water; and that in the upper reaches of the Sulina, disaster of every kind was imminent, from the many intricate windings and numerous shoals—the navigable width being rarely more than 300 feet, and the depth over the shallows during seasons of low water varying from 10 to 14 feet.

The delta proper was described as being bounded on the north by the Kilia branch, on the south by the Toultcha and St. George branches, and on the east by the Black Sea; the enclosed space comprising an area of 1000 square miles and forming a triangle of which the Ismail Chatal was the western apex, and the sea coast, from the mouths of the St. George to those of the Kilia, the base. During extraordinary high floods, the delta, being unprovided with artificial banks to contain the swollen waters, was almost entirely submerged; whilst at seasons of drought, its banks were elevated from 10 to 12 feet above the level of the river at the Upper Chatal, and from 8 to 10 feet at the Chatal of St. George. In the lower reaches of the three branches, the level of the river was but little affected by variations in the upland waters. Adjacent to the mouths it never varied more than 1 foot, except when influenced by the wind. During high floods the inclination of the surface water of the Sulina branch was 3 inches per mile, whilst during extreme low water it did not exceed 1 inch per mile. At times of ordinary high water, when the current had attained a velocity of from 2¼ to 3 miles an hour, the Danube before it divided at Ismail Chatal delivered a volume of water equal to nineteen and a-half millions cubic feet per minute; while in the dry season, when the current was reduced to 1 mile per hour, the flow did not exceed seven and a-half millions cubic feet per minute. At times of extraordinary floods, such as that which occurred in March 1861, the velocity was increased to 5 miles per hour, and the volume of water then delivered amounted to 60 millions cubic feet per minute, or eight times the quantity discharged at ordinary low water. It was stated, as the result of careful observations, that when the waters were most surcharged, they carried to sea at the rate of 1 cubic inch of sedimentary matter, supposing it to be solidified into coherent earth, per cubic foot of water, and that not more than one-fortieth part of this proportion was transported when the floods had subsided. Thus, at the former period, upwards of 600,000 cubic yards of diluvial detritus passed into the sea by the several mouths of the river in twenty-four hours, and at the latter not more than 15,000 cubic yards. The results of these investigations accounted in a great degree, for the changes which took place from time to time, in the position and extent of the sand banks forming the bars across the several mouths. At times of high floods, these bars were further from the shore, their magnitude was considerably increased, and the depth over them was diminished; their distance from the shore, and their height, being much influenced by the direction of the prevailing winds. The depth of the sea opposite the delta decreased to the north; thus at 3 miles from the land the depth was 16 fathoms opposite the St. George's mouth, and only 10 fathoms opposite the Sulina and Kilia mouths.

During the interval from 1830 to 1857, the shallows of the Kilia advanced fully one mile in the direction of the Sulina mouth. This, combined with uncertain and changeable nature of the many branches issuing from the Wilkov basin to the sea, and the distance of the bars from the shore, were the chief considerations which induced the author to form an unfavourable opinion of the Kilia—in spite of its possessing the best river channel—and to recommend, in preference, the improvement either of the St. George or of the Sulina, where the sea depths were greater, and the advance of the sand banks was less remarkable. In comparing the merits of the two latter branches, the author arrived at the conclusion, that in nearly every respect the St. George offered decided advantages over the Sulina. It is true, that in order to reach the Kedrilles bar of the St. George, double the length of works would be necessary; but when once the sand-banks were passed, the greater sea depths opposite the St. George would insure for a longer period a constant good navigable depth at the sea entrance. The St. George's mouth was situated at the most salient angle of the delta, was nearer to the Bosphorus, by 18 nautical miles, than the Sulina, and was more favourably placed with regard to the safe manœuvring of vessels during N.N.E. winds.

Although there was a great difference of opinion as to the merits of each of the three principal branches, or mouths, all the technical authorities, who had studied the question on the ground, agreed in recommending that, whichever mouth was chosen, the system of improvement should be that of guiding the river water across the bar by means of piers projected from the most advanced dry angles of the mouth; so as to concentrate the strength of the river current on the bottom of the proposed improved channel, by an artificial prolongation of the river banks into deep water. After considerable discussion, the Commission resolved to improve the bar channel of the Sulina, by guiding piers of a temporary character, in order to give the speediest relief to the navigation in the cheapest manner; but it was distinctly guaranteed that this should not prejudice the choice of the mouth to be selected for permanent treatment. The author then received instructions to provide works which, for the expenditure of a sum limited to £80,000, should have the effect of giving an increased depth of at least 2 feet over a period of from six to eight years. This duration of time was based on the assumption that during such an interval, either the St. George would be opened, or it might be considered expedient to limit the improvement of the Danube to rendering permanent the provisional works.

The designs for the provisional works were then matured; and as it was found in practice, that the cost of strong timber cribs, to be loaded with stone, and sunk at intervals of 20 feet along the line of the works, would exceed the original estimate, choice was finally made of a structure composed of timber piling and pierre purdue, surmounted by a timber platform 14 feet wide, strengthened occasionally by solidly-constructed cribs of the same width. The works were commenced on the 21st April, 1858, a temporary staging fixed on piles, being always run out from 200 to 300 feet in advance of the permanent piling. This staging supported nine crab engines, by which three rows of three piles, each 13 inches square, and 7 feet apart, were frequently driven in one day to a depth of 16 feet into the hard fine sand of which the bottom was composed. The piles were immediately secured by double longitudinal walings and double cross-ties, the whole being surmounted by two thick trampieces and planking, at 4 feet above the level of the sea. From this permanent platform the close piling on the side next to the sea was driven. The daily rate of progress during fine weather was 20 lineal feet; and as soon as this length of sheet piles was completed, stones were thrown down to protect the footing in the sand, which was liable to be washed away by the action of the sea. This scouring action of the sea was so serious, when the skirt of the bar was reached, that it threatened at one time to demand, for the completion of the works, double the quantity of stone originally estimated. Several plans were tried to reduce its pernicious effects. That eventually adopted, and which was perfectly successful, was to advance the open pile work with all possible expedition, and then to pave the proposed seat of the pier with stones delivered from barges. This pavement withstood the attacks of the sea, and offered no great obstruction to the penetrations of the sheet piles, which, without being shod, had frequently been driven 10 feet into the ground, after having been forced through 8 feet of rubble stone. The section of the finished stone work was described as being a solid mass of closely packed third-class rubble, resting on a broad base, and narrowing upwards at slopes varying from 2 to 1, near the pier heads, to 1 to 1 and 1½ to 1 near the shore, until slightly below the level of the water it became a mere ridge against the close piling. The time occupied in the actual construction of the piers was thirty-one months, exclusive of three winter months each year, during which the Danube was frozen over, and all work was suspended, but inclusive of two hundred and seven days when it was impossible to work on account of stormy weather. The length of the north pier was 4631 feet, that of the south pier was 3000 feet, and the depth of water in which they were built varied from 6 to 20 feet. In their construction 200,000 tons of stone and 12,500 piles had been employed, and the cost had not exceeded ten guineas per lineal foot. The stone was brought from a distance of 60 miles, and its price delivered in place varied from four shillings to five shillings per ton; the oak used for the longitudinal and transverse timbers and for the planking and fender piles, cost two shillings and threepence per cubic foot, while the fir timber piles were delivered ready for driving for fourpence per cubic foot. The workmen, of whom there were generally three hundred, were composed of men belonging to more than ten different nations. Labourers were paid two shillings and sixpence and carpenters four shillings and sixpence per day.

The changes which had taken place at the Sulina mouth, consequent on the projection of the piers, were then noticed. The depth on the bar since the year 1829 had varied between the extremes of 7 and 12 feet, the least depth occurring during the subsidence of high-water floods, and the greatest when the deposits lodged by those floods had been dispersed by autumnal and winter gales. In April 1858, when the works were commenced, there was a navigable channel only 9 feet deep over the centre of the long shoal forming the Sulina bar. In November 1859, when the works had been brought to a close for the winter, the north pier had advanced 3000 feet, and the south pier 500 feet, and then the depth on the bar was 10 feet, which was increased to 14 feet by the following April, although the works had remained stationary. Hopes were consequently entertained that the action of the north pier would, in itself, be sufficient to maintain an improvement; but these expectations were disappointed, as in August, when the north pier had reached a length of 4600 feet, the depth on the bar had diminished to 9½ feet. Every exertion was then made to bring the opposite pier into play. Accordingly, during the next three months, the south pier was advanced 1500 feet, and as it was now within 600 feet of the north pier, the good effect of concentrating the whole force of the river current directly on the bar became at once apparent. Thus on the 30th of November, 1860, there was a navigable channel of 12 feet, and on the 28th February, 1861, of 16 feet. Then came the breaking up of the ice in the river, and the furious descent of the extraordinary high floods, which caused so much damage at Galatz, and submerged the whole delta; but this time instead of the depth on the bar being diminished, the swollen waters confined between the two piers and directed in a proper line, fairly swept away the remains of the bar on to the south bank and into deep water. From that time to the present, the depth had never been less than 16½ feet, and frequently it was as much as 17½ feet, over a navigable width of 500 feet. This result had been accomplished by works the cost of which had not exceeded the sum that had been paid in one year only for lightening vessels over the bar; and without taking into account the excellent shelter which had been afforded, and the great risks which vessels formerly ran of being wrecked off the entrance.

In conclusion, the author expressed his gratitude to the members of the European Commission of the Danube, for the generous support he had always received; and especially to Major Stokes, R.E., the representative of Great Britain, whose enlightened policy, if allowed to prevail, could not fail eventually to insure to the commerce of all nations, the best possible means of water communication with the rich corn-growing countries bordering the shores of the Lower Danube.

ON PICTORIAL MOSAIC AS AN ARCHITECTURAL EMBELLISHMENT.

By M. Digby Wyatt, Architect.

It is now fifteen years since I had the honour of bringing under the notice of this Institute a branch of the art upon another department of which I purpose making a few observations this evening. I was induced for some time prior to that date to pay attention to the subject of *geometrical* mosaic for two reasons—the one general, the other special. The general, because I looked upon any possible addition to the technical pharmacopœia (if I may so express it) of the architect as conducive to the introduction of the most legitimate novelty in his art: and the special, because I recognised in the contemporary efforts making by enterprising manufacturers, and in a rapidly-growing demand on the part of the cultivated public, every probability that an important branch of industry was incubating by the one, and likely to be hailed with welcome by the other.

A parallel conjuncture of demand and supply one cannot fail to perceive to be approximating at the present date in relation to *pictorial* mosaic; and in the hope that my humble exertions may contribute in some degree to the development amongst us of that branch of the art, as to a certain extent they may have done in past years with respect to geometrical mosaic, I venture to address to the meeting this evening a few remarks, mainly limited to the practical interest of the subject.

It would however be an act of dereliction to the real grandeur of my theme if I failed to notice what important subjects of inquiry for the art-student any such limitation necessarily precludes our taking cognisance of this evening.

Thus, firstly, there is the invaluable illustration which the series of still existing pictorial mosaics, dating from the earliest to the most recent Christian epochs, might be made to afford of the changeful spirit in which, at various periods, fervid faith has as it were assimilated to itself now one, and now another, cycle of religious personifications of a more or less simple or complicated Christian mythology; sometimes veiling its aspirations in symbolism, and at others setting forth dramatically the leading events upon which its hopes and fears were based.

Next perhaps to this, which may be designated the liturgical interest of the art, is that which is, more strictly speaking, iconographical, including the much-vexed question of the degree in which many of those generally rude but nearly imperishable pictures—which survive while almost every cotemporary graphic record has perished—reflect the usual aspect, the costume, and true physical characteristics of the clergy and laity, the rulers and the ruled, in the early ages of Christianity.

Von Rümhor, in the "Italienische Forschüngen," thus ably hints at the suggestive value of such primitive records:—"There is, indeed, much in the representations of the early Christian mosaics which carries us back into extreme antiquity, perhaps into the very first century of the reign of Christianity. In these our Saviour, the Apostles, and Prophets, invariably appear in complete classical costume, in long tunics, with the palliums superposed, and with naked feet, protected only by the sandals commonly worn in imperial times. When recent saints are introduced the habits of antiquity are exchanged for rich and more barbaric dresses; and the feet are usually completely covered." The value of these ancient types we find acknowledged by subsequent artists, as celebrated and modern as Raphael himself; for as the same writer justly remarks, in the cartoons and in some of the most remarkable of the Vatican frescoes we cannot fail to recognise an approach to the primitive forms of early Christianity, in the guise of a return to classical models, subordinated to the conventions handed down from the Church of the Early Fathers by tradition, from artist to artist, and from priest to priest.

Thus, thirdly, is there a purely archæological interest attaching to pictorial mosaics, connecting those decorations with the individuals by whom, or for whom, they were executed, with the specific periods at which they were wrought, and with the structural peculiarities of the monuments they adorn. On this branch of the subject, Ciampini, Furietti, and Spreti, have left but little virgin soil for the nineteenth century literary labourers to dig into.

Thus, fourthly and lastly, is there also an interest which affects us as architects more nearly, probably, than either the liturgical, iconographic, or archæological. I allude to the illustration afforded to the general history of graphic art by the numerous relics of pictorial mosaic, which supply, for nearly every century from the Christian era downwards, an unbroken series of documentary evidence of those fluctuations of progress in design which, bridging over a Mediæval chasm, connect ancient Classical art with its revival under the great masters of the fifteenth century in Italy and their disciples to the present day. Having in two addresses delivered before this Institute, one in 1847, and the other in 1855, dwelt at some length, although incidentally, on the position of pictorial mosaic in art history, I may trust to your indulgence for treating, in general terms only, this really most interesting aspect of our evening's theme.

Having thus noted what I desire to eliminate, let me briefly define the point of view from which I would fain engage you to look with me at the whole matter this evening. That point of view is simply the one from which we may best realise what architects have to learn and to do in order to effect a practical revival of the art in the present day. In describing, in one of the addresses already alluded to, some of the mechanical operations of the mosaic worker, I repeated in the year 1855 what I had first advanced in 1847, viz.—that I saw no reason whatever why we should not carry out in the various processes of mosaic "exactly what the Greeks and Latins practised of old." If I was justified in that remark then, I am more than justified now, for as I shall hope to presently convince you, many practical difficulties formerly existing have been removed, and convictions as to the eligibility of the revival entertained by a few then, are now heartily sympathised with by many, able not to dream and desire only, but to work and to do. So strongly, indeed, is the current now setting in, that I feel convinced it will be ere long incumbent on every architect practising in the higher walks of the profession to make himself acquainted with the best mode of dealing with what when once adopted, will, I do not doubt, become the most popular means of adding the graces of colour to the refinements of form and proportion. Mural painting must in our climate ever have to contend with elements certain to shorten its ephemeral beauty. If attempted in real fresco, damp, fog, and frost speedily fastes upon its very vitals, tending to set the lime against the oxiden and other pigments, which in time are eaten away, as even in Italy we frequently see them, into nothingness. Fresco secco is still less permanent. Tempera, or distemper, I need not waste a word upon. Oil or encaustic painting involves the use of vehicles darkening, turning yellow, shrinking irregularly, and ultimately often detaching themselves from the ground to which they are applied. What, then, is left to us, if we would have our decorations live after we have ceased to live, but those processes the most delicate and the boldest pictures produced by which, experience has proved that a thousand years may pass over, "and steal no grace away."

I purpose now, in the first place, putting before you in a summary form the nature of such experience derived from the past; and in the second glancing at the various scopes and difficulties of the art, in its production and application. The main historical phases of pictorial mosaic were the following seven:—

1st. Classical.
2nd. Latin.
3rd. Byzantine.
4th. Greco-Italian.
5th. Italian monumental.
6th. Italian portable.
7th. Mosaic in *pietre dure*.

The first, or *Classical*, is no doubt well known to all present in its general aspect; but, as the foundation of all the other styles, it demands a somewhat closer view: the more especially, I think, because this closer view may enable the architect to realise some distinctive features in ancient decoration; revealed to us through no branch of art more distinctly than through mosaic. These features I essayed to produce from ancient illuminated manuscripts, in a paper read in this room in June 1860; but they may be better recognised in the various remains of Classical mosaic. In the Roman decoration of imperial times, two distinct schools may be traced; the one most ancient—founded on Egyptian, Dorian, and Etruscan models—chiefly affecting monochrome combinations of black and red or buff, or delicately coloured subjects and ornaments on uniformly flat grounds; and the other rejoicing in the glowing tints and golden and spangled grounds of the East, popularised after the spoils of Ionian, Corinthian, Phœnician, and Syrian magnificence had given that taste for gorgeous costume which led to the substitution of the Babylonian embroidery and figured tissues in costume and wall-hangings, for the simpler stuffs indulged in during the republican ages. Whether the art of fabricating gold ground mosaic was of Oriental discovery, or whether, as is more likely, it was derived from the north of Africa—the nursery of the glass and enamel trade—are as yet unsettled points; but that it was freely adopted in imperial times is proved by the various specimens still existing at Pompeii and Naples. It is certainly curious to remark how devoted the ancients were to tesselation as a system, whether in their finest or coarsest examples. Large surfaces of uniform colour are invariably made up of small cubes, little varying in size in any portion of the work. No special labour is bestowed on fine joints, and no effort is made to disguise their effect by using coloured cement stoppings. The jointing was evidently accepted as an artistic invention, and with good taste and judgment it was kept regular, so as to prevent distracting the eye from the pictured forms. Its lines were invariably made to subserve by contrast the effect of the flowing contours wrought upon it; and no effort was made by the use of large slabs, combined with tesseræ, to save the labour or expense consequent on reducing the whole to one uniform gauge of size or rectangularity. This reduction of all to a common modulus is one of the sources of that appearance of flatness and repose which peculiarly marks all well-designed pictorial mosaic. Such regularity is infinitely more important than fineness of work. The best specimens of the value of this adherence to gauge over large plain surfaces with which I am acquainted, are those noble black and white pavements, and wall and vault linings, which abounded in the baths of Caracella, at Rome.

To those of my hearers familiar with such mosaics as those of the "Battle of Issus," at Pompeii; of Pliny's "Doves," in the Museum of the Capitol at Rome; of the fine pavement found amidst the ruins of Hadrian's Villa at Tivoli, now in the Hall of the Masks in the Vatican; of the splendid arabesques and head of Minerva, brought from the site of Cicero's Villa at Tusculum, and now in the Hall of the Greek Cross; it is needless to state that, in all that constitutes perfection in graphic imitation, the fine *opus vermiculatum* of the ancients left nothing to be desired. Not only was form represented by light and shade, and local colour expressed by positive colour, but the utmost refinement of graduation in shadow-tints and reflected lights was accurately copied from nature. Even in that curious mosaic removed from the Temple of Fortune to the Barberini Palace, at the ancient Præneste, now Palestrina, in which the learned have recognised the identical primitive specimen referred to by Pliny in the words, "Lithostrata cœptavere sub Sylla æxtat quod in Fortunæ delubro Præneste fecit," a great variety of colouring and much minute execution in the animals, figures, and landscape are to be observed. For the production of such vivid and varied tints, natural self-coloured materials, such as marbles, stones, &c., could not suffice; and the skill of the glass-worker was therefore pressed into the service, to enrich the mosaic-worker's palette. For him not only were vitreous pastes prepared, glowing with every colour of the rainbow, but chemical processes for staining and tinting natural materials were brought into use; and finally the vitreous pastes were overlaid with gold, covered in its turn by a thin film of pure white glass, which effectually secured the metal surface from contact with noxious gases or damp vapours. Not content with applying his incrustation to plane surfaces, the mosaic-worker learnt also to adapt it to the varied forms of basso relievo. In this country, among the Pembroke marbles at Wilton, we possess one of the few specimens known of this curious mosaic, which was at once sculpture and painting. Nor is it in such exceptional productions only that we are rich, since in the more ordinary kinds of pictorial mosaic, in which figure subjects are combined with flowing and conventional ornament, the soil of this country has teemed with valuable reliques of the Roman occupation of our island. Of these, from my own portfolios, and through the kindness of many friends (Mr. George Maw being the one to whom I am most indebted), I am enabled to present to your notice this evening a very fair assemblage of representations. Among them let me direct your special attention to the following:—The magnificent head of Ceres, from Corinium (Cirencester); the subject of Orpheus, from Winterton, near Lincoln; the Bacchus, at Thruxton, Hants; the scenes of the Circus, from Horkstow-on-Humber, Lincolnshire; the head full-size, showing the tesselation, from Bignor, Sussex; the fine Bacchus, from Stonesfield, near Warwick; the grand pavement, from Littlecoat, Wilts; and the Bacchus found on the site of the East India House, Leadenhall-street, now in the Indian Museum. The most remarkable specimens of Roman work brought to this country from other lands are a few small pieces in the Temple collection, and the noble fragments of an extensive pavement found at Carthage by Mr. Davis, and now in the British Museum In addition to the Italian examples, most of which have been engraved, many specimens exist in other countries. Among the best of these, I would note the great pavement at Constantine, in Algeria; those found near Lyons (published by M. Artaud); and the Spanish varieties at Italica and Rielves. I have dwelt on Classical mosaic at greater length than I purpose doing upon any other species, because the careful student will find, I think, that evidence exists that every kind of technical process or artistic convention applied at any subsequent period to the art was known to and practised by the ancients.

The second variety of pictorial mosaic may be designated as *Latin*, since it long retained the marked peculiarities of style which distinguish Latin from Byzantine art. Thus, not in the choice of subjects only, but in the retention of the ruddy flesh-tints, the deep brown shadows, and the stumpy figures and simple costumes of the decline of Roman painting, do such mosaics as those of the fifth century at Santa Sabina, Santa Maria Maggiore, and San Paolo Fuori delle Mura, at Rome, differ from later specimens executed in the same city; if not by Greeks alone, at least by a preponderance of Greeks over the direct descendants of the original classical mosaicists. M. Barbet de Jouy, of the Louvre, who has profoundly studied the subject, remarks that "the mosaics executed from the time of Constantine to the Pontificate of Nicholas I. (A.D. 858) do not possess the Byzantine character." This, though partially correct, is far too sweeping an assertion: it suffices, however, to show that the separation in classification of Latin from Byzantine style in mosaics is essential to preserve a correct idea of real, not fanciful, distinctions. The earliest Christian Latin mosaic known is that which lines the vaulting of the little baptistery of Santa Costanza, adjoining the basilica of St. Agnese, and dates from the age of Constantine. It would be extremely difficult to say which was the latest.

The more closely the matter is studied, the more evident it becomes that a distinct Latin influence in the history of art is to be traced, running beside, mingling with, but never altogether losing its identity in, the great tide of progress which swept from a thousand springs and sources over the whole continent of Mediæval Europe. Thus, amongst existing remains of the Middle Ages, we may point to three in particular in which many of the Latin peculiarities of mosaic working have been faithfully preserved to a comparatively late date; one in the north of Italy, and the other two in that district over which we may frequently recognise traces of the influence exercised by the long-flourishing Latin schools of Aix la Chapelle and Cologne. In the pavement of the cathedral at Novara—a work executed at intervals probably between the beginning of the twelfth and the middle of the thirteenth centuries—we meet with a very fair reproduction of a black and white classical pavement. In various medallions are birds and allegorical figures, of one of which I produce a facsimile traced by Mr. George Maw from the original. From this may be readily observed the coincidence which occurs between the tesselation of the Novara pavement and that of the ancient pavements of Pompeii, such as I have sought to reproduce in the Crystal Palace at Sydenham. It is probable that a somewhat similar mosaic pavement, with figures representing Rhetoric, Logic, Prudence, &c., and a zodiac, was formerly in the church of

St. Irene, at Lyons,—a city in the neighbourhood of which many fine classical mosaics existed, which might have well served as models for this mediæval specimen of tesselation.

In the year 1831, extensive excavations, fully described in the work of M. Wallet, were commenced, to uncover the crypt and choir of one of the ancient churches of St. Bertin, at St. Omer. These laid bare one of the most interesting monuments of art ever exhumed in France. A reference to the engravings taken from M. Wallet's learned work, will show at once the nature of the pavement, which represented—by a regular classical tesselation of black, red, yellow, and bluish gray, executed in terra-cotta, stone, granite and marble—the zodiac surrounding a square, divided diagonally by conventional ornament, and containing three medallions and a monumental slab in the several triangles so spaced out. Of these the most interesting is the monumental slab, which is covered by a figure of William, son of Robert, Count of Flanders. Time does not permit of my dwelling in detail upon the workmanship of the medallions, which show a curious transition from the mosaic to the purely-incised slab pavements; but I may be permitted to congratulate France and its archæologists upon the fact that the date of 1108 wrought round the supine figure of Prince William leaves no doubt as to the retention at that period of workmen perfectly capable of imitating in mosaic the important fragments of classical mosaic which served, so far as processes of manufacture and ornament are concerned, as models for the execution of this precious work. The third rare specimen of mediæval Latin mosaic is the monumental slab of Frumualdus, Bishop of Arras, found in the cathedral of St. Waast, at Arras, in 1835, and now preserved in the museum of that city. Frumualdus, who died in 1183, is represented standing and in full episcopal costume. The details are worked out, as you may observe by an inspection of the elaborate coloured plate given in Gailhabaud's 'Architecture et les Arts qui en dependent,' in tesseræ, among which are many obviously gilt. One peculiarly classical feature, the retention of which would go far to prove a Latin rather than a Byzantine tradition for this work, is to be noticed in the strong black outlining of the figure. I am not aware of the existence of any later Latin tesselation than is shown in these three examples.

We come now to our third species—*Byzantine mosaic*—which includes all that was done in Greece and Asia Minor, and much that was done in Italy, from the transfer of the seat of empire in the year 329, until the Italians began to learn from the Greeks to practise the art for themselves. History tells us that Constantine took artificers to Constantinople with him skilled in all the arts of Rome; and hence we naturally find that the earliest Byzantine monuments can scarcely be distinguished from the classical; but the new soil and the old soil soon caused the same parent stock to bear very different fruits. Byzantium rose as Rome sank. No doubt a freer intercourse with the nations of the east, and more especially with Persia, soon led the Greeks to engraft enhanced brilliancy on their fading recollections of classical art; and gorgeousness in costume, in textile fabrics, in illuminated manuscripts, and in pictorial mosaic, soon usurped the foremost place, once assigned to severer sources of beautiful effect. To the pages of Hope, Lord Lindsay, Gally Knight, Von Quast, Salzenberg, and Ciampini, I must refer my hearers for detailed information upon the productions of the Byzantine mosaic workers, contenting myself with noting that it is in their earliest labours at Santa Sofia at Constantinople, and in the churches of San Nazareo e Celso (the tomb of Galla Placidia), San Vitale, and the two churches of Sant Apollinare di-fuori, and di-dentro, at Ravenna, that the finest models for our imitation are to be met with. Byzantine pictorial mosaic is exclusively upon gold ground; and there is ample evidence that from the date of the commencement of the iconoclastic troubles in 742, when multitudes of Greek artists and monks were driven out by persecution to seek a precarious living in foreign countries, the staple of such work was invariably executed, and the necessary materials probably manufactured by these itinerant mosaicists. What are to be peculiarly admired in the Byzantine interiors are the breadth of decorative effect invariably aimed at; the good proportioning of the scale of the pictures and ornaments to the distance from which they require to be viewed; the judicious use of bands, margins, and string-courses, to keep their compositions distinct, and make them subservient to an architectural disposition; and the judgment with which they invariably accentuate or emphasise leading architectural features. For instance, nothing can be happier than the mode in which they almost always treated the soffits and faces of arches, and the arrêtes or salient angles of vaults. Many of these may be seen in the sketches now submitted, the whole of which were executed by me from the original models. No arrangements of decorative form can be happier than such as exist in some of the cupolas of St. Mark's, at Venice, of which I offer to your notice after the conclusion of my paper some careful sections taken from Kreutz's elaborate work.

Next to Constantinople and Ravenna, Rome certainly offers the noblest specimens of Greek work; done probably, to a great extent, through the "Scuola Greca" established by Pope Adrian I., in the year 782, and attached to the church of Santa Maria, in Cosmedino. As if to reward the patronage of the pontiff, the great mosaic of Santa Pudenziana, done in his days, is by far the best in which the Greeks appear to have played the leading part. The mosaics executed at Rome for the next three centuries, although numerous, and on a grand scale, exhibit—with the exception, perhaps, of those of Santa Prassede—a marked falling off. In those of the apse of San Clemente, carried out early in the thirteenth century, a decided revival is manifested, but destined to burn brightly for a short time only; being as it were almost the last burning up of the already waning flame, which had for so many centuries shed a brilliant light from the capital of the Eastern Empire far and wide over the continent of Europe.

We now come to the fourth, or *Greco-Italian* series, which are important on two accounts—firstly, because they illustrate a gradual emancipation from tradition in the limitation of subjects and action; and secondly, because they constitute the transition, which ended in the transfer of the art, from one nationality peculiarly fitted to maintain technical efficiency, to another not less qualified to graft pictorial excellence on mechanical precision and perfection. The first mosaics executed in Sicily—those of the Church of the Admiral and of the Capella Palatina—bear Greek inscriptions, and were wrought by Greeks,—in the first exclusively, and in the second probably under the guidance, as to design, of Saracenic artists.

For the later and far more extensive works at Monreale and Cefalu, the mixed races, protected under the Norman dominion, each contributed their quota of skill. The Duca di Serradifalco, and Cicognara, agree in recognising the influence exerted on Pisa by the advance made in Sicily, and, through Pisa, Sienna and Florence, were ultimately unquestionably stimulated to rapid advance in art. The cathedral at Monreale—a beautiful drawing of the interior of which, by the late Herr Zanth, was bequeathed by him to this Institute—offers I believe, next to Santa Sofia at Constantinople, and St. Mark's at Venice, the noblest and grandest instance of a church decorated throughout with mosaic. Having worked hard in it for many a day from dawn to sunset, I can bear a humble testimony to its invariable beauty under every changing condition of light and shade. Whether bathed in sunshine and all alive with glowing colour, or almost dark at closing day, retaining to the last some lingering gleam upon its gilded wall-faces, its aspect is one, not of gaudiness nor gloom, but of serene and dignified magnificence. As in Sicily, so in Venice, the art was at first kept entirely in the hands of Greeks, who not only worked at St. Mark's, but at Torcello and Murano as well. In the latter island they no doubt laid the foundation of the glass trade, previously a Constantinopolitan monopoly, so far as the more difficult branches of the manufacture were concerned. From the Murano glass-houses, from the Scuola Greca at Rome, and from a manufactory established at Palermo, as well as by direct importation from Greece, the materials were supplied with which the Greco-Italian mosaics were executed. The profits made by the itinerant Greeks in Italy, coupled with an increased demand for works of decoration consequent on the wealth accumulated by the northern republics, through trade gains, soon caused an attempt to be made by the Italians to break up the Byzantine monopoly.

The success of this attempt led to the development of the fifth species of pictorial mosaic, which I have designated *Italian monumental*. It was in Florence, early in the thirteenth century, that the transfer of the monopoly was consummated. Andrea Tafi, a Florentine, having insinuated himself into the confidence of certain Greeks working on St. Mark's at Venice, prevailed at last—as Vasari says, "con preghi con danari, e conpromesse"—on a certain Apollonius to go to Florence, and work with him upon the mosaics which still line the vault of the Baptistery in that city. A rival of Andrea's was the even more celebrated Mino da Turrita, who, having gained an earlier although probably less accurate knowledge of the Greek processes, preceded Andrea in working on the Baptistery. Subsequently Gaddo Gaddi was employed as an assistant on these works; and by these artists, and by their pupils, and pupils' pupils, almost all the pictorial mosaics subsequently executed in Italy were carried out. Among such may be specially noticed, as combining fine execution and decorative colour with really good art, the splendid apse lining of San Giovanni Laterano, and Santa Maria Maggiore, at Rome; executed by Mino da Turrita and Gaddo Gaddi, by the latter of whom Giotto's celebrated "Navicella," at St. Peter's, was also wrought.

So highly did the Italians esteem the products of Andrea's combined talent and cunning, that after his death they honoured him with the following epitaph:—

"Qui giace Andrea, ch' opre leggiadre e belle
Fece in tutta Toscana, ed ora e ito
A far vago lo regno delle stelle."

Pietro Cavillini and the Cosmati subsequently obtained reputation by their mosaic, principally at Rome; the latter working in the Gothic manner altogether. I have every reason to believe that the Greeks continued to labour at Venice long after their services were dispensed with in other cities of Italy; although, after 1400, I think the work at St. Mark's to have been altogether Italian. With the uprising of the great school of fresco painting, the employment of mosaic, a far more costly decoration, was to a great extent dispensed with; although at Pisa, Orvieto, Sienna, and Rome, both styles of mural embellishment are constantly to be seen together. Their union is not, however, to be admired, owing to their unequal durability—the permanence of the colour of the one frequently making needlessly conspicuous the fading or staining of the other. The best early Renaissance monumental mosaics with which I am acquainted are those from the designs of Raffaelle in the Capella Chigiana, in Santa Maria del Popolo (illustrated in colour by Mr. Gruner), and the vault of a subterranean chapel in Santa Croce in Gierusalemme, at Rome; the design of which is attributed to Baldassare Peruzzi. The best late Renaissance mosaics on a grand scale are unquestionably the magnificent decorations of the vast cupola and pendentives of St. Peter's—models which one would fain see rivalled, not slavishly imitated, in our great metropolitan cathedral. For the production of the Papal mosaics, a fabrica, or government establishment, was founded, which has not failed, up to the present time, in providing materials and labourers equal to the repair of old and the initiation of new work; equal in all respects to, and surpassing in some, the peculiarities of each style we have hitherto noticed.

(To be continued.)

ON BENSON'S HIGH PRESSURE STEAM BOILER.

By John James Russell.

(Concluded from page 88.)

The leading feature of this boiler is the use of the circulating pump, to maintain a constant and regular circulation of the water through the entire set of tubes forming the heating surface of the boiler. This principle of mechanical circulation is found essential in order to carry out completely the idea of a tubular boiler, in which the heating surface consists entirely of the tubes having the pressure internal, and thereby attaining a maximum of strength and safety with a minimum of material. The rapid generation of steam in the lower portion of such a boiler would so far choke the passage of the tubes as to check the natural circulation of the water, and cause the tubes to be rapidly burnt out. The objection arising at first against the adoption of artificial or forced circulation instead of natural,—that it is not self-acting and may therefore be liable to cause interruption to the working of the boiler,—has been satisfactorily proved by the results of the continued working of this boiler to be practically met by the simplicity of construction of the circulating pump, as shown in Fig. 10, Plate VI., previously described. During the ten months that the boiler has been in continual work the circulating pump has always worked well, and never given any trouble except from causes foreign to its principle of working; such as the water freezing in it and breaking it, which occurred once during the late severe frost. In first raising steam in the boiler no difficulty is experienced from the circulating pump not being at work, since the tubes do not require circulation of the water until steam is raised, and the pump then starts with a small pressure of steam, so little power being required to work it.

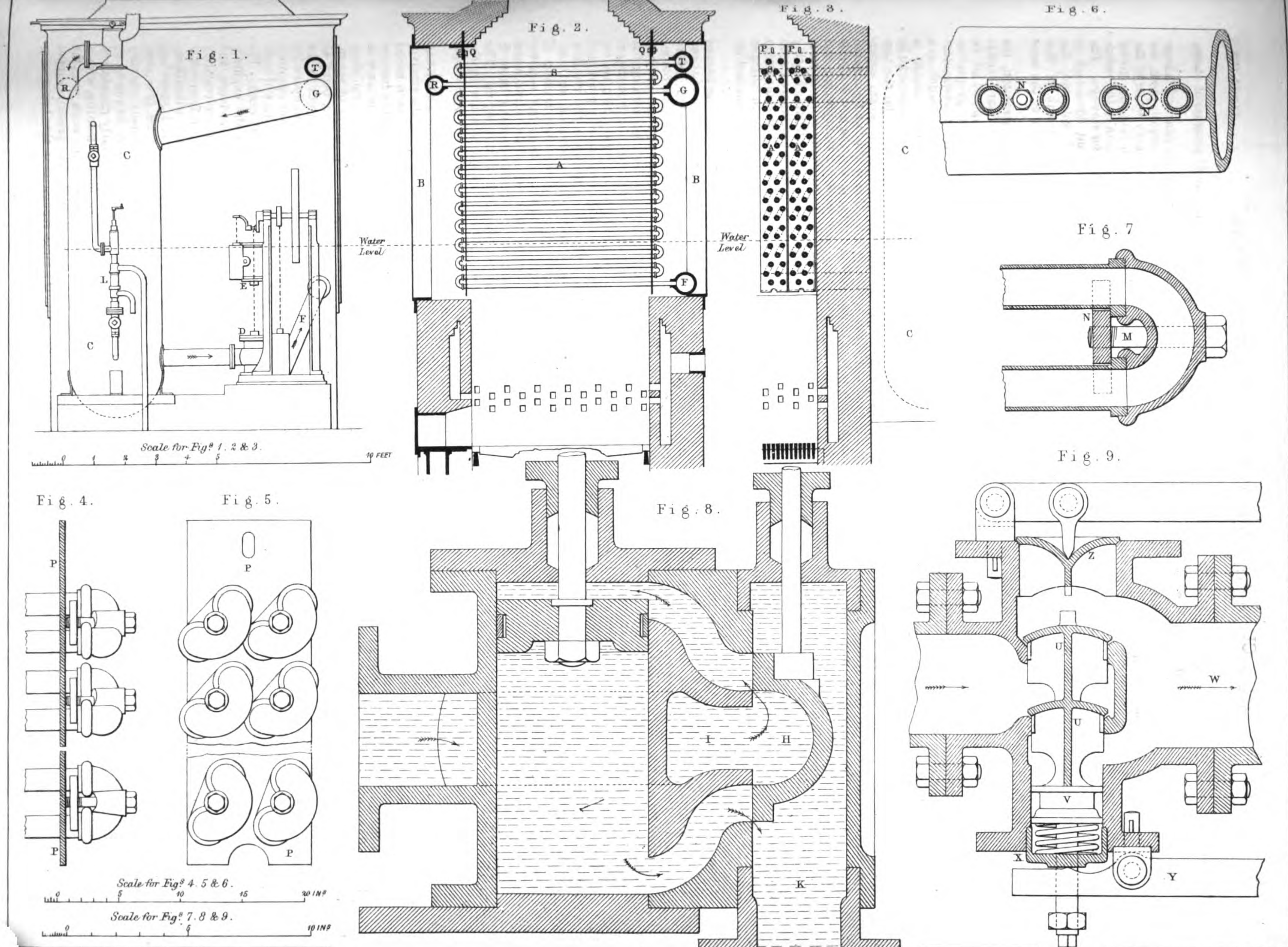
The portability of this boiler is an important practical advantage for several cases of application. The largest piece, the receiver, is only one-tenth the size of an ordinary boiler of the same power; and the tubes can be packed in bundles, giving great advantage for shipping over other boilers both in the reduction of total weight and in the increased facility for stowage. The economy of space is very great, and an important advantage in many situations where space is limited and valuable; the space occupied being only one-sixth to one-fourth of that required for ordinary Cornish or cylindrical boilers of the same power.

Owing to the duplication of parts in its construction, the cost of the boiler is but little more than that of ordinary boilers above 25 horse power, including the circulating pump and all the mountings. A small boiler of the kind costs more in proportion than a large one; for in all cases it is best to have an independent circulating pump, and a small pump costs nearly as much as a large one. In this comparison it is supposed that the steam is worked at the ordinary pressures in both cases, say from 25 to 50 lb. per square inch; but the suitable working pressure for the new boiler is 100 to 150 lb. per square inch, with the steam superheated and worked expansively; when thus worked and compared with other boilers in first cost per horse power, the new boiler is much cheaper, and in all cases far cheaper for transporting and setting in masonry. The average thickness of the boiler tubes is not more than $\frac{1}{8}$ inch, and their whole surface is effective heating surface; this results in a great saving of weight compared with ordinary boilers with plates $\frac{3}{8}$ to $\frac{1}{2}$ inch thick. In comparison with marine boilers the new boiler can be made much cheaper than those on the ordinary mode of construction, while the facility for repair gives a decided advantage.

Though the steam and water from the tubes are discharged together into the receiver, there is a complete separation of them, and there has not been the least trouble from priming. More fully to prove the fact of their separation, cocks have been placed on the upper and lower sides of the delivery pipe G, Fig. 1, leading from the tubes to the receiver: from the upper cock nothing but steam was found to issue, and from the lower nothing but water; and supposing priming to be caused by taking steam from boilers exposed to the direct action of the fire, it is effectually prevented in this boiler for the reason that no fire acts upon the receiver containing the water, from which the steam is taken off, and consequently the water remains in a quiet state. Superheating of the steam is effected by returning the steam from the receiver back by the pipe R, Fig. 2, to the upper part of the furnace and passing it through a sufficient number of superheating tubes S, whence it is taken off by the steam pipe T to the engine. The superheating tubes S are arranged and united together in the same manner as the boiler tubes, and are consequently as simple and convenient to get at for erecting and repairing.

The evaporative duty of the boiler with Staffordshire slack has been $5\frac{1}{2}$ lb. of water per lb. of fuel, without covering the receiver and steam pipes to prevent condensation. Steam has been raised from the time the first shovel of fire was placed in the furnace when cold, without wood or forced draught, to 10 lb. pressure in 25 minutes, when the steam was sufficient to start the circulating pump; in 10 minutes more there was 35 lb. pressure of steam, when the engine was started; and in 10 minutes more, being 45 minutes from the time the first the shovel of fire was put in the furnace, all the machinery driven by the engine was in operation and there was sufficient steam to produce all the power required. This was with only $\frac{7}{17}$ths of the boiler or 460 square feet of heating surface, $\frac{10}{17}$ths of the boiler being then not at work. The practice at dinner hours and other times when the engine is stopped has been to close the damper, open the firedoors, and cover the fire with ashes and slack, and work the circulating pump as slow as its construction will permit; this entirely prevents generation of steam, and in the meantime saves the tubes from overheating. For starting the engine again, the fire is stirred up and supplied with coals 5 or 10 minutes before steam is wanted, which is ample time to generate a regular and sufficient quantity of steam to commence working all the machinery driven by an engine of 60 horse power. Steam can be regularly maintained in the boiler that has now been in use for ten months, with a variation of from 10 to 15 lb. pressure when all the work is on the engine with 40 to 55 lb. steam in the boiler. The pressure cannot be maintained with quite the same regularity in this boiler as in

HIGH PRESSURE STEAM BOILER.



ordinary boilers, on account of the comparatively small amount of steam room; at the same time it is found that a sufficient quantity of steam is made with regularity enough for all practical purposes.

For the purpose of ensuring that the pressure of steam supplied to the engine shall never exceed the intended limit, and of preventing any risk of injury to the engine by over pressure arising from the comparatively small steam room in the boiler, the regulating valve shown in Fig. 9, has been designed by the writer, and is found to fulfil this object with complete success. It consists of a double-beat valve U, having a piston V below it fixed upon the same spindle and of the same area as the lower valve, and supported by a spiral spring which presses the valves open. The steam from the boiler, passing through both the valve seats, is delivered to the engine by the pipe W; at the same time it acts upon the top of the piston V, compressing the spiral spring below to a greater or less extent according to the pressure of the steam, and thus partially closing the valve and withdrawing the steam whenever its pressure at entrance approaches the intended limit. The spiral spring is adjusted so as to hold the valve full open until this limit of pressure is nearly reached; but whenever that takes place, the partial closing of the valve checks the supply of steam and prevents the pressure of the steam supplied to the engine from rising above the intended amount. The bottom of the spiral spring is carried by a cylindrical cap X, sliding vertically and supported by the end of the weighted lever Y, which is adjusted to balance the pressure on the piston at the limit of steam pressure. As soon as the intended pressure is exceeded, this lever is depressed immediately, closing the valve entirely and shutting off the supply of steam, thus preventing any increase of pressure in the steam pipe W when the engine is standing, which would otherwise be occasioned by the accumulation of steam gradually passing through the contracted opening of the valve that serves to supply the engine when working. A safety valve Z is added on the top of the casing to make the precaution complete. This regulating valve is in constant work, and maintains the steam supplied to the engine at a uniform pressure. It may also be applied with advantage to low pressure and high pressure engines working in connection, serving completely to regulate the limit of pressure of the steam supplied to the low pressure engine.

THE SOCIETY FOR THE ENCOURAGEMENT OF THE FINE ARTS.

SINCE our last record of the proceedings of this society, it would seem to have gained a firm hold upon public favour. Nor is this to be wondered at, considering the inducements it offers to its members at so nominal a subscription. An institution such as this, where those engaged in the higher branches of art could regularly associate one with another, and each in its turn lend its aid towards the furtherance of the common good purpose, had long been a desideratum; and when the scheme was broached, now scarcely three years ago, it was based on so liberal a plan, and was so cheerfully seconded by influential men in the several departments, as at once to inspire confidence of an ultimate success. The society has now recommenced its series of *conversazioni* for the season. At the first, held at the "Winter Exhibition," 120, Pall-mall, by the permission of Mr. Wallis, the proceedings of the evening were unusually attractive, since in addition to the musical entertainment, which forms so agreeable a feature at these gatherings, the prize medals awarded last session were presented as follows:—for "Historical Painting," to Mr. Marcus Stone; for "Landscape," to Mr. McCallum; for "Genre," to Mr. Calderon; for "Water Colours" (two prizes), to Mr. S. Read and Mr. E. H. Warren; for "Sculpture," to Mr. G. Halse; and for "Architecture," to Mr. A. W. Blomfield, in consideration of the "Mission House," just completed in Bedfordbury, Westminster, from the designs of the latter gentleman. The second *conversazione* was held last week in the galleries of the "Architectural Exhibition," Conduit-street, and the next, which is arranged for the 17th of the present month, will take place in the Exhibition rooms of the Society of British Artists, in Suffolk-street, Pall-mall. During the remainder of the season, successive monthly *conversazioni* have been organised for different localities, in addition to the usual Thursday evening lectures, which for the present month stand thus:—April 3rd, "On Common Things in reference to Art," by Mr. James Fahey; 10th, "On the Street Architecture of London," by Mr. James Edmeston; 24th, "On Painting and Painters in England from 1760 to the present time," by Mr. H. Ottley, the Hon. Secretary to the Society.

REVIEWS.

The Dictionary of Architecture, from FEL to FYN. The Architectural Publication Society.

We have already had occasion to speak in the highest terms of the Dictionary of the Architectural Publication Society, and to urge the importance of supporting that Society upon our readers who, we may add, will find the volumes issued by it fully to repay the very moderate subscription in return for which they are furnished. The part before us quite keeps up the character of the Dictionary, both for comprehensiveness, for minute investigation, and for trustworthy accuracy. As specimens of the varied nature of its contents and of their excellence, whether the matter under discussion be theoretical and æsthetic, practical, or historical, we cannot do better than mention the articles occurring under the words FLAMBOYANT, FOOTING, and FONTANA: we subjoin an extract from one of them:—

"FOOTING OF A WALL. The projecting first or lowest courses of stone or brick, at the bottom of a wall, which are intended, by providing a substantial base, to prevent the wall from cutting into the foundation, and from slipping or sliding upon it. When stone is used for the footing, it should be laid in large sizes of even thickness in level beds throughout each course. When brickwork is used, the intention of the footing is often frustrated by the introduction of inferior bricks, and even of bats, drowned in mortar. Pasley, *Limes*, etc., 8vo., London, 1836, 266, and App. 32, speaking of some presumed failures in government works, observes that care must be taken, in commencing the brick footings of a building on a concrete foundation, not only to use cement, mortar, and hoop-iron bond, in order to do away with the necessity of the more expensive expedients of Yorkshire landing stones and chain timbers, but also to construct inverted arches under all the proposed openings for doors and windows, in order to equalize the pressure. It may be mentioned that the footing courses of the pillars of Lincoln cathedral have so much projection that they extend laterally until they meet those of the side aisles; Penrose, in *Memoirs*, etc., read at meeting of Archæological Institute held at Lincoln 1848, 8vo., London, 1850, p. 133. The footings of the cathedral at Amiens are given by Viollet le Duc, *Dict.*, s. v. Construction, 176. Footings should never be less, it is said, than 5 feet below the surface in clay lands, and no drain should be laid below the level of them; consequently the necessary precautions must be taken to prevent, above a certain height in the walls, the rise of damp from land springs or other causes."

Hand-Book of the Slide Rule. By W. H. BAILEY, H.M. East India Civil Service. London: Bell and Daldy, 1861.

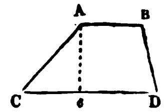
This book is a good instance of the value of a work thoroughly well done. Long practice has evidently made Mr. Bailey a perfect expert in the use of the slide rule, which he makes applicable (to quote the words of his friend in the opening dialogue) "to all sorts of cases; and tosses off his answers as if it gave him no trouble at all." Being thus a master of his subject, and as a natural consequence having his heart in it, he proceeds with great ability, clearness, and in a most readable way, to offer all who care to learn the benefit of his knowledge and skill. This he effects by giving, not only a lucid explanation of the slides and the way of handling them, but also some very serviceable tables, and short and ready arithmetical rules. A third point, and the most valuable of all, is the host of examples (showing the mode of working in every instance) with which the book is filled, and which certainly seem to show our author's wooden rule of three, well handled, to be indeed a divining rod. The principle adopted throughout is, that what is worth learning at all is worth learning well: and we believe that any one who has an ordinary head for figures, and reads the book with his slide rule in his hand,—carefully noting the explanations, storing his memory with a few useful numbers, and faithfully going through each example step by step,—will find at the end of his study that he has acquired something very like a new faculty in computation.

We extract a few examples to show the wide field open to the application of the slide rule in Mr. Bailey's practised hands. Those who wish to acquire equal facility we must refer to the volume itself.

"*Ex.* 323.—Let Fig. 3 represent a field of a trapezoidal shape, in which AB=320 feet, CD=720 feet, and the perpendicular Ae=360 feet. Required the area in acres.

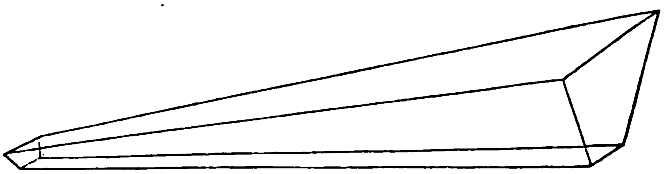
A	4·3 acres.	1040 (sum)
B	360	87120

FIG. 3



Ex. 414.—Let the following figure represent the section of a railway cutting, of which the roadway is 640 feet long, and has its width 30 feet throughout.

Fig. 2.



At the smaller end the width at top is 90 feet, and the perpendicular depth 12 feet; at the other end the width at top is 230 feet, and the perpendicular depth 40 feet. Required the content in cubic feet. (The two parallel ends being trapezoids, their area is found by multiplying the mean width by the height.)

$60 \times 12 = 720 =$ area of end
$130 \times 40 = 5200 =$ area of end

$190 \times 52 = 9880 = 4m$

15800

Then $S = \dfrac{15800 \times 640}{6}$

A	1686333 cub. ft.	640
B	15800	6

Ex. 454.—Required the weight in lbs. of a bar of wrought-iron $2\frac{1}{4}$ ins' square and 108 inches long.

$x = \dfrac{108 \times 2{\cdot}25^2}{3{\cdot}551}$

A	3·551 "Divisor"	
B	108	
C		154 lbs.
D		2·25

or

$x = \dfrac{108 \times 2{\cdot}25^2}{1885^2}$

C	108	154 lbs.
D	1·885	2·25

Ex. 478.—Suppose a field measured with an imperial chain of 66 feet gives a content of 8·6 acres; and doubts being expressed as to the correctness of the chain, it is measured again with a standard chain, and found to be 8·95 acres;—how many feet was the first chain too long?

Here $\sqrt{8{\cdot}6} : \sqrt{8{\cdot}95} :: 66 : x$.

C	8·6	8·95
C	66	67·3; or 1·8 ft. too long.

Ex. $478\frac{1}{2}$.—Suppose a field measured with a chain said to be 50 feet long, and entered as 3 acres, is again measured with a chain known to be correct, and found to be 2·9 acres;—how many inches was the first chain too short?

Here $\sqrt{3} : \sqrt{2{\cdot}9} :: 50 : x$.

C	2·9	3
D	49·25; or 9 inches short	50

Ex. 519.—If a shaft making 68 revolutions a minute has six drums upon it, whose diameters are respectively 24, 16, 18, 32, 14, 30 inches, each of which drives a separate machine, what will be the diameters of six others to replace them, when the speed of the shaft cannot be kept up above 62 revolutions per minute? (Here a reduction of speed is equivalent to wheels of larger diameter.)

A	14	16	18	24	32	30	68
B	15·3	17·5	19·7	26·4	35·1	32·7	62

DISCHARGE THROUGH ORIFICES.

Circular orifice. Velocity in feet per second $= \sqrt{\text{depth}} \times 8{\cdot}1$.

Ex. 527.—Required the velocity in feet per second, of water issuing from an orifice whose centre is 11 feet below the surface of the water.

C	1	11
D	8·1	2·69

Rectangular orifice open to surface. Discharge in cubic feet per second

$$= \frac{\text{area in square feet} \times \sqrt{\text{depth in feet}}}{\sqrt{\cdot 864}}$$

Ex. 530.—What is the horse power of a double-acting low-pressure engine, working at full stroke, the diameter of whose cylinder is 30 in., the stroke 5 feet, the number of strokes 22, and effective pressure on the piston 9·3 lb. per square inch? The "velocity" $= 5 \times 2 \times 22 = 220$. The pressure per circular inch $= 7{\cdot}3$ lb.

$$\text{Then H.P.} = \frac{30^2 \times 7{\cdot}3 \times 220}{33000} = \frac{30^2 \times 1600}{33000}$$

A	33000	
B	$1600 = p \times v$	
C		43·8 H.P.
D		30

or

C	$1600 = p \times v$	43·8 H.P.
D	181·66	30

Ex. 531.—What will be the horse power of the above engine if worked expansively, with a mean pressure of 6·1 lb. per square inch, or 4·8 per circular inch?

A	33000	
B	$1056 = p \times v$	
C		29 H.P.
D		30

or

C	$1056 = p \times v$	29 H.P.
D	181·66	30

DEPRESSION OF THE HORIZON.

The curvature of the earth in feet, when D = distance in statute miles, is $\frac{2}{3}$ D²; which at the distance of 1 mile, wonld make a difference of level of 8 inches. But as the effect of 'refraction' is to raise a distant object, the difference to the eye, is $\frac{5}{9}$ D², or $6\frac{2}{3}$ inches in 1 mile. So that if the horizontal wire of a levelling instrument duly adjusted, is in a line with the window sill of a house 1 mile off, the sill is really $6\frac{2}{3}$ inches below the wire of the telescope. On the surface of the ocean, and at long distances, the effect of the curvature of the earth must be taken into consideration, and the formula $h = \frac{5}{9} D^2$, is set as follows on the slide rule, so that either the "difference in feet," or the "distance in miles," can be found for a whole series, at one setting of the slide.

Ex. 538.—If my eye is 22 feet above the sea, and I can just see on the horizon a light (of a lighthouse) known to be 125 feet above the sea, what is my distance in miles? $\left(x = \sqrt{\dfrac{9 \times 125}{5}}\right.$

C	5	22	125
D	3	6·3	15

The answer is $6{\cdot}3 + 15 = 21{\cdot}3$ statute, or $18\frac{1}{2}$ nautical miles.

We need hardly add that we warmly recommend the Hand-Book of the Slide Rule to all whose duties lead them to count and measure.

Modern Architecture: Illustrated by Views and Plans of Gothic and Classic Buildings which have been erected since 1850, from the designs of James Murray, Architect. Part I. Coventry: 1862.

The first part of this work, just issued, is before us. When completed it will consist of about sixty plates, twenty-five of which will be views executed in lithography by the author, and printed in tints; the remaining plates are to be plans and sketches of the various works. Part I. contains five plates, and illustrates the Church of St. James, at Stratford-on-Avon, a pair of Villas at Coventry, and a Drinking Fountain at Stoke-upon-Trent. These buildings are all good in their several ways, and present examples of novel treatment of familiar subjects. The drinking fountain in particular forms a most striking exception to the great majority of such fountains. The material is Mansfieldstone; the shafts of columns being of red granite, and the back of recess of terra-cotta, representing water-plants, ferns, &c., in low relief, and from this springs a jet of water. The fountain is one of the best designed we have seen, and fully bespeaks its purpose. The ornamentation is judiciously confined to the upper part, beyond the reach of accident and wear. The idea of the jet springing from the water-plants is pleasing and appropriate, and one which might with great advantage be applied to some of our metropolitan fountains, many of which are so very inconsistent in character and choice of materials. The subject is moreover engraved in a way which leaves nothing to be desired. Mr. Murray's name has for a considerable time been favourably known to the public; we do not doubt that this series of plates, which we shall hope to notice again when the publication shall have advanced further, will add to his already well-earned reputation as a skilful and original designer.

Considerations respecting the Figure of the Earth in relation to the action of Centrifugal Force, and to the attempts to determine the Ellipticity of the Globe by Pendulum Experiments. By F. C. Bakewell. London: Longman & Co.

The articles by Mr. Bakewell on "A New Theory of the Figure of the Earth," which appeared in the August and November numbers of our Journal, have been published in a separate form considerably enlarged. The argument as now presented may be thus summed up:—In a rotating solid spheroid the centrifugal force is completely absorbed by the large mass of matter collected at the equator, and the attraction of particles on the surface is therefore towards the poles; that assuming the attraction on a solid rotating spheroid to be in those directions, it follows, that the earth could only have received its present spheroidal shape, by the action of centrifugal force, when it was in a fluid state; that during the subsequent process of solidification the mass must have contracted, and the velocity of rotation have been thereby increased, after the formation of a solid crust prevented the adjustment of form to the increased velocity; that under such circumstances the equilibrium would be disturbed, and that the difference now observed in the attraction of bodies at the equator and at the poles is due only to the excess of velocity, above the velocity of equilibrium which was established when the mass was in a fluid state. From the foregoing premises it is inferred, that variations in the vibrations of the pendulum in different latitudes indicate only the effect of the excess of velocity above the rate of rotation when in a fluid state, and that calculations of the figure of the earth founded on those variations, or on the estimates of the effects of centrifugal force, must be erroneous, because they rest on fallacious bases. It would appear, therefore, that the only reliable means we possess of estimating the figure of the earth are by actual measurements of arcs of the meridian. It will be observed that the latter position depends on proving that the earth must necessarily have been originally in a fluid condition, and that proof rests on the arguments adduced to show that the attraction of particles on the surface of a solid rotating spheroid is towards the poles and not towards the equator. In endeavouring to establish that fundamental part of his theory, Mr. Bakewell has adduced several additional arguments and illustrations, but the following is the one on which he seems principally to rely:—

"The admitted fact, that a particle free to move on the surface of a solid spheroid at rest would be attracted to the shortest diameter, affords, indeed, a conclusive argument in support of my view, that such particles would be drawn there also when the spheroid was in rotation. It being admitted, for example, that particles would be drawn to one of the poles of a spheroid at rest, it is evident that they would remain there until the spheroid had attained a velocity of rotation sufficient to overcome the polar attraction. Not only so, but they would, if placed on any part of the spheroid, be attracted to the poles, notwithstanding the action of centrifugal force. Thus, then, we perceive that, in accordance with the law established by the most eminent mathematicians, water on the surface of a solid rotating spheroid would be attracted to the axis until the velocity of rotation were sufficiently rapid to counteract the attraction to the poles. Is there any evidence to prove that one revolution of the globe in twenty-four hours is sufficient to counteract that attraction? Observed facts seem, on the contrary, to contradict such a supposition, for we know that the attraction of matter increases on proceeding from the equator to the poles. I might, indeed, be content to rest my hypothesis on this admitted law, that moveable particles on a solid spheroid would be drawn towards the axis unless they were prevented from being so by a *sufficiently counteracting* centrifugal force."

Gothic Memorials. By W. C. Brangwyn, Architect. Part I. London: 1862.

This publication contains a series of designs for head-stones, crosses, mural monuments, and similar objects, apparently drawn by the author, and printed by the anastatic process. They are, as the title implies, all of them of Gothic character, and of varied and on the whole clever design, and many, especially of the mural tablets, are somewhat elaborate. These drawings are perhaps more successful than the plainer ones, which all err more or less, by a want of that sobriety and simplicity which ought to characterise the design of all small objects the destination of which is of so solemn a nature as that of these "memorials." The mouldings, splays, stoppings, &c. too, as shown, are put in with a heavy hand, and seem to betoken that the author has studied more closely the productions of his contemporaries than the works of the mediæval masters, whose *monuments* are conspicuous among all their works for delicacy of detail and simplicity of conception.

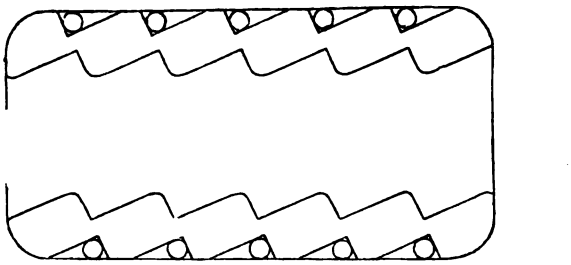
We do not make these observations with any desire to deny the originality and power of design of which these plates afford evidence, but because we feel that when, by engraving and publication, an artist puts his designs before his professional brethren and the world, as things from which they may learn, and which they would do well to make themselves possessed of by purchase, we have a right to expect marks of study and care beyond what it seems to us have been bestowed on these sketches, and more analagous to the trouble their author would no doubt bestow upon works actually intended for execution.

Hints on Ventilation, By John Lough, Architect, Surveyor, and Valuator. Maidstone: 1860.

This pamphlet, the substance of which originally appeared in the 'Dublin Medical Press,' shows a practical acquaintance with the subject. The author has procured data especially with regard to hospital ventilation, which are of considerable interest and value; although he has not perhaps arranged them so systematically, or made quite as great a use of them as he might have done. Still the publication only pretends to contain "hints," and not to be a complete treatise, and as such deserves attention. There is a list of works executed by the author appended, which it would have been in better taste to have dispensed with.

The Royal Institute of British Architects.—Subjects for Medals and Prizes, 1862.—The council will proceed, in January 1863, to take into consideration the appropriation of the Royal Medal. The Silver Medal of the Institute will be awarded to the author of the best essay on either of the following subjects:—(1) The application of coloured bricks and terra-cotta to modern architecture; (2) The application of timber work in England, constructively and artistically, from the year 1400 to the present time; (3) On the stained glass of the twelfth and thirteenth centuries; (4) On the use of concrete for vaults and roofing purposes. The Silver Medal of the Institute, with five guineas, will be awarded for the best illustrations, geometrically drawn from actual measurement (with dimensions figured, both on the drawings showing the general arrangements, and on the details), together with descriptive particulars, of an abbey gateway, a bridge, or other Mediæval building in the United Kingdom, hitherto unpublished in that manner. The council suggest certain subjects.——*Soane Medallion*: The Soane Medallion will be awarded for the best design, well illustrated by a sufficient number of drawings, for—A parochial church to contain 1500 persons, and arranged for the Protestant worship, without any detached columns or piers, and so as to leave the sight and view clear and unobstructed throughout. The style may be either Italian or Mediæval. The successful competitor, if he go abroad within three years after receiving the medallion, will be entitled to the sum of £50 at the end of one years' absence, on sending satisfactory evidence of his progress and his studies.——*The Prize offered by the President, Mr. Tite, M.P., F.R.S.*: Ten guineas, will be awarded to the author of the best set of architectural drawings, executed in the best manner, and in the Italian style of architecture, for public buildings adapted to modern wants, *e.g.* churches, town-halls, railway-stations, public offices, &c., in England.——*Sir Francis E. Scott's Prize*: Ten guineas will be given to the author of the best set of drawings for a building of moderate dimensions, devoted to civic or domestic purposes, in accordance, throughout, with modern requirements, and designed in harmony with the style of architecture of the thirteenth or of the fourteenth century. The subject of the design for the Students' Prize in Books for the year 1862 is "A Drinking-Fountain."

Improved Omnibus.—An improvement in these vehicles has long been needed, but those constructed to give more comfortable sitting room and other conveniences have been of such increased size as to prevent their general adoption. Want of room—as most of our readers no doubt know by experience—is very often, to a great extent, occasioned by the immoveable selfishness of one particular rider, who will secure ample sitting room for himself, regardless of the comfort of his fellow passengers. And where all are equally accommodating, it will be found that, while there is a great deal of squeezing and crowding about the shoulder region, the room on the seat itself is sufficient. Our attention has been called to a very ingenious arrangement recently registered, and which is shown in the accompanying diagram, exhibiting a plan of the seats by which these inconveniences are obviated. It will be seen at once that each person's seat is defined, without any division being used, while the passengers in sitting, as it were, overlap each other, thus securing perfect freedom and abundance of room to each. Our readers can try the effect of the improvement, by placing chairs at first side by side, and then



PLAN OF SEATS OF OMNIBUS.

obliquely against each other. The spaces behind the seats are for umbrellas—intolerable nuisances in an omnibus in wet weather. The increase of size is only eight inches in the length of the omnibus.

CLASSIFIED LIST OF PATENTS SEALED IN MARCH 1862.

Arrangements are in progress by which increased facilities, in connection with the management of this Journal, will be afforded to Inventors for securing valid Patents.

2315 Wrigley, F.—Armour plates for ships—September 17

1236 Fonder, J. B.—Improvements in fire grates of steam boilers—August 27
2507 Riwan, J. M., Horton, T. R.—Improvement in steam boilers—September 5
2255 Anthony. J.—Steam boilers—September 10
2258 McNab, W.—Marine steam boilers—October 14

2357 Creamer, W. J.—Railway brakes—September 20
2365 Stableford, W.—Railway wheels—September 21
2369 Dully, J. H.—Railway axle boxes—September 23
2241 Holland, J.—Railway signals—September 7
2292 Barnett, F.—Railway signals—September 14
2376 Price, J.—Improvements in permanent way—September 23
2476 Hughes, C. T.—Improvements in permanent way (a com.)—October 4

2468 Dickinson, J. C.—Improvements in steam engines—October 3
2321 Lee, J., Taplin, B. D.—Traction Engine—September 17
2632 Johnson, J. H.—Traction Engine (a com)—October 21
2543 Newton, W. E.—Improvements in condensers (a com.)—October 11
2569 Newton, W. E.—Improvements in condensers (a com.)—October 15
2536 Newton, W. E.—Heating feed water (a com.)—October 10
2392 Brooman, R. A.—Lubricating steam cylinders (a com.)—September 25

2589 Merritt, T. E.—Improvement in obtaining motive power—October 17
80 Clark, W.—Applying steam as a motive power (a com.)—January 10, 1862
2389 Musgrave, J.—Improvements in the application of steam power—September 25

2211 Effertz, P.—Brick machines—September 5
2497 Squire, W.—Planing and shaping machines—October 5
2416 Kimberley, J.—Morticeing machine—September 27
2405 Robson, G. S.—Apparatus for lifting heavy bodies—September 26
2669 Chambers, E.—Crushing machines—October 25

2320 Statham, J.—Mowing machines—September 17
3201 Green, T.—Mowing machines—December 20
2302 Sedges, W. E.—Apparatus for drying grain (a com.)—September 16
2274 Delamore, W. H.—Grain cleaning machinery—September 13
2353 Davidson, J. C.—Grain thrashing machines—September 20
3188 Smith, J.—Grinding and thrashing machines—September 20
2313 Tuxford, W.—Thrashing machines—September 16
2279 Brooman, R. A.—Weighing machines (a com.)—September 13
2664 Steerens, W.—Steam cultivation—September 12
2411 Rowsell, S.—Horse rakes—September 27
2802 Darby, T. C.—Horse hoes—November 8
2373 Brinsmead, H.—Apparatus for stacking straw—September 23
2520 Davies, G.—Horse shoes—October 9
2319 Davies, G.—Horse shoe nails—September 17

2347 Dagron, R. P. P.—Microscope for exhibiting photographic views, &c.—Sept. 19
2368 Cockey, H., Cockey, C. F.—Manufacture of gas—September 21

2238 Maillard, N. D. P.—Manufacture of soda and potash—September 7
2240 Morris, G.—Manufacture of soap—September 7
2974 Kerr, D.—Manufacture of soap—November 26
2286 Knight, J. A.—Rendering fatty matters (com.)—September 14
2288 Waller, R.—Sugar refining—September 14
2410 Lété, V. C.—Ærating wines—September 26
2597 Abel, C. D.—Manufacture of whitelead and vinegar (com.)—October 18
2383 Watt, C. Bleaching palm oil—September 24
2920 Johnson, J. H.—Treatment of zinc ores (com.)—November 20
3208 Williams, W. M.—Distillation of bituminous substances—September 21
2339 Breffer, E.—Improved fuel—September 19
2283 Dixon, H.—Carbonizing sawdust, &c.—September 13
2412 Clark, W.—Manufacture of peat (com.)—September 26
2229 Kirkman, C. F.—Utilizing sewage products.—September 6
2441 Boboeuf, P. A. F.—Preparation and application of anti-septic agent—Sept. 30

2988 Mearing, H.—Manufacture of lucifer matches—November 27
3096 Higgin, T.—Manufacture of lucifer matches—December 10
2800 Shepard, W. A.—Treatment of gutta percha and India rubber—November 7
2351 Oliver, J.—Utilising waste product from the manufacture of vegetable fibres—September 20
2431 Lush, J.—Improvement in apparatus for brewing—September 30

2298 Weare, T. M. R., Monckton, E. H. C.—Electric batteries—September 14
2997 Wild, H.—Magnetic Electric Telegraphs—November 28
2429 Theiler, M.—Improvements in electric telegraphs—September 28
2310 Brooman, R. A.—Improvements in fixing telegraph wires (a com.) September 16
2303 Reeves, J.—Electro magnetic engines—September 16

2542 Collingwood, T. B.—Spinning Machines—October 11
2402 Openshaw, J.—Spinning Machines—September 26
2291 King, J.—Spinning Machines—September 14
2803 Dobson, B.—Spinning Machines—November 8
2486 Tweedale, J.—Spinning Machines—October 4
2231 Brown, J.—Weaving Machines—September 6
2237 Ainsworth, W.—Weaving Machines—September 7
2231 Suckow, E., Habel, E.—Machines for cleaning cotton—September 19.
2334 Clough, J.—Improvement in preparing cotton and other fibrous substances—October 4
2475 Knowles, P.—Improvement in preparing cotton and other fibrous substances—October 4
2245 Malcolm, G.—Improvements in preparing jute, &c. &c.—September 9
2371 Plantrou, H.—Cleaning wool—September 23
2384 Fawcett, J.—Cleaning woollen cloths—September 24
2253 Brooman, R. A.—Improvements in use of coloured and other threads (a com)—September 9
2275 Dubrule, P.—Improvements in weaving ornamented stuffs—September 13
3260 Tongue, W.—Improvements in bobbin net fabrics—December 31
2269 Clay, W. W.—Knitting Machines—September 12
2285 Dixon, G.—Manufacture of Upholsterers' trimmings—September 14
2390 Bright, T.—Printing yarns for carpets—September 25

2225 Spence, W.—Pulping Apparatus (a com.)—September 6
2328 Partington, E.—Manufacture of Paper—September 18

2206 McConnell, M.—Improvements in locks—September 5
2294 Green, A.—Vice boxes—September 14
2248 O'Neill, P. B.—Screw spanners—September 9
3197 Redfern, J.—Warming Apparatus—December 20
2391 Purnell, H.—Warming Apparatus—September 25
2316 Barnett, F.—Improvements in lamps—September 17
2398 Russell, G.—Camp bedsteads—September 25
2273 Farlar, W.—Sash fastenings—September 13
2332 Surman, J.—Hanging window sashes—September 18

2235 Minenger, T. G.—Glazing large roofs—September 6
2276 Smith, R.—Improvements in constructing roofs—September 18
2715 Johnson, J. H.—Manufacture of picture frames (a com.)—October 29
2280 Murray, T. L.—Mica letters (a com.)—September 13
2356 Burnand, J.—Knife handles—September 28
2362 Board, C.—Veneering presses—September 21
2345 Hawksworth, S.—Floor cloth—September 19
2740 Maling, E. A.—Wardean cases—November 1
2209 Ridges, J. E.—Improvements in funeral carriages—September 5
2272 Davis, W.—Apparatus preventing accidents to vehicles from affrighted horses—September 13
2417 McCallum, D.—Bottle filling machine—September 27
2400 Bentley, T.—Apparatus for beating eggs—September 26
2300 Horsley, S., Jones, E. H.,—Shoe cleaning machine—September 16
2449 Hogg, W. S.—Fireproofing building materials—October 1

2333 Condroy, L. G. A.—Washing Machines—September 19
2511 Bremner, S.—Printing Machines—October 8
2257 Smith, J.—Sewing Machines—September 10

2422 Knight, J. A.—Pumping Engines—September 28
2342 Wilson, J. H.—Improvement in pumps—September 19
2344 Graham, J.—Improvement in pumps—September 19
2341 Tongue, W. T.—Water and fire engines—September 19
2426 Lane, D.—gas and water taps—September 28
2265 Greares, C.—Water taps and service—September 12
2312 Ransome, F. M., and Ramsome, E. L.—Filters—September 16
2323 White, G.—Filters (a com.)—September 18
2282 Sutton, C.—Indicator showing position of sunken vessels—September 13
2340 Clark, W.—Improvements in machinery for manufacture of fishing nets—Sept. 19
2308 Stewart, W.—Life preservers—September 16

2289 Wheatstone, W.—Vibrators for musical instruments—September 14

2440 Walton, F., Beard R.—Manufacture of varnish for fabrics, &c.—September 30
2208 Edkins, C.—Ladies' dress suspenders—September 5
2745 Myers M. and Myers M.—Ladies' dress suspenders—November 1
2548 Carrington, S. R.—Hats and caps—October 12
2368 Desborough, S.—Pins for hair, dress, and jewellery—September 21
3262 Tongue, W.—Umbrellas and parasols—December 31
2466 Warwick, T.—Umbrellas and Parasols—October 3

2249 Fryer, A.—Improvements in propellers—September 9
2448 Payne, W. H.—Apparatus for preventing the loss of ships' moorings (a com.) October 1
2246 Simons, W.—Improvements in ship building—September 9
2304 Meriton, T.—Steering apparatus—September 16
3252 Dormay, J. P.—Sailing or rowing boats—December 30
2381 Gladstone, G. J.—Apparatus for disengaging boats—September 24
2359 Wymer, F. W.—Apparatus for sounding the holds of ships—September 20

2380 Sedley, A. J.—Improvement in construction of Bridges and Viaducts—Sept. 24
2213 Bennett, F.—Tinning interior of lead pipes—September 5

2377 Jacob, J.—Manufacture of iron and steel (com.)—September 23
3298 Newton, W. E.—Manufacture of iron and steel—February 4, 1862
132 Newton, T.—Improvements in sights for rifles—January 18, 1862
24 Nugent, E.—Improvement in fire-arms—January 3, 1862
2260 Thomas, W. L.—Improvement in projectiles—September 11
2382 Davey, T.—Safety fuses—September 24

THE INTERNATIONAL EXHIBITION, 1862.

BEFORE the present number of our Journal is in the hands of many of our readers, the Second exhibition in this country of the industry and products of all nations will have been opened. Writing, necessarily, a few days before that event, and when thousands of workmen are busily occupied in unpacking goods, in fitting-up and decorating courts and cases, and in erecting and completing "trophies" in all parts of the building, it is impossible to form a correct idea of what the effect will be when they have finished their labours, and the packing-boxes and rubbish have been cleared away; and it would be in vain to attempt to consider, under such circumstances, the merits of even the most prominent objects that will form attractive features of the Exhibition. Of the external appearance of the structure we have already expressed no favourable opinion, and since the removal of the scaffolding from the interior of the domes, the multiplicity of ribs seen in transparency add to the confusion and apparent irregularity which was previously too conspicuous in its duodecimal shape. The interior contrasts strongly with that of the Crystal Palace of 1851. On looking along the nave, from under the eastern dome, the length seems so much shorter that the first impression is, that the building must be much less, the large area that it really occupies being so divided that it is only after traversing its various compartments that the visitor becomes aware of its vast extent. The covered roof of the nave, with its gaily decorated ceiling, the gilded columns and gallery railings, and the painted windows at each end, present a far more highly-finished appearance than the ridged-glass covering and plain colouring of the former building; but we miss the aerial lightness that gave a fairy-like character to that structure.

The injudicious manner in which the nave is crowded with what are called "trophies" tends to make it look shorter than it is, and cannot fail to impair the general effect. Some of these so-called trophies are far from ornamental. One of the most conspicuous is a large globular red danger-signal mounted on the top of a red mast; and other obstructions, almost more objectionable, consist of glass cases piled on the top of one another, and filled with samples of manufactured fancy articles. These should not have been allowed to obstruct the view and stop the way; and some of them will no doubt be cleared away before all the arrangements for the opening are completed.

The following will convey an idea how the general masses of the material exhibited have been arranged in the building,—beginning with the Western Annexe, that runs along Prince Albert's-road, the greater portion has been appropriated to machinery in motion and at rest, the work of British manufacturers. Austria, Italy, Belgium, France, America (with a small comparative amount), Prussia, and the Zollverein States, have each a share at the north end of this, France taking the extreme eastern side of the northern third, Austria a square plot abutting upon this on the southern end of the central space. Several foreign countries hold place together at the north end of Austria's share, and fill up the central division of the foreign machinery section towards the north. Belgium, well represented by many things worthy of an engineer's consideration, lies in a long strip parallel to this; the Zollverein holding a similar strip at the western side of the Eastern Annexe. The Eastern Annexe has an open court in its centre. On the west side of this court lies Class 9—agricultural implements; on the west will be found machinery; at the north end, Class 4, animal and vegetable substances; to the north of this, Classes 2 and 3, food. An open court containing articles of Class 1, a large section devoted to mining implements and products, lies on the east of this, from whence we pass under the wooden-bridge, which gives access (the only access on this side) to the Horticultural Society's Garden. Class 1 reappears on the south end of this Western Annexe.

The North-east Transept contains chiefly colonial products from Canada; some fine timber and wonderful grain. New Brunswick and Prince Edward's Island come next; with Newfoundland, followed by Ceylon; going south, Malta, Dominica, Jamaica, Trinidad. On the opposite side lie Nova Scotia, Tasmania, South Australia, New South Wales, and Queensland. Guiana and the last but one bring us upon the dome at the east end of the entire building, and fill up the whole North-eastern Transept. The South-east Transept, articles of Class 10, at its north-eastern angle, continued down the same side with the production of the Skidmore Art Company, Messrs. Hardman, Messrs. Hart and Son, Messrs. Naylor, Vickars & Co., as before referred to. The United States' department is isolated under the south-east tower, at the eastern end of the enormous carriage department. The carriage department extends from this south-east or United States' apartment, to the central tower or main south entrance to the building from the Cromwell-road. On the western side of the lower floor, under the picture galleries alloted to the foreign schools (as the carriage apartment lies under the English galleries), lies a huge space given to France; and more still to the west, a larger space appropriated to the Zollverein. This brings us to the west end of the building, under the south-west tower.

The Hanse Towns and Zollverein hold the western side of the south-western transept. Austria mainly fills the north-western transept, her space beneath the dome holding some pieces of sculpture, and a large collection of walking-sticks and umbrellas from Vienna. In this locality will be found an elaborately carved oak pulpit from Louvain, the ancient seat of such work, and other ecclesiastical furniture. Passing under the western dome to the north side of the nave, the glazed courts, roofed like those at the former Exhibition, are occupied by Belgium, Switzerland, Denmark, Sweden, and Norway, which with Russia, Turkey, Brazil, and Greece, bring us to the central transept again, as it is called, from facing with a wider than usual opening the great southern entrance of the building, and that which gives access to the Horticultural Gardens. Here lie the Ionian Islands, with China and Japan; more to the eastward two vast glazed courts contain an enormous collection of furniture, which brings us again to the space allotted to the British Colonies, abutting on the eastern dome. The south-eastern quarter of the edifice, opposite to the furniture bazaar, is appropriated to Class 10, civil engineering; Class 11, military engineering; next this comes Class 12, Sheffield goods; furs and leather, hardware and processes of manufacture lie to the west, with pottery, precious metals, close upon the central transept; with glass and naval architecture close to military engineering on the other side. On the western side of the central transept, south of the nave, France claimed and received an immense allotment three weeks before any other country moved into the building. This is to be fitted up elaborately, if not beautifully, at an enormous cost: and like the share of the nave given to the same country is anything but complete. Rome, Italy, Portugal, and Spain hold sections in this quarter.

We have thus generally surveyed the entire arrangement of the structure on the ground floor so as to give an idea of the disposition of its contents. From official sources we will now append the following summary. Eight thousand persons applied for space for exhibition of industrial products, the greatest number in connection with iron and general hardware. Those in steel and cutlery were fewer. Glass and pottery very sparse. Agricultural implements came forward boldly with 289 applications, of which 160 only were accepted. Three hundred and sixty exhibitors contributed in mining and metallurgic matters. Five thousand five hundred exhibitors of British industrial character have been chosen to occupy about 386,700 square feet of superficial space, horizontal, including passages. Of these the following approximate estimates may interest our readers. In raw materials, mining quarrying, metallurgy and mineral products, 260 exhibitors occupy 8400 square feet. Chemical substances, 202 exhibitors, take 5,100 square feet. Substances used as food, including wines, 163 exhibitors,—4500 square feet. Animal and vegetable substances used in manufactures, 247 exhibitors hold 7500 square feet. In the machinery sections, the exhibitors hold 113,532 square feet, which is divided between 83 exhibitors of railway plant, including locomotive engines and carriages, 83 exhibitors. Carriages, not connected with rail or tram roads, 1116. Manufacturing machines and tools, 241. Machinery in general, 242. Agricultural and horticultural machines and implements, 150 exhibitors, 33,800 feet space. Civil engineering, architectural and building contrivances, 164 exhibitors, 13,962 square feet. Military engineering, armour, accoutrements, ordnance and small arms, 130 exhibitors, and naval architecture, ships' tackle, 180 exhibitors, hold 12,610 feet space. Philosophical instruments and processes dependent on their use, 149 exhibitors, 7625 feet. Photography and apparatus, 165 exhibitors, 2966 feet space. Horological instruments, 130 exhibitors hold 2700 feet. Musical instruments, by 91 exhibitors, fill 5870 feet. Surgical instruments 134 exhibitors, 2475 feet space. Of section 3, Manufactures,—cotton has 4684 feet. Hemp and flax, 6483. Silk and velvet, 4722. Woollen and worsted, 21,093. Carpets,—vertical space filled by 44 exhibitors. Woven, spun, felted, and laid products, shown as specimens of printing and dyeing, 3546. Skins, feathers, and hair, 1316. Leather, including saddlery and harness, 4583. Articles of clothing, 7402. Paper, stationery, printing, and book-binding, 6250. Educational works and appliances, 4344. Furniture and upholstery, including paper hangings and papier maché, iron and general hardware, 25,272. Steel and cutlery, 13,316. Works in precious metals and their imitations, and jewellery, 7968. Glass, 15,580. Pottery, 5475. Manufactures not included in the above, 2800.

In the Western Annexe, appropriated to machinery in motion, it will be some time before the machines can be set in action. In the boiler-house, which is a short distance from the building, there are six large boilers for the supply of steam, and three steam-pipes twelve inches in diameter have been laid from one end to the other in trenches under the floor, with accompanying exhaust pipes for carrying away the waste steam. The steam will supply engines in various parts of the annexe; and shafts have been erected from which power will be taken to supply the working machinery, of which there will be a much larger quantity than in 1851. The greater portion of the heavy machinery is of course of English manufacture, though there are some huge masses contributed by foreign exhibitors, among which may be mentioned a pumping-engine that occupies a large space. Among the conspicuous objects in this department are locomotive engines of various sizes, many of which are beautifully finished, and exhibit the most recent improvements as applied to railways of different gauges and for different countries. Mr. Ramsbottom's invention for watering tanks while at full speed will be shown in action in a model on a railway 80 feet long; and a full-sized engine, with the new contrivance applied, is placed near the model. Marine engines, by Maudslay, Penn, Tennant, and other eminent makers, show the perfection to which that branch of mechanism has been brought. A trunk engine of 600-horse power is among the contributions by Mr. Penn. Examples of railway construction and railway appliances are shown in innumerable quantities; and among the curiosities connected with this department may be named a railway waggon, which was constructed and finished in twelve hours from the raw materials of wood, iron, tin, lead, &c., specimens of which are placed beside it.

Cotton machinery is amply represented, Messrs. Platt alone occupying 6000 square feet of space, with machinery illustrating all the processes of manufacture. Messrs. Harrison of Blackburn, and Mr. Hodgson of Bradford, exhibit weaving machines for cotton and alpaca, and several looms for silks and lace will also be in operation. Messrs. Gwynn have sent a centrifugal pump that is to raise a volume of water to a height of 25 feet, which will fall in a cascade 10 feet wide and 6 inches thick. On this occasion, so far as we perceive, they will be unrivalled in their hydraulic display by centrifugal action; Mr. Appold having been satisfied with the laurels he gained in 1851. There are, however, other kinds of pumps that are much larger and more powerful, one of which is of French construction. A quartz crushing-machine will be exhibited, a ship load of auriferous quartz having been sent from Australia to feed it. Specimens of Mr. Condie's improved steam hammer are also placed among the machinery in action. This department, when finished, will be far more complete than the similar one in the former Exhibition; the total space occupied by the machinery classes, being upwards of 110,000 square feet.

The south end of the east transept is occupied by "trophies" of manufactures in iron and steel, among which, steel made by Mr. Bessemer's process figures conspicuously. In his collection there is a crank-shaft of a 50-horse engine in one piece, with piston rods for engines of from 50 to 250 horse-power. A circular saw made from one disk of steel upwards of 7 feet in diameter, and specimens of steel ordnance, and of steel railway bars, contribute to the formation of the trophy illustrative of the results of the new process of making steel.

Messrs. Hardman and Co. occupy a court on the eastern side of the building with numerous admirable examples of the ecclesiastical, domestic, and decorative arts, from the 12th to the 15th centuries, comprising sculpture in alabaster and stone, enamels, chalices, flagons, &c., in gold and silver, with monumental brasses and memorial tablets. In the east transept there is the cast-iron rood screen for Hereford Cathedral, manufactured by the Skidmore Art Company, of Coventry, from a design by Mr. G. G. Scott, A trophy of Mediæval iron and brass work, to which Messrs. Hart and Sons, Messrs. Benham and Sons, and Messrs. Fulham and Co. contributed, is placed in the same portion of the building.

Birmingham has a large and handsome court appropriated to its manufactures, midway between the central avenue and the eastern transept; and Sheffield has a separate court nearly adjoining, for the exhibition of steel goods and cutlery of all descriptions, from steel grates and railway springs to scalping knives. Messrs, Naylor and Vickars of that town have a "trophy" of a peal of cast-steel bells, the largest of which weighs six tons.

In the Eastern Annexe, which is devoted principally to mining and minerals, chemistry, articles of food, and raw materials, there are placed many objects that have no direct bearing on those classes, among which is a monster double crank, made at a single forging at the Mersey Steel works, weighing upwards of 24 tons. In this department are placed numerous specimens of railway iron, one of which is 117 feet long, made without joint or welding, at a single rolling. Immense armour plates for ships, sheets of wrought-iron, and specimens of manufactured iron, showing the excellence of the quality that can now be produced from English iron ore, have been contributed by the Blaenarvon and Butterley Companies, by Lord Dudley and others.

Messrs. Schneider of Ulverstone, display a very large and highly-finished model of their iron works, to illustrate recent imimprovements in the blast furnace; and models to exhibit the best methods of ventilating coal mines, and of the most approved working appliances in collieries, have beek sent by the Northumberland and Durham Coal Trade Association. These models are accompanied by specimens of the mineral products of each district. Many of the owners of collieries have sent specimens of coal, and some of the single blocks weigh as much as three tons. Specimens of mineral products have been forwarded from various parts of the kingdom, from our colonies, and from foreign countries, which when arranged will form an interesting feature of the Exhibition. Belgium has set a good example, the numerous specimens from that metalliferous region having been all classified according to their geological positions. Among the mineral products of England and Wales are specimens of "auriferous quartz" from Merionethshire, and of "auriferous gossan" from Devonshire. Western Australia sends abundance of auriferous quartz, and of copper, iron, and lead ores; and from the Zollverein a trophy consisting of a block of red granite, carved and polished, weighing 15 tons, has been contributed.

The class of military engineering and ordnance occupies a very prominent position compared with the corresponding class in the Exhibition of 1851; and it is a curious fact that the contrivances for destroying life have made greater progress since that fancied inauguration of perpetual and universal peace than any of the arts for improving the condition of mankind. Sir William Armstrong and Mr. Whitworth have made more rapid advances in the construction of engines of war than in the improvement of engines of any other kind; and whilst they have succeeded in propelling massive bolts of destruction to distances of four and five miles with comparatively small charges of powder, the attention of other engineers has been directed to the construction of armour that would resist the concentrated momentum of such missiles. There is accordingly an immense "trophy," representing the construction of an Armstrong gun, from the formation of the coils to the finished ordnance: a court is appropriated to the exhibition of weapons of all kinds, including a gun that will propel a bolt of 600 lbs.; and in the front of this court there are to be placed two of the large guns of the rival military engineers—Armstrong and Whitworth. Specimens of the armour-plates made to withstand the effects of such powerful ordnance, and a complete model of the Warrior in section, are also exhibited.

The present perfection in the manufacture of philosophical instruments, and the most recent applications of scientific principles, are well represented. There are electric telegraphs of every form, including those that transmit audible messages and those that transmit copies of the original writing. Electric clocks, air-pumps on a large scale, micrometer gauges for shot and shell, a self-adjusting electric lamp, binocular microscopes of improved construction, lighthouse lenses, and, in short, philosophical instruments of every kind; most of the eminent English makers having contributed to make the Exhibition in their department as complete as possible.

Mr D. K. Clark, C.E., has had charge of Classes 5, 7, 8, 10, which represent railway plant, locomotive engines and carriages, manufacturing machines and tools, machinery in general; and civil engineering, architectural, and building contrivances. A single line of railway runs from end to end on each side of the western annexe, where most of these articles are accommodated, as before stated. Six double-flue boilers, 30 feet long by 6½ feet diameter, are built in the north end, communicating by a chimney 75 feet high. The driving shafting, which is 2000 feet in extent, 2½ inches in diameter, has been raised above the floor, and 2000 feet of steam-pipes sunk in a pipe culvert in the floor, graduated from 15 to 8 inches diameter, lying side by side with the same quantity of exhaust pipe, 18 inches in diameter. Two travelling steam-cranes, lifting 5 tons each, unloaded the heavy goods in this department; steam-power is supplied equal to that of four or five hundred horses. Here are the pumps to work the great fountains, placed in the Horticultural Gardens by the French; and a travelling crane to lift 24 tons, in two twelves. The French send the largest steam-engines, of 60 horse-power each. Pile carpet, and worsted looms, new steam-hammers, and a "radial" hammer, by Messrs. Neilson, of Glasgow; and Messrs. Penn's engines (parts) for the Achilles, sister to the Warrior, with a 17 ton crank shaft, and many traction engines for common roads, are here. The actual processes of needle-making, medal-striking, gold chain-making, type-casting, type-printing by hand, lithographic-pressing, copper-plate printing, a potter's wheel, brick and drain tile-making, and wood-carving, are to be carried on before the public by illustrative process. Models of the Boyne viaduct, the Saltash viaduct, and Rennie's docks at Saltash, are to be found in this department. Agricultural implements are in the Eastern Annexe, and form a collection more probably than any others illustrating the material improvement of the Empire. Near this will be seen the straw thatch weaving-machine, for working straw into a portable covering. In the section of military engineering and manufactures will be found the Armstrong and Whitworth guns, 100-pounders; Blakely 500-pounder, and the Mersey Steel Company's 600-pounder. There is a trophy of great guns, made by Mr. Anderson, for the Royal Carriage Department, being a development of the Armstrong process of manufacture of great guns, with a microscopic lens arrrangement.

Here is Col. S. Adair's model of London, with its projected lines of defence, and the model of Fort Pitt, by Col. Harness, with Capt. Ducane's details of the same. A series of models illustrating the progress of naval architecture, from Henry the Eighth's times to the present, comes from the Admiralty, from the Great Harry to the Warrior, which is placed in the nave, and a second model of the same. Here is also modelled the Queen and the Northumberland, displaying what may be looked for on the seas, by way of excelling the Warrior herself, a work now in hand. Here are also all the improved steering machines for the use of these vast ships; models, and one actual life-boat; beacons; the American system of boat-building by machinery, by which a boat comes out of a log of timber in a few hours. Models of submarine steam vessels, gun-boats and floating batteries, penetrable and impenetrable. Amongst philosophical instruments, Mr. Caselli's pentagraph, for transmitting autographic messages; numerous and valuable electrical applications are seen, as well as microscopes, balances for assayists, magnificent series of photographic views of the recent solar eclipse as seen in Spain; telescopes, light-house lanterns, magnetometrical improvements. The photographic section is of great interest, amongst which will be admired M. Joubert's process for burning in art-designs and other works in ceramic materials, or glass, by which perfect reproduction of originals may be obtained on imperishable grounds, or transparent glass. In some cases these are united with colour. Mr. Fox Talbot's photographic engraving; Sir. H. James's photo-zincography; photo-lithography, by Mr. Field; and Mr. Powney's carbon printing, which produces protographs as permanent as engravings. Full-length portraits enlarged to the size of life will startle the spectators; and Messrs. Thompson's and Caldesi's magnificent series from Raphael's cartoons will find admirers here. Horology is rich with electro-magnetic clocks and mercurial time-pieces, steam and speed clocks, geographical clocks showing the time for any part of the world, an astronomical clock impelled by gravitation, requiring no oil to the escapement, magnificent watches, and new compensation balances.

Paper manufactures of various kinds, showing immense improvements and novel applications, as for water pipes, &c., come next, with the Bank of England precautions against forgery of its notes, and the Great Seal of England, by Mr. Wyon. Printing and type founding, nature-printing, by Messrs. Bradbury and Evans; the new art of auto-typography, invented by Mr. George Wallis, by which drawings can be engraved in a few seconds on a metal plate, for printing from an ordinary press. The Electro-Block Company's process for enlarging or reducing the size of drawings. Various improvements in chromo-lithography, and steam printing, and wood blocks, and wonderful bindings, come here. In the Music Court an historical series of instruments, from an oak piano of the time Charles I., a self-blowing harmonium worked by clockwork, and a double bass for producing, by ingenious apparatus, enharmonic scales of harmonics; an oblique piano, with a new action; metal bag-pipes suitable for tropical climates; a new music time-keeper, an omnitonic flute, adjustable to any key, and a novel machine, called the Orchestrion, or self-acting organ, "which fairly imitates the melody of a full orchesta," will be found in the centre of this department. We need do no more than name a magnificent selection of surgical instruments, or a perfect world of textile fabrics in silk, from pocket-handkerchiefs by Keymer of Dartford, to huge tapestries and carpets from Huddersfield and Kidderminster. This general division only comes short in cotton manufactures and calico printing. The educational section is not so perfect as was hoped for at starting, but still of the most remarkable interest. Considerations of space have intervened.

The Mediæval Court, which has been under the excellent hands of Messrs. Burges and Slater, shows a reredos by Mr. Street, executed by Mr. Earp, and a part of that for Waltham Abbey, with the cartoons of the rest; a cast of the sculpture of the Bedminster reredos; Mr. Redfern's casts from his sculptures of the Ascension; the Digby mortuary chapel at Sherborne, the Westrupp monument in Limerick Cathedral, and many fonts, particularly the Renaissance font at Witley, carved by Mr. Forsyth; a cast from Dr. Mill's monument and effigy at Ely, by Mr. G. G. Scott. Mr. Nichol sends an effigy under a high tomb, the latter to Lord Cawdor, and one of the circular panels, with a cut subject, for the Lichfield pavement. The new stalls for Chichester Cathedral, a rich bureau, and a decorated organ, are in wood. In metal is a rich font cover. The frontal for St. Paul's, to be presented by the Ecclesiological Society, designed according to the Cologne method, and the new Peterborough frontal, are embroideries. Some beautifully designed furniture, by Messrs Morris, Marshall and Faulkener, of Red Lion-square; with paintings by Mr. D. Rossetti, show happy union of handicraft, antiquarian knowledge, and art of the best kind. The goldsmiths' work both here and in the nave is admirable. The ceramic collection is mainly supported by the works of Messrs. Marochetti, Foley, Durham, Marshall, and Gibson, sculptors. There is a superb china trophy in the nave, and in the proper court we find magnificent Della Robbia friezes, encaustic tiles, and Palliasy ware. The stained glass gallery, which is approximated to that for the pictures, contains many very fine works of art, and some very bad ones, especially the transparencies or mere pictures on glass, which is but a misapplication of labour, showing perfect ignorance of the nature of art. Amongst the hardware, the Hereford screen has got placed in consideration for display. In the nave are the (really almost perfect of their kind) wrought-iron park-gates, manufactured by Messrs. Bernard Bishop and Co., of Norwich. The Birmingham Court is in superb strength; those of Sheffield, Wolverhampton, and Rotherham are almost equally fine.

To speak of the foreign division of the building is to speak of that which does not exist in any other state than chaos. At present it will be better to say nothing, than to lead our readers into a wilderness of packing-cases and sea of shavings.

From the English or eastern dome a view may be obtained of the whole length of the nave, to such an extent at least as the trophies will permit. About this spot the great masses of English work are grouped. Let us consider which are most remarkable in the objects before us, standing with our backs to the temporary orchestra, to which a day's existence only is given, and by Minton's beautiful majolica fountain, which stands on the centre of the raised platform under this dome. To the right and left are trophies of furniture, modern and mediæval, on each hand, behind which appears, on the right a drinking fountain, designed by Mr. Earp, and very elaborately carved in the Gothic cross form, enriched with coloured marble shafts, and studs of spar of dark tint. Opposed to this is a granite obelisk, twenty-five feet high, monolithic, on a base of the same. Bevington's leather trophy, a somewhat inartistic production, stands behind the fountains, while behind the obelisk comes the Bradford woollen trophy, a mere show-case of bad design. Between these is the model of the 'Warrior,' before referred to. Behind is the Birmingham small arms trophy, pretty enough, but not very good; on one side thereof, the Whitworth gun, on the other the Armstrong gun, admirable specimens of manufacture. Nicholay's fur trophy. The Hull organ, by Messrs. Forster and Andrews, comes next, with its 46 registers, 2475 pipes, 6 composition pedals, 6 sforzendo pedals, and one pneumatic combination pedal. The pneumatic power is applied to the great and pedal organ, and there are four different pressures of wind. The bellows is blown by two of Jay's hydraulic engines, having a water pressure of 35 lbs to the square inch. These are succeeded by a four horse-drag; Walker's organ; the beautiful Norwich gates, of wrought-iron; food trophies, animal and vegetable substances of the same; philosophical instruments; Chance's first-class revolving light; dressing cases; Copeland's china trophy, and splendid telescope; Messrs. Kerr and Binn's china; the second granite obelisk; Cremer's toys; Elkington's plate; H. Emmanuel's plate and jewellery; and Hunt and Roskell's plate, succeed each other to fill up the English end of the nave. In the foreign side there is little to be seen, except a magnificent sheet of glass, some very ugly ironwork in the form of park-gates, and some magnificent sculpture, particularly a Norwegian group, styled the Duel, represented according to the ancient Scandinavian custom of buckling duellists together round the waist, arming them with knives, and setting them naked to destroy each other, or one only, as happened. On the steps leading up to the western dome is some fine sculpture, the work of Prussian artists.

The south-eastern transept, from the dome, contains, firstly, the gas chandelier work of Mr. Forester, next Skidmore's corona for gas, the Hereford screen, by the same; Messrs. Naylor and Vickar's pretty and very artistically coloured trophy of bells of cast steel, the London hardware trophy, Bessemer's steel, Warner's bells, Dent's clock, and a mass of work from Coalbrookdale, fills up this end of the transept, abutting on to the United States' allotment, which seems to contain a few agricultural implements and apple-slicers only.

In every department it is evident that there will be a much more complete display of the industry and products of all nations, with the exception of the American States, than in the Exhibition of 1851, and that no efforts and no expense have been spared by the exhibitors to illustrate the improvements that have been made in their respective branches of industry during the last eleven years.

THE ARCHITECTURAL TREATMENT OF ENGINEERING WORKS.

Nothing more strongly marks the present age than the universal application of the "division of labour" to both head and hand work, and to this rather than to any real diversity of calling do we owe the subdivision of scientific building into two distinctly recognised professions, those of civil architecture and civil engineering. Without attempting too nicely to define the exact nature of either of these two branches of art, we may take it as admitted, that buildings which are to serve as works of art, and in which beauty forms the prominent characteristic, are among the undoubted objects of architecture; while works which are to serve purely material ends—and can from their very nature afford no scope for artistic design—are equally the unchallenged property of the engineer. Thus, no one would dream of calling the New Palace of Westminster or York Minster works of engineering, or of considering the Main Drainage Works, or Plymouth Breakwater, as pieces of architecture.

Midway between most extremes lies a debatable ground, and between the extreme instances which we have cited a vast number of works might be pointed out which from their utilitarian character, or their structural peculiarities, might be claimed as engineering works, while on the other hand their capacity for artistic treatment gives them a claim to be considered as among the legitimate objects of architecture. As a rule it may be considered that where the objects forming this uncertain class are of the nature of buildings, with roofs and walls, they have with some exceptions remained matters which it has been customary for an architect to superintend; while if they have been of a different nature, such as for instance viaducts or aqueducts, they have been considered as coming within the province of engineering.

Now it often happens that engineering works, and especially bridges, retaining walls, aqueducts, and other works of masonry, are erected in situations where they become very prominent features in the aspect of great cities or of striking scenery, and that there is a sufficient margin of funds to allow of their receiving some decorative treatment, if it be thought right to add it; and it occasionally occurs that the success of such objects as works of art is of as much importance to their promoters as their suitability to perform the material duty required of them; and this being so, it becomes very important that the engineer, when such works are placed under his care, should be prepared to treat them with the good taste of an artist, as well as the skill of an artisan, and the science of a mathematician. This taste is not so invariably displayed as to lead us to think that a little more constant and careful direction of attention to the architectural treatment of engineering work is entirely uncalled for.

Architecture—as a fine art—consists mainly in such decoration of scientific construction as shall at least make it satisfactory, and, where carried far enough, render it beautiful to the eye; by decoration being here meant, not merely the addition of ornaments, but any treatment calculated to produce the desired effect on the eye. Sometimes the simplest means will suffice to produce beauty, at other times the most elaborate are brought into play, but they ought never to overstep the limit just assigned to them, that of being an amplification of good construction.

A familiar illustration will show what is here meant, and for this purpose, perhaps, the case of a simple column in a portico will be as good as any other. So far as carrying superposed weight goes, square posts of stone with an architrave over them, well bedded and truly set, will perform the work quite as well as circular columns with caps and bases, but nothing can be less effective or less *apparently* satisfactory to the eye. To remedy this defect, and make the stone posts architectural objects, the first step is to add a cap and a base, which have the effect of satisfying the eye, though they do not really improve the structural fitness of the post. A second and further improvement will be to work the stone post and the cap and base added to it into a circular column, and now the eye will be far more thoroughly satisfied than it was with the square shaft, and although some structural superiority exists in a circular column over a square one, this superiority is not at all equal in degree to the *optical* advantage gained by substituting the curved form for the square.

If we go to the other extreme, and take some architectural feature of the most purely ornamental character, we find it still only a highly developed feature of structure. A spire, for example, is not a thing invented solely as an ornament,—it is a stone or a slate roof, greatly modified it is true by being rendered lofty, and enriched with various subsidiary features, but still it is never other than a roof; and similarly, any feature of a building, as long as it remains an object of architecture, never can be other than a structural feature, or some appropriate addition to or development of one.

Let us apply these considerations to engineering works. One of the peculiarities of these works is, that ordinarily speaking, they show a great deal of their construction from their very nature; and a second is, that in the majority of cases the amount of material required to bear the various strains and weights is in excess of that requisite merely to ensure equilibrium and stability. Works requiring large masses of material, and displaying the methods in which that material is made to do its work, seem to possess in themselves the elements of that which is satisfactory to the eye, and consequently to require little or no external aid. It is to the facts that in ordinary buildings so much of the construction is necessarily concealed, in order to its protection from weather, and that the amount of material necessary for stability and keeping out cold and wet is so greatly in excess of that requisite merely to take the strains and loads, that the architect owes most of his difficulties. Where he can show structure, and where he has really to meet a strong thrust, weight, or strain, he seldom does more than provide in the readiest and simplest way for the requirements of the case; and, after perhaps the addition of a few mouldings or subsidiary features, or a little colour, he leaves the structure to tell its own tale. It is the necessity for creating features from the merest structural hints or rudiments, or from none at all, which alone embarrasses him. The engineer, however, too often behaves as if he were unaware of his advantage, and in cases where his best policy would have been to "let well alone," introduces features and adds ornaments which anything but improve the effect of his work.

The leading principle then to be observed is, when structure is shown, and when the masses, features, &c., are *apparently* as well as really sufficient for the work they appear to the eye to have to perform, so to arrange all decoration as to fall in with and give expression to the structure, and not to hide it.

Perhaps the existing bridges across the Thames in London and Westminster, will give as good a series of illustrations of these views as any set of examples we could select.

In London Bridge and Waterloo Bridge, we have admirable examples of the artistic treatment of works of masonry. Very little has been done at London Bridge beyond selecting fine stone for the exterior, and marking the joints of the masonry, by making them plain rustic work; and very little more than this has been accomplished in Waterloo Bridge, as the columns and the open balustrades there added are of the simplest possible design; and yet it would be hard to find anywhere two more thoroughly appropriate stone bridges than these. In Southwark Bridge we have an admirable example (from the same engineer, Mr. Rennie) of the proper treatment of a cast-iron bridge. Here the construction is even more frankly shown than in the stone bridges above mentioned, and the requisite form having been given to the iron-work, and the necessary bulk to the masonry, both are left to show themselves as exactly what they are, with hardly a stroke upon the one, or a moulding upon the other for effect. To these examples we may add the Hungerford Suspension Bridge, of Mr. Brunel, in which design the points selected to receive ornament, the piers, are certainly somewhat decorated, but only appropriately and judiciously so, yet not an attempt has been made to interfere with, or add to, the mechanical features of the chains, the roadway, or the mode of suspension, and the result must be admitted to be a happy one.

In contrast with these, the method which it has been thought right to pursue with regard to the New Westminster Bridge is to be regretted. Its very masterly construction is not left to be seen by those who view it from the water or the banks, but is covered by plates of open tracery, which are not very appropriate in design to the material in which they are worked, and which are in no sense decorated structure, but additions placed to act as screens or blinds to mask the real working parts. Other illustrations of this mistake might be obtained from very recent engineering works, and it is simply because this error is more visible in modern than in early works that we have thought right to draw attention to it.

One other point must be noted in connection with this subject. We have referred to mouldings as appropriate means for giving expression or ornament to structural forms, and having done this, we must remind our engineering readers that the art of designing mouldings is one that can only be acquired by long study, and the repeated application of a generally cultivated taste to the study of mouldings in existing works, and to the attempt to compose profiles suitable for various positions. Few engineers have given much attention to this study, or have much time to give to it; and yet it would be much better for them to acquire some familiarity with the subject than to delegate the work to an architect, or, as is more often the case, a mere architectural draughtsman called in for that duty solely. The engineer of a bridge or other structure is much more likely to feel accurately the value of the effect which he desires his work to convey to the beholder than anyone not concerned in the designing of the whole. If, however, assistance is called in, the person consulted ought to be a man of great skill and experience. This has not always been the case, and the difference between the results of employing a master or a tyro has more than once been rendered evident, in a manner more permanent than satisfactory.

To conclude, then, we would urge solid simplicity, and a straightforward exhibition of structure, as the method most consonant with good taste in the treatment of all engineering works; and we desire to point out the desirability of such a cultivation of taste combined with skill in all scientific builders, whether they call themselves engineers or architects, as shall render each of them competent to design and carry out every portion of every structure with which his name is associated.

THE DEPARTMENT OF BUILDING MATERIALS, INVENTIONS, AND PATENTS, AT THE ARCHITECTURAL EXHIBITION.

In the preliminary remarks in our April number on the aspect of this year's Exhibition generally, we stated that practical art is not represented so liberally as it has hitherto been done, and by no means adequately to the importance or the interest (as it should be) of the subject. From the first decision of the committee in favour of establishing a department of this kind, we hailed it as a special boon—one that had long been needed, and which would here find an appropriate locale, the annual changes necessitated by the periodical exhibitions giving opportunities for the rearraugment of such articles of this class as are of permanent value in the way of display from year to year, and also admitting of such extra contributions as may be desirable occasionally to illustrate new inventions, or the improvements that are continually taking place in old ones. All the available wall-space which the galleries can afford has been conceded to the furtherance of this object, and one apartment appropriated almost exclusively to the fitting up of such articles as required intricate or extensive apparatus, and it is this kind of subject in which the exhibition is most lacking. Some excellent devices for window fastenings and shutters, also ventilation, may be taken, however, as exceptions to the many varieties of contrivances for domestic purposes which are now, unfortunately, conspicuous by their absence. If it be urged that this department appears to be deemed of secondary importance only, it is entirely a mistaken idea. The managers of the exhibition will, we are persuaded, give every facility, and with the strictest impartiality to all intending exhibitors, even if it should involve an extension of their suite of rooms, a proposition to this effect having been broached, we believe, some time since, when there was a prospect of a favourable treaty with regard to adjoining premises.

Metal-work, as heretofore, is well represented, though Hardman, Skidmore, and some others of our well-known artists in this material, are wanting. Messrs, Johnston, Brothers, have as usual a goodly show of admirably designed objects (70); and Messrs. Peard and Jackson, who are in full force, (in No. 2 in the North Gallery) exhibit an unusual variety of articles, decidedly far superior in point of taste and finish to any we have previously seen from that establishment. We may point attention in particular to a beautiful collection of bell handles, and some other domestic furniture of the kind, also to a large gas standard, in which both the skill which prompted the design and the workmanlike way in which it has been carried out are alike deserving of mention. Besides these there are specimens of grilles, hinges, crosses, finials, and brackets, which among abundance of other things arrest the attention.

The specimens of Mediæval Brass work, &c., by Messrs. Johnston, Brothers, are above the average, showing, as we have before had occasion to remark, the especial degree of emulation which has been aroused among the various artists in metal work. Some of these brackets and font covers are particularly deserving of attention. Another branch of practical art which various manufacturers are now bringing to a high degree of perfection, is the "tile" and "tesseræ" manufacture, of which some very choice specimens come under our notice in (74); these are by Mr. W. Godwin, of Lugwardine, near Hereford. We have, on former occasions, expressed ourselves in terms of high commendation of these productions, and we need only observe here that those before us appear in some respects even superior to specimens previously exhibited. Mr. Godwin's machinery enables him to produce surfaces of various degrees of finish, from the rugged and irregular effect of Mediæval examples, to perfectly smooth tiles, of an even colour, and an almost imperceptible joint, these being often a desideratum in modern requirements. Adjoining these latter is Messrs. Maw and Co's. show of similar materials (75), which we described at length in noticing the previous exhibition. We are glad to see that Messrs. Maw, in common with some other manufacturers, have wisely sought aid from architects in the production and arrangement of their articles. It is by such means as these that artists and manufacturers are reciprocally benefitted, though, after all, the public at large are the greatest gainers.

In the lobby to the north gallery may be seen specimens of Martin's Cement, an excellent material, and one which is capable of being successfully applied in various ways, as it will stand the test of time better than most. We have before us different processes of its application, viz.: when the surface is to be papered over; when in imitation of ashlar (good as showing its imitative qualities, but on that account it does not receive our sanction); and a panel inlaid with colours which has been exposed to great heat, it is stated, for several years, and it has certainly stood the test well. The same firm also show a specimen of Part's "Improved Cement," recommended where paint or papering is not desired, and this, it would appear, is an eligible mode of using it. The bracket cast in Martin's Cement is less to our taste.

Brown's Patent Cloth-padded Wood Strips, for rendering window sashes, casements, doors, show cases, &c., air, dust, and water-tight, appear likely to fulfil their intention, although the models illustrating the method of applying them are not on a sufficient scale to prove this. Another system of "Waterproof Casements" is exhibited in the adjoining gallery (149), and is by Messrs. Rattray and Tickell. These casements, which possess the same imperviousness to water, dust, and air, are based on a system of over-lapping and double rebating, which is said to prove efficacious, although the casements open into the room. A working model explains the scheme very completely. Ransome's artificial stone is displayed in its various applications in the north gallery (3), adjoining to which (4) is a very superior collection of bricks, pantiles, and kiln-tiles, sent by Mr. E. Fison, of Stowmarket, Suffolk. These red and white pantiles constitute a "new waterproof pattern," and are warranted to stand the sharpest frost. The white ones are serviceable where protection from heat is important.

Messrs. Devaux and Co. have increased their number of specimens of zinc-work as recently applied, under the direction of Mr. Edmeston, to the manufacture of stamped ornaments and other architectural features. Among these the finials and crestings are particularly successful; nor must the rain-water pipe-heads be overlooked. Mr. E. P. North, too, shows in (148) some pressed zinc metal-work as applied to architectural panelling and other decorative purposes. In (6) we observe a model of Tyler's Patent Octagon "Chimney-head for the cure of smoky chimneys," of which we know nothing practically; but inasmuch as there is scarcely a greater nuisance in a house than smoke, it is unquestionably worth a trial, for certainly in the model some of the usual difficulties would seem to be successfully combated. Wright's "Self-acting Water-closet" (7) was described at length by us this year, as also those by Messrs. Tylor and Son, which with other apparatus is shown in (8). The lavatories produced by this firm are of a very complete kind, and possess every improvement needed under the present system of water-supply. In these the "regulator valve" allows of the water being adjusted at pleasure by simply turning the small tap, and the valve for the hot-water is of metal, of the most approved construction. (74) contains several kinds of "Pan-closets" sent by the makers and patentees, the North Devon Pottery Company, of Annery, near Bideford. Like in others, the claims of simplicity and economy are put forth as recommendations, but especial stress is laid upon the receiver and capsizing-cup or spoon being made of vitrified stoneware, or glazed earthenware, so that it is not liable to corrode, as is the case with metal. Messrs. Sharpe, Brothers, and Co. are also candidates for public patronage in a similar way, and exhibit some excellent specimens in (13.)

Several cleanly-executed "Models or Patterns in Wood, Wax, &c.," for the use of founders, in reproducing in iron, brass, and other metals, deserve examination in (11.) Some of the designs themselves are scarcely in keeping with the ideas of the present day, but there is a beautiful yet simple pattern for a grating which cannot fail to be effective. Messrs. Moore and Sons retain (12) their show of "Church and Turret Clocks, and Pressed Glass Clock Dials" for illuminating by night, and having a solid opaque appearance by day.

The show-cases of "Locks and Lock-furniture" by Messrs. Bond and Scammell (18), and of Messrs. Hobbs, Ashley, and Co. (19), are replete with excellent contrivances and beautiful workmanship. Besides the usual mortice locks, specimens of which are on view sufficiently thin for the smallest cottage or bed-room doors, Messrs. Hobbs and Co. have perfected their machinery for the manufacture of similar locks, suited for doors made on the continental plan, without the lock-vail.

The use of coloured cement for the purpose of forming inlay patterns as a species of surface decoration, has of late come much into vogue; and it possesses the desirable requisites of simplicity, durability, and cheapness. One method of its application is shown by Mr. Georgi, and stated to be after the manner of the Italian Graffitto work, and to be an imperishable mode of ornamenting any given surface by means of two different coloured cements, one of which serves for the ground, and the other for the ornament, and alike suitable for inside or outside works. The price would be from a shilling a foot, according to the richness of the design.

(15) Again introduces us to bricks and brickwork, being an assortment of "Patent Stone Bricks," manufactured by Bodmer, Brothers, of Newport, Monmouthshire. Their London office is at 2, Thavies-inn, Holborn. In the printed statement appended we find them thus described:—"These bricks consist chiefly of sand and lime, intimately mixed in certain proportions, and subjected to great pressure in moulds. Upon being removed from the press, the bricks are piled in heaps in the open air, and a chemical process of induration almost immediately commences on the surface, and gradually penetrates towards the centre of the brick until it is ultimately converted into stone. Instead of deteriorating on exposure to the atmosphere, the patent stone bricks improve, and become more durable; nor are they affected by frost, however severe, after having once become indurated to a certain extent, a property which many clay bricks do not possess. Hydraulic bricks, most particularly adapted for pits, sewers, and other similar works, are made to order; but even the ordinary patent stone brick remains uninjured on being immersed in water.

Messrs. G. Jackson and Son's Carton Pierre and Papier Maché is again displayed (147) in various new and elegant designs, chiefly of Renaissance character. Thus several of the specimens have been executed from the designs of Mr. S. Angell, architect, specially for enriching the beautiful hall he has lately erected for the Clothworkers' Company, Mincing Lane. The most effective of these is unquestionably a group of Chimeræ, executed in carton pierre; but we may also note some festoons of fruit, a capital for a pilaster, and a pattern panel for a ceiling in papier maché. Messrs. White and Parlby, in (152), show fresh specimens of relievo wall coverings and internal decorations in papier maché, carton pierre, and composition, which well maintain their character for excellence of material and finish. The very perfect "Encaustic and Mosaic Tiles," exhibited by Mr. W. England (151A), are equally meritorious in colour and workmanship, the patterns selected for their display being of the most intricate kind, yet the arrangement and fitting of all the parts are completely satisfactory. In one of these particularly is this observable—the Mosaic, imitated from early Italian examples; while the "arrangements" for wall-tiling are for the most part also successful.

In the centre of the end gallery may be seen a large model of "Gurman's Patent Sash Pocket and Fittings for Weight Sashes," so as to admit of the cleaning, repairing, and painting of sashes without endangering life. Also his "Patent Sash Pocket and Fittings for Balance Sashes." These sashes move easily, and give proper ventilation; they have solid frames, require no weights, and exact less labour in their manufacture, as well as less material. Another advantage is the readiness with which they can be taken out and replaced when wanted; the prices are very reasonable. Wild's Patent "British" Ventilator is shown by two large models in (150), and is very simple in its application. These ventilators are fixed in the ceiling of an apartment, being opened and closed by means of a balance-weight suspended either from the centre or over the ceiling by a weight lodged against the wall, by means of a cord and pulley. Messrs. Bellman and Ivey's Scagliola appears to advantage in imitation of various marbles (151), some of which, if we mistake not, are renewed from last year.

A very large model of Sedley's Patent Iron Bridge for crossing rivers and valleys at one span, "at any height or any width up to 1500 feet," without the aid of intermediate piers or support of any kind, is one of the most novel and attractive things in the Exhibition. Without pronouncing on this occasion as to whether or not it would be likely to fulfil its conditions, we give from the author's description an epitome of what it comprises. "This bridge combines in its structure the uses and advantages of the tubular, girder, and suspension principles. The manner of raising and fixing the bridge in its proper position when completed is entirely new; for it matters but little whether the bridge to be constructed be 5 feet or 500 feet above the level of the river or valley intended to be crossed. This description of bridge is available for many purposes, especially for crossing rivers where it is desirable to have the navigation of the river open. The model is constructed on a scale of 1 foot to 60 feet. The bridge, with a mean width and depth of 4¼ inches, has a span of 17 ft. 6 in. without any intermediate support, and represents a bridge of 1050 feet in length. It is composed of deal, in no part more than 3-16ths of an inch thick, bradded and glued together, weighs only 24 lb., and has been severely tested by means of heavy weights, placed on it at short intervals of space, also by trains of shot being drawn over it at a quick pace while weighted. The deflection has not exceded more than 1-16th of an inch at most, which is hardly more than that caused by the difference in the temperature of a wet or dry week. In building bridges on these principles, iron and steel would be used in combination where practicable, so as to get lightness with great strength. The leading features of this invention are, simplicity of construction in the mechanical portions, and method of elevation to the desired height; economy of first cost; the total absence of intermediate piers for support, and the heavy expenses and great difficulties attending all subaqueous undertakings. In devising and constructing this bridge, Mr. Sedley has relied much on what has been done previously by Messrs. Fairbairn, of Manchester, and the late Mr. Robert Stephenson, C.E., and he believes that bridges built on this plan will be found thoroughly practicable, and that before many years have passed we shall find wide streams and valleys crossed without difficulty at one span. Up to the present time the three bridges most remarkable for wide spans are, the Menai Bridge, and the Bridge over the St. Lawrence, both built by Mr. R. Stephenson, C.E., and the Saltash Bridge, built by Mr. Brunel; in neither of which structures there is any span exceeding 455 feet without intermediate piers."

In the great gallery, one of the large recesses is occupied by goods exhibited by Cox and Son, of Southampton-street, Strand, principally consisting of Church Furniture and Carved Oakwork, in the preparation of which much aid is obtained through its being roughed out by machinery. This process is now well known, and has been extensively applied. On the table in the room is an ingenious and well-executed model of "Miles's Patent Sashes" (356), presenting either side of the glass to be cleaned from the interior of the chamber; and over the door of the west gallery are some specimens of mural and ceiling decorations (357) in various styles, in which Mr. W. Homann has employed "Tempera" as the medium of embellishment, the cost but little exceeding that of first-class paper-hangings. This mode of decoration is one which is capable of application in several ways, inasmuch as it can be used either in places where papering would not so well answer, or in combination with other methods of enrichment, thus producing variety as well as harmony of effect. Mr. Homann is also a contributor of numerous designs for decorative purposes, which are interspersed among the more grave-looking architectural pictures on the walls, and to some of which we called attention in our notice of the other part of this exhibition.

NEW IRON LIGHTHOUSE, AT CAPE CANAVERAL, FLORIDA, U.S. AMERICA.

(*With Engravings.*)

The accompanying Plates, Nos. 9, 10, and 11, illustrate a new Iron Lighthouse, which it was intended by the United States Lighthouse Board to erect in 1861, at Cape Canaveral, Florida. The designs were prepared under the superintendence of Capt. Wm. F. Smith, Engineer Secretary to the Lighthouse Board, Washington; the drawings being made by Mr. J. K. Whilldin, C.E. The structure exhibits many features of interest. It is the largest *iron* tower on the whole coast of the United States, and may be taken as a fair sample of the present state of lighthouse engineering in that country.

The mode of lining the tower with brickwork, arranged as exhibited in the plates, is considered to be preferable to concentrating a great weight at the base of the tower (as is not unusually done to gain stability), as, when the latter arrangement is adopted, the strains arising from hurricanes are to a large extent transmitted through the connections; and the oscillations from the same source must also prove more serious.

The following copious extract from the specification conveys a full description of the details:—

General description.—The tower has a curved outline generated by the revolution of a rectangular hyperbola around one of its asymtotes as an axis. The diameter of the shell at the base, (not including the projecting flanges) is 28 feet; and at the top, immediately under the cornice it is 12 feet. The main part of the tower, exclusive of lantern, is composed of cast-iron panels arranged in horizontal sections, breaking joint with those above and below them; there are 15 such sections, each 8 feet high, making 120 feet in height for the body of the tower. There are 12 panels in each section, firmly secured together and to the adjoining sections by wrought-iron bolts. The thickness of the section at the base of tower is 1⅛ inch, and the thickness of each succeeding section decreases as it approaches the top; that under the lantern being ⅞ of an inch thick.

Brick lining of tower.—The lower flange of each section projects inward sufficiently far to sustain part of the brick wall which lines the interior of the iron tower. The whole wall being thus subdivided in similar sections to the iron work, the contraction and expansion of the two materials (iron and brick) from changes of the temperature, become inappreciable for each section of 8 feet.

Keeper's dwelling.—The first four lower sections of the tower are intended to be used as the keeper's dwelling; and the stairway through these is enclosed with a boiler-plate cylinder, 6 ft. diam. The stairways beyond section Fig. 6, Plate 10, are open, and each flight is formed of cast-iron steps, which are strung on a wrought-iron shaft which passes through their hubs from floor to floor. Immediately under the watch-room deck the steps are again enclosed, and a plate-iron door is provided to prevent draught reaching the lantern. The general elevation and vertical section of tower is shown on Plate 9, Figs. 1 and 2, and various details on Plates 10 and 11.

Shell of tower.—The panels forming the shell of tower to be of cast-iron, made in dry sand. The iron used must be remelted iron of the best American brands, and of such a mixture as shall insure the greatest strength and toughness. The weight necessary to tear asunder one square inch must not be less than 20,000 pounds.

Joints to be planed.—The top, bottom, and side flanges of the panels forming surfaces of contact, must be planed. The only exception being the lower flange of section Fig. 3, Plate 10, which rests on the masonry. For the purpose of ventilating the space between the shell of tower and the brickwork, there must be drilled through the top and bottom flanges forming each joint between the sections, 12 holes, equally distributed, and one inch diameter. The panels and sections to be firmly secured together by wrought-iron bolts. The holes in the flanges must be reamed, and the bolts turned to neatly fit them.

Bolts for connecting the sections of tower.—Each of the panels for all the sections will have six bolts for each top flange, six for each bottom flange, and five for each side flange.

Foundation bolts.—The foundation bolts to be of wrought-iron. They will be firmly bedded in the masonry, and will pass through and be secured to the outer lower flange of section Fig. 3. There must be attached to the lower part of two foundation bolts, opposite each other, copper rods 1" diameter, to pass through the masonry horizontally, and penetrate moist ground at about 20 feet from the centre of bolt, and descend vertically 8 feet. Projections for the window-frames, with their cable-mouldings on the outside, must be formed on panels; and in sections Figs. 4, 5, and 6, openings must be made for the smoke-pipe.

Plate iron floors.—The floors of the interior of tower must be of boiler plate ¼ of an inch thick, sustained by rolled iron girders and T iron.

Rolled Girders.—The 6, 9, and 12 inch rolled girders, with their chairs, sockets, &c., are to be similar to those made by the "Phœnix Iron Company," Philadelphia, Pa. The 6" girders for floors in sections Figs 3, 4, and 5 of tower radiate from the plate iron cylinder, to which they are secured by means of cast-iron sockets and wrought-iron bolts, with hexagonal heads and nuts. The outer ends rest on the lower panel flanges.

Floors in sections Figs. 4, 5, 6.—The floors must be secured to each 6" girder with two sets of wrought-iron connections. The T iron for stiffening the under side of floors in sections Figs 4, 5, and 6 to be $3\frac{1}{2}'' \times 3'' \times \frac{1}{2}''$, and to be secured by rivets with countersunk heads, not exceeding 4 inches apart from centre to centre. The floors are supported mainly by rolled iron girders, whose ends are secured to the lower flanges of the panels. The under sides of the floor are further supported by T iron, extending from said girders to the brick work. As all the floors must be flush on their upper sides, the rivets for connecting the T iron to the floors must have countersunk heads; and they must be placed not exceeding 4″ apart from centre to centre. The trap doors of boiler plate, $\frac{1}{4}$″ thick, must be furnished with strong wrought-iron hinges, and handles for opening them. Each one must have two pieces of angle iron, 2″ × 2″ × $\frac{1}{4}$″, secured to the under side by rivets, $\frac{1}{2}$″ diam., not exceeding 4″ apart. The frames for the doors where not formed of the girders or 4″ T iron, must be of angle iron 3″ × 3″ × $\frac{3}{8}$″, secured by rivets not exceeding 3″ apart from centre to centre.

Diameter of floors.—The outlines of all the plate iron floors are circular, and are all to be built in the brick work a few inches. Their extreme diameters are as follows:

For the floor of section			Fig. 4	23′ 6″
Do.	do.	do.	Fig. 5	21′ 10″
Do.	do.	do.	Fig. 6	20′ 2″
Do.	do.	do.	Fig. 7	11′ 3″

Chairs for beams.—The chairs for the ends of the 9-inch and 12-inch rolled beams to be of cast-iron. Wrought-iron bolts, 1″ diameter, and provided with suitable nuts and washers, must be furnished to secure the beams to the chairs, and the chairs to the flanges of the panels of tower. The sockets at the middle of the 9-inch and 12-inch beams, and at the watch-room floor, must be of cast-iron, neatly fitted and secured to the beams. They must be bored to fit the ends of the wrought-iron shaft which passes through the open stairway; and their surfaces of contact with the steps of the open stairway must be faced. Around each opening in the floors, for the stairway, angle iron 3″ × 3″ × $\frac{3}{8}$″, must be neatly fitted and secured.

Railings around openings in floors.—Wrought-iron railings, seen in the vertical section, Plate 9, surround these openings; the standards of which, at their lower ends, secure the floor-plates and angle iron together.

Cylinder around lower stairway.—A plate-iron cylinder surrounds the stairway in the lower part of the tower, Fig. 2. The exterior diameter of which, exclusive of battens, is to be 6 feet. The plating and battens to be $\frac{1}{4}$-inch in thickness, secured by rivets $\frac{5}{8}$″ diameter, not exceeding 3″ apart from centre to centre, and driven *hot*. Where the steps would come in contact with the rivet-heads, the rivets must be driven with countersunk heads. The cylinder must be secured to the cast-iron base-plate by a single row of rivets, of the same diameter and the same distance apart as above. Each door-frame in the cylinder must be formed of 3 strips of bar-iron 1$\frac{1}{4}$″ square, secured with rivets not over 4″ apart. Recesses for the (gun-metal, 3″ × 3″) hinges of doors must be cut in the frames, and the hinges secured to them by gun-metal screws. The top of cylinder must fit up closely to the floor, and the plating cut to suit the T iron and beams on the under side of the floor. That part of the floor which has in it the opening for the stairs, must be secured to the cylinder with angle-iron 3″ × 3″ × $\frac{3}{8}$″. A piece of the same sized angle-iron, and two feet in length, must be rivetted to the cylinder on each side, immediately under the rolled girders.

Base-plate of cylinder.—The base-plate of cylinder must be of cast-iron. The rebate on the periphery, for the attachment of the cylinder, must be turned; and the upper part of the centre hub, on which the steps rest, must be faced.

Steps inside of cylinder.—The steps for the enclosed stairway to be of cast-iron. The upper and under surfaces of the hubs must be accurately faced. The outer end of each step to be placed $\frac{1}{20}$ of a circle in advance of the one beneath it; and must be secured to the cylinder with 2 wrought-iron bolts $\frac{5}{8}$″ diameter, the heads and nuts to be hexagonal, and tool-finished.

Landing-plates in cylinder.—The cast-iron landing-plates to be faced on the upper and lower surfaces. The periphery of each plate must be secured to the cylinder with 4 bolts like those for the steps. A casting must be inserted in the top step of the enclosed stairway. The upper part of which casting will penetrate the socket which is between the rolled girders.

Steps of open stairway.—The steps of the open stairway to be of cast-iron. The position only of these steps is shown in Fig. 1, as they are the same throughout. The hubs must be made so as to allow a rolled iron shaft, 3 inches in diameter, to pass through them. For each flight of steps there must be a space of half an inch between the upper end of the wrought-iron shaft and the under side of the division piece in the socket. And the total height of the steps in each flight must be about $\frac{3}{16}$″ less than the clear space between the sockets. Each step is made in three parts; the tread must be secured to the riser with 3 wrought-iron bolts, with countersunk heads. The upper and lower surfaces of main hubs, and the sockets through which the railing-standards pass, must be faced. The lower part of each standard passes through two steps, thereby securing the parts together, and determining the position of one step relative to the other.

Tread of step.—The tread of each step, thus determined, is nearly one-twentieth of a circle. The sum of treads for each flight of 20 steps, measured on a circle drawn with a radius of 2′ 9$\frac{1}{2}$″, lacks about 2$\frac{1}{4}$″ of being a complete circle.

Stairway railing.—The part of each railing standard above the steps must be smooth-forged; below that point it must be tool-finished. The rail must be made of 1″ round iron, and scarfed at intervals of five steps. Each standard must be riveted to the rail at the upper part.

Steps at the head of main stairway.—Nine steps, similar to those for the enclosed stairway, will terminate the main stairway immediately under the watch room. They must be enclosed with, and be secured to, plate iron, one-eighth of an inch in thickness.

Door under watch-room.—A door of plate iron $\frac{1}{8}$″ thick, stiffened with bar iron 1$\frac{1}{2}$″ × $\frac{1}{2}$″ on the inside, must be attached to the plating with strong wrought-iron hinges, and furnished with suitable fixtures for opening and closing. Rebates, not less than $\frac{1}{2}$ inch wide, must be formed around the top and sides of door with bar iron 2$\frac{1}{2}$″ × $\frac{1}{2}$″. The plating must be secured to the floor of the watch-room by angle iron 3″ × 3″ × $\frac{3}{8}$″, and to the steps by bolts $\frac{5}{8}$″ diameter, as for the other enclosed stairway. In order further to exclude any draught from the lantern, there must be fitted to each of these steps a sheet iron riser $\frac{1}{16}$″ thick, secured with wrought-iron screws $\frac{1}{4}$″ diameter, and not over 4″ apart. The railing of the main stairway terminates at, and must be secured to, the frame of door.

Stairways in watch-room and lantern.—The stringers of the lantern and watch-room stairways are to be of wrought-iron secured at both ends to the floors and galleries with wrought-iron bolts, $\frac{3}{4}$″ diameter. Those bolts at the upper ends to have countersunk heads. The brackets which form the rise of the steps to be cast-iron, each one secured to the stringer by two $\frac{5}{8}$″ bolts with countersunk heads. All the brackets must be in contact—the joints to be neatly fitted. The treads of the steps to be of cast-iron; each one must be secured, at each end, to the flange of the bracket with wrought-iron bolts $\frac{5}{8}$″ diameter. The railings for these stairways, and around the openings in the watch-room and lantern floors, to be of wrought-iron. The rail to be of one inch round-iron; the standards for all the steps, and for the lantern deck, to be $\frac{7}{8}$″ diameter at the lower part; and standards at the watch-room floor to be 1$\frac{1}{8}$″ diameter at the lower part.

Lantern deck.—The lantern deck to be of cast-iron, made in dry sand. It will be made in four parts, one of which is to contain the opening for stairway. The joints must be planed, and well fitted. The segments must be secured together with 1$\frac{1}{4}$″ "ream" bolts of wrought iron. The nuts, heads, and washers to be for 1$\frac{1}{4}$″ bolts. The circular seat in the centre of the deck, for the lens pedestal, must be faced. The periphery of the deck must be secured to the flanges of the panels with wrought-iron bolts $\frac{3}{4}$″ diameter.

References to Plates 9, 10, *and* 11.

(Similar letters throughout refer to the same parts.)

Plate 9, Fig. 1, is a general elevation, and Fig. 2 a vertical section, showing the interior construction. (The stairway being the same throughout, parts of it only are shown).

Plates 10 and 11 show sections at various parts of the tower, taken on the lines indicated by the letters on Fig. 1, and other details.

Fig. 3 is a section at A B, which shows the internal arrangement at base of tower, *a*, *a*, *a*, is the brickwork; *b*, space for fuel; *c*, *c*, cellarage; *d*, *d*, *d*, water-tanks.

Fig. 4 shows a section on the line C, D; *e*, is the kitchen; *f*, *f*, bedrooms; *g*, the central stairway; *h*, the landing-place; *i*, trap door; *k*, smoke-pipe.

Fig. 5, section at E, F; *l*, *l*, 6-inch rolled beams or girders; *m*, T irons for stiffening under-side of floors; and *n* living room.

Fig. 6, section at G, H; *o*, passage; *p*, *p*, closets.

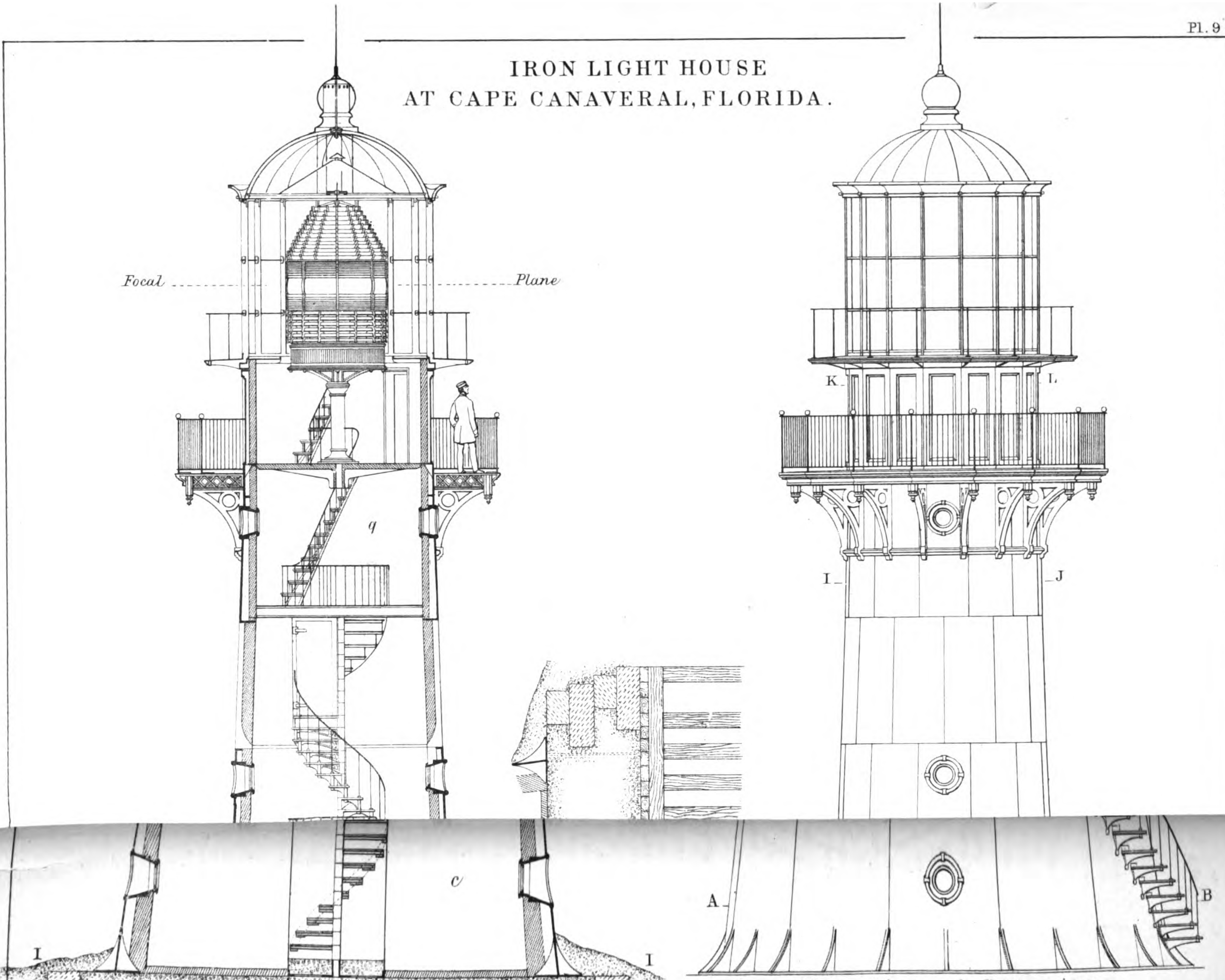
Fig. 7, section at I, J; *q*, *q*, watch-room; *r*, stairs to lantern.

Fig. 8, section at K, L, stairs; *s*, gallery round lantern; *t*, shaft supporting lantern.

Figs. 9, 10, 11, and 12, details of tie-rods about the axis of lantern; *v*, *v*, rods; *u*, wrought-iron rim; *w*, brass staples screwed down on rim which receive the arms, *x*, *x*, *x*, of circular rim.

(To be concluded in our next.)

IRON LIGHT HOUSE AT CAPE CANAVERAL, FLORIDA.



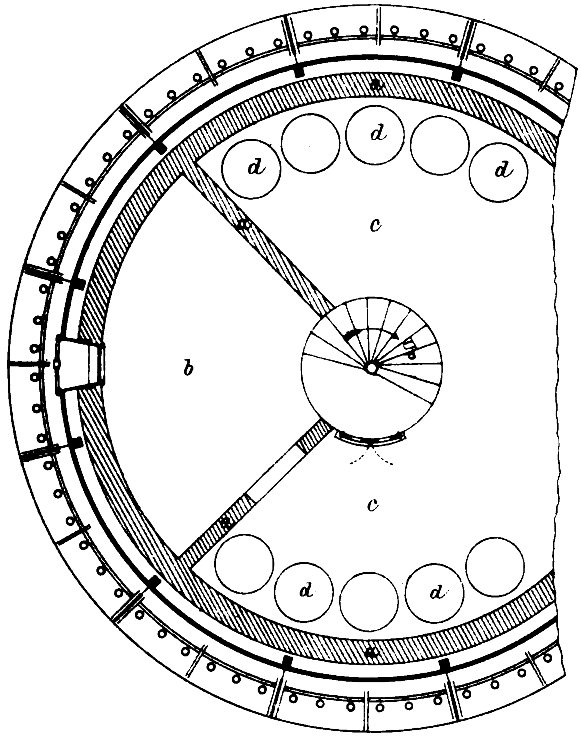
Vertical Section.

Elevation of Exterior.

IRON LIGHT HOUSE AT CAPE CANAVERAL, FLORIDA.

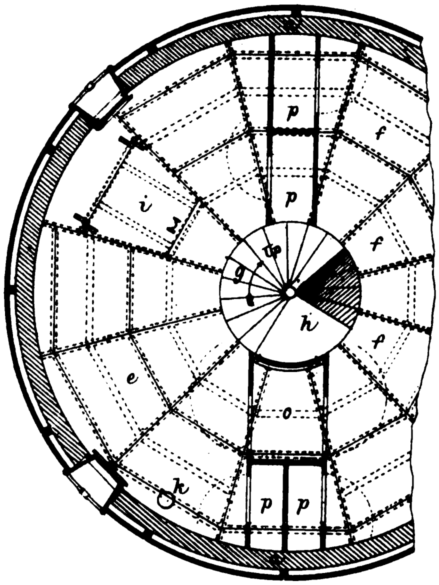
Details.

Fig. 3



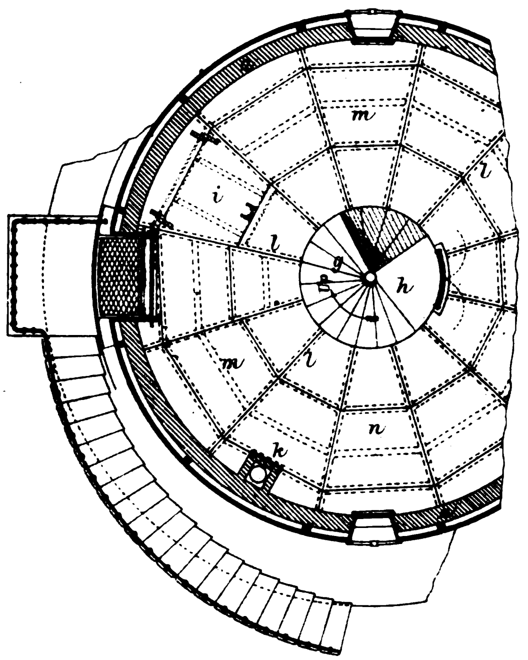
Section at A.B.

Fig. 4.



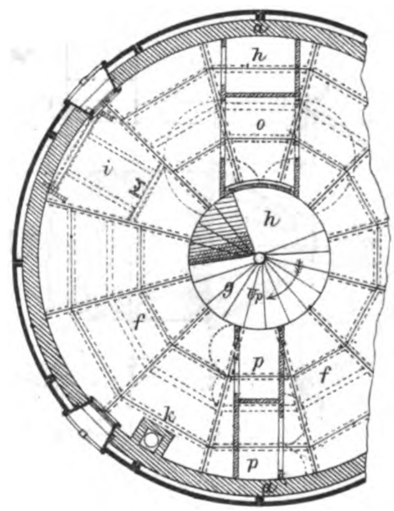
Section at C.D.

Fig. 5.



Section at E.F.

Fig. 6.



Section at G.H.

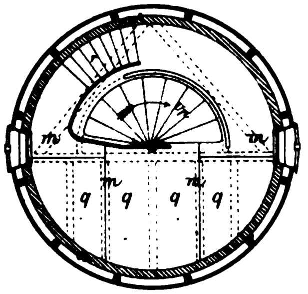
Scale of 0 1 2 3 4 5 10 20 30 *Feet*

J.R. Jobbins.

IRON LIGHT HOUSE AT CAPE CANAVERAL, FLORIDA.

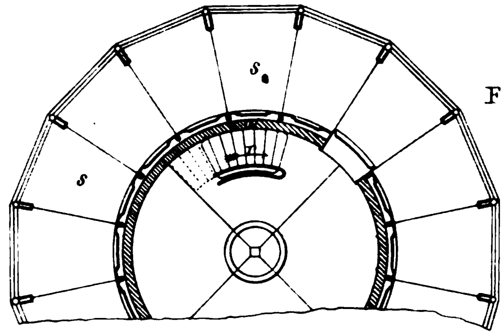
Details.

Fig. 7.



Section at I. J.

Fig. 8.



Section at K. L.

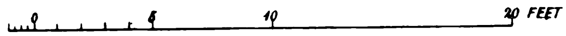


Fig. 9.

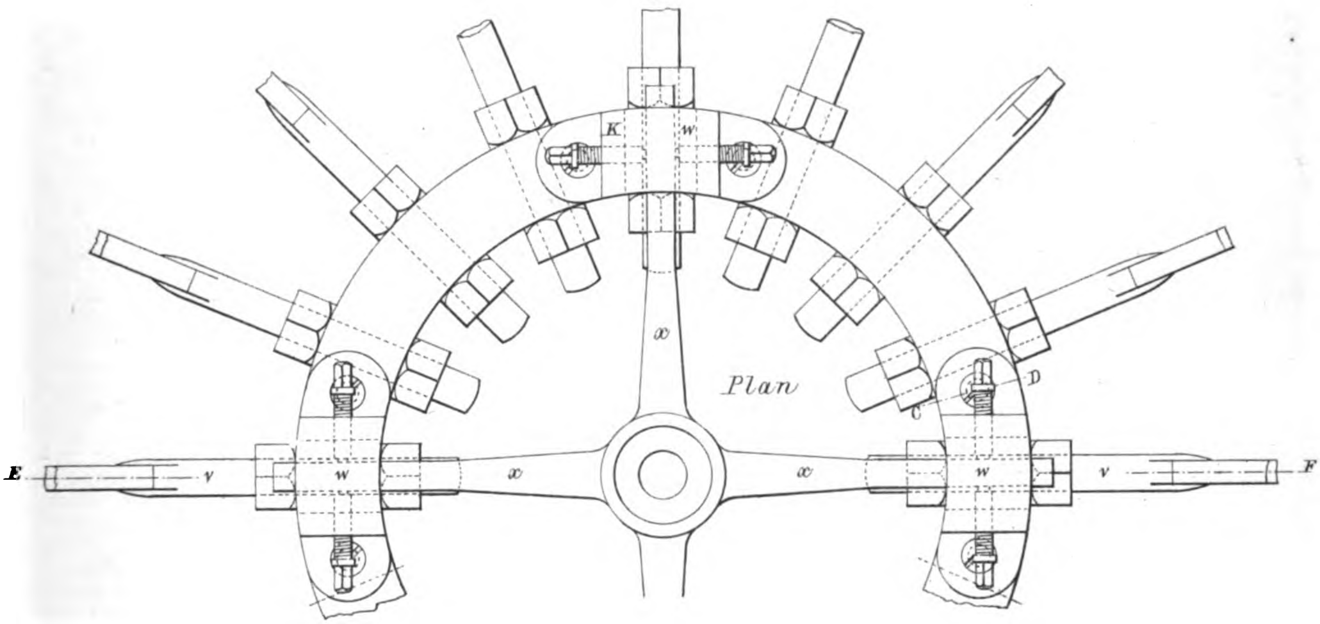
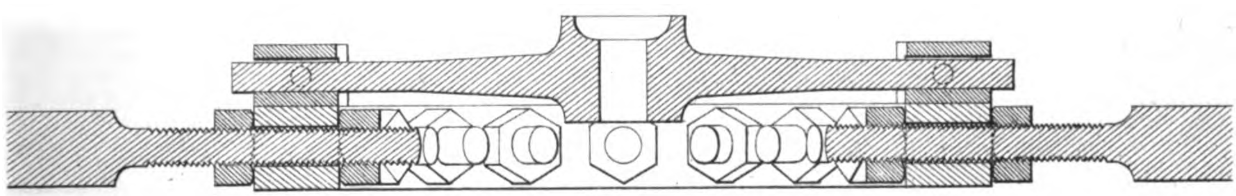
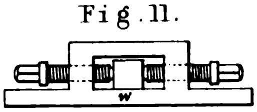


Fig. 10.



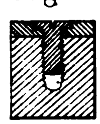
Section at E. F

Fig. 11.

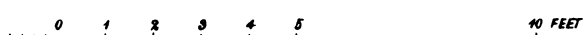


Elevation K.

Fig. 12.



Section at C. D



LECTURES ON ARCHITECTURE AT THE ROYAL ACADEMY.*

By Sydney Smirke, R.A.

Lecture III.

In my last lecture I touched upon a few of the more interesting objects on the shelves of the British Museum that have special reference to architecture. The subject is well-nigh interminable; for I doubt whether any library in the world equals that in the British Museum, either in extent or value; and I purpose on a future occasion to pursue the subject, and continue, in a cursory way, to direct your attention to such other works as seem to me best calculated to impart instruction or to excite interest in the minds of those engaged in the pursuit of architectural knowledge. But I will this evening call your attention to another library, which may be in some sense regarded as a public library, but which is very different, no doubt both in respect to extent and value, from that to which I have already adverted. I refer to the library which forms an important part of the Soane Museum. Being a library formed by an architect, and bequeathed by him in trust for the express use of architects, it seems to have special claims on my attention here; and those claims are enhanced by the long connexion that existed between this Academy and Sir John Soane.

It is by no means my intention or desire to constitute myself the apologist or the critic of that in some respects remarkable man. With his personal peculiarities, with his temper and disposition, with his foibles and eccentricities, we have nothing whatever to do here. Let those who have no defects of temper or of character throw the first stone. I certainly will not venture to do so.

As an architect he was, undoubtedly, in some respects remarkable. He sought for novelty and originality in whatever he did; and not unfrequently he succeeded in attaining the object of his search. He was very deficient in greatness of style, delighting rather in small *concetti* and whimsical contrivances to produce effect. Though he can hardly be said to possess genius in the higher sense of that word, he had much ingenuity. He moreover had some aspirations after the attractive but hazardous quality of the picturesque in architecture.

If I had declined, on the present occasion, to be the censor of his personal peculiarities; so I would equally refrain from investigating his motives, which may or may not have influenced him to devote his museum and library to its present semi-public purpose. Let us take the fact as we find it, and admit at once that the bequest was a liberal contribution towards the education of his professional posterity. It pleased Sir John to apply for and obtain the sanction of Parliament for the formation of a trust, imposing on the trustees certain very clearly defined duties; which duties the trustees, by accepting their office, become morally and legally bound truly and faithfully to perform,—at all events until the same authority that imposed them shall have thought fit to modify or annul them.

I have ventured to say thus much publicly to you, because the trustees have not unfrequently been made the subject of considerable misrepresentation. Sir John evidently desired to limit the examination of his collection to those only who studied architecture, either as professors or amateurs; certainly not intending to throw it open to indiscriminate view. That such was his intention is conclusively shown by the particular conditions which he so carefully imposed; and a trustee, like an executor, can by no means depart from, or even vary, a single condition laid down by the testator, without incurring the very serious charge of neglecting or exceeding the powers of his trust.

The museum, properly so called, will not engage our attention this evening. Those who have made themselves acquainted with its contents know that they are of a very miscellaneous character, comprising some objects of great value and interest, and some of a most trivial and insignificant nature.

It is to the library only that I am now about to advert, avoiding as far as may be possible such objects as exclusively concern the mere antiquary, inasmuch as the time at our disposal is very limited; and as the special purpose of these lectures is by the very constitution of the Academy confined to such objects as are calculated to further the professional education of the students. This same consideration excludes us also from adverting here to the rich stores of mechanical knowledge which are to be found on the shelves of this library.

That Sir John was perfectly aware of the high importance to every architect of a thoroughly practical knowledge of building is sufficiently apparent from the contents of his library, and was repeatedly dwelt on by him in the lectures which he delivered from this place. But it is to his books on architecture as a fine art that I am bound here to confine my attention, and it is certainly to the works of this character that the library owes its chief attraction, and from them it derives its chief value. It comprises nearly every architectural publication of value that appeared during his own professional career, down to the period of his death in 1837, as well as a large store of books of early date.

Among the earliest in the catalogue you will find Alberti's 'Libri decem de re Edificatoriâ.' Of this well known book there are here six editions, but among those I do not find the original and earliest Latin edition of 1512. A folio edition, in Italian and English, appears to be that which its owner read with greatest ease, as it contains many marginal notes by him, and other evidences of his having carefully read it.

On a former occasion I have from this place expressed my admiration of Alberti's works at Rimini and elsewhere. His church of San Francesco is in the best style of the early Renaissance, before it had degenerated into the commonplace manner of the following century. It is worthy of note, that Vasari touches but slightly and with some apparent indifference upon the work, although he must have been especially familiar with it, seeing that Vasari dwelt some time in Rimini. In truth, Vasari, excellent though he may be as a biographer, had as an artist but litle genius; and he was unable to appreciate the somewhat dry, antiquated manner of Alberti. That artist not only possessed undoubted talent as a practical architect, but remarkable merit also as a writer. His book is full of valuable remarks, and attests at once his good sense and his erudition. What is also specially worthy of our observation is that he appears in an eminent degree to have united a minute and accurate technical knowledge with a fine æsthetic feeling. The distinction which he draws between beauty and ornament is, I think, most just and true. "Beauty," he says, "is something lovely which is proper and innate, and diffused over the whole body; whilst ornament is something superadded, or adventitious rather than innate."

Alberti, and I might say Alberti's school,—the school of the early Renaissance,—well understood the distinction between beauty and ornament. The vulgar of all ages, countries, and ranks, are apt to think that ornament means beauty; and that in order to be beautiful we must needs be lavish in ornamentation. This great error leads directly to that excess which degrades art, whether it be architecture or her sister arts. It was excess which marked the decadence of Roman and of Mediæval art; and it was the disfigurement of excess which stained the purity of the early Renaissance.

I speak, as it is fitting and becoming that I should speak, with great reserve, and in the most general terms, when touching on the state of our art in the present day; but I think I am only fulfilling a plain duty in denouncing the tendency to a meretricious use of ornament, which may perhaps be discerned amidst the conflict and rivalry of prevailing tastes.

No doubt, in this country, the greatest diversity of feeling exists in matters of art. So impatient of all restraint is our countryman, that there is no privilege that he more freely exercises than that of differing from his neighbour in opinion;—and in taste, especially, we all proverbially and most widely differ.

Some will teach us that ornament alone is architecture, and that a building without ornament is but handicraft work, necessarily devoid of art, and beneath an artist's attention; whilst others will look with equal contempt upon all mere ornament as a frivolous and puerile inutility, altogether unworthy of any serious regard. I believe that in this case, as in most others, each of these extreme opinions is equally remote from the truth. At all events, I am confident that, however we may be led away by our imitative habits into occasional extravagances and unseemly excesses, the natural bent of the English mind is towards moderation in the use of ornament.

Flagrantly as we may sometimes err, and wild as may be the caprices we sometimes indulge in; still, in the main, the tendency of public taste is of a plain, grave, and practical character; and I am greatly mistaken if, when we regard—either on this side of the Atlantic or the other—the overloaded piles of enrichment which constitute the pretentious façades occasionally presented to us for our admiration, by far the majority of us fall

* Continued from page 114.

into the unimpassioned and calculating inquiry of "*cui bono?*" Not only does this excess offend, as it appears to me, the naturally simple taste of this country, but it is plainly at variance with the lessons daily taught us by our English climate. Moistness is the normal condition of our air, and clouds are the normal clothing of our sky. For at least two-thirds of the year our buildings are constantly liable to be drenched in rain, whilst for the remaining third they are subjected to the still severer trials of frost. And thus, in this matter, the dictates of common sense are in perfect harmony with the suggestions of our natural taste.

I perceive that the short and pointed sentence which I have quoted from Alberti has led me into a somewhat verbose diversion. In this respect I am failing to profit by the example of my author, whose style of writing is as free from verbiage and prolixity as his style of architecture is exempt from frivolous and intrusive ornament.

The next book which comes to hand is of a very different character. Indeed, one is sometimes almost led to feel suprise how books so widely asunder in their character and quality can submit to the close and constant juxta-position that they are subjected to on our bookshelves. The book, I say, which I now take up is that of Dietterlin's 'Architectura de Constitutione, Symmetriâ, ac Proportione quinque Columnarum,' published at Nuremburg, in 1598. It bears sad testimony to the rapid deterioration of art, and to a special proneness to a corrupt excess among our German neighbours.

In the extravagant and grotesque scrolls and cartouches which abound in this volume, we see at once from whence were derived the strange ornaments of our Elizabethan and Jacobite styles; although those styles, as displayed in our own country, might lay claim to the character of simplicity and sobriety by the side of these wild enormities of Dietterlin.

In a former lecture I expressed my belief that much of the degradation of architecture in the seventeenth century might be due to the practice at that period of the same individual pursuing all the three sister arts. Whilst any remnant of the purity of early art and of the good sense of the early artists survived, this combined cultivation of the fine arts was not attended by any evil consequences. On the contrary, the arts lent to each other that mutual aid from which they derived mutual advantage; but it was when the torch of genius had died out, and our art fell into decay, that the dangers consequent on this union began to develop themselves. When men ceased to understand the true scope of each art, and to recognise their respective limits, they lost the power of designing well in any art. The sculptor and the architect became merged in one artist, who was fain to build up his clouds and to construct celestial glories as if he was erecting a stone wall, whilst, on the other hand, he designed buildings wanting many of the essential attributes of real architecture,—buildings, indeed, that could only be made to stand by dint of ties and other hidden mechanical contrivances. The physical impossibility of executing in solid materials the architectural vagaries of Dietterlin, as exhibited in the designs before us, is sufficient evidence of his unfitness to design architecture. He seems to have been utterly regardless of the great fact that architecture is a constructive art, subject to static and dynamic laws. Far different was it in the good times of the previous century. I believe we may defy the most scrupulous critic to point out in any one picture of Raffaelle's, of Giulio Romano's, or of Michael Angelo's, a single building or fragment of architecture which might not with perfect facility be executed, line for line, in stone or timber.

I touch with great reserve on the confines of my neighbours, and should regard it as presumptuous on my part to affect the critic in the sister arts; but still I would venture to urge on the students of the painting school, that, in the architecture which they may deem it proper to introduce in their pictures, they should never be unmindful of the practicability of the structures they represent. It appears to me that it is just as incumbent on the painter or sculptor to give to his building a suitable and sufficient base, as it is to place his figures properly and naturally on their feet: the error of representing an impossible structure is, in its degree, just as great as that of representing a man in an impossible attitude.

I must, however, at once revert to the Soane Museum. I find on the shelves a volume of drawings, chiefly executed on vellum, described in its manuscript title as "Disegni di Architettura del Anno 1400." It is a curious volume, the history of which I know nothing, although of its authenticity, for various reasons there can be, I think, no reasonable doubt. The execution of the drawings is very indifferent, and, there is little attempt at correct delineation; and yet there is not wanting freedom and a certain amount of manual and almost artistic dexterity. The volume seems to do for the fifteenth century what Willars de Honicourt's book of drawings, recently submitted to the Institute of British Architects, does for the thirteenth century.

There are between sixty and seventy drawings, but none bear any titles, and they are probably original studies or exercises in architectural and ornamental design. A very little correction and modification would make some of these designs elegant compositions. I have upon a former occasion observed upon the absence of the regular orders of architecture in the early works of the Renaissance. This volume remarkably corroborates my statement. There is not, I believe, a single instance in the book of a dominant order determining the proportions of a building. Columns there are in abundance, and of a great variety of whimsical forms; but in all cases, I believe, each tier of columns and arches represents a separate floor. A constant use of arches and niches; a prevailing habit of panelling and enriching the panels with arabesques, as on the sides of square columns and pilasters; and a habit of covering all vacant spaces with square and circular panels and medallions, filled in either with slabs of coloured marble, or with foliage generally in somewhat flat relief;—these appear to be the prevailing distinctions of the quartocento style, which stands out with very marked difference from the style immediately preceding and succeeding it.

Another book which I must not pass by is a fine copy of the earliest edition, "Philiberte de l'Ormés Architecture," bearing date 1567. Under the auspices of Catherine di Medicis, he may be regarded as the introducer of the Renaissance into Northern Europe. She came of a race eminently distinguished in the history of art; and the author in his dedication eulogistically refers to her as delighting in architecture, and as sketching with her own hand the noble palaces which she caused to be erected.

It is curious to find at this early period the author groaning over the degeneracy of his profession, and complaining how few *true* architects there *then* were. Some self-styled architects were, he says, but mere "master masons;" whilst others were but geometricians, or men addicted to the literature, but neglecting the practice, of their profession. His imaginary portraiture of the beau-idéal of an architect savours of the quaint, allegorical taste of his time.

He would represent an architect, he says (and there is an illustrative diagram of such a man), with three eyes;—one, for the observation of divine things and the works of God; the second, for the careful observation of things present and around him; and the third, for looking into the future, foreseeing, and so providing against, coming evils. He should also have four ears, indicating that it more behoves him to listen than to speak. Four hands should be given to him, that he might be the better able to do all that is required and expected that he should do; whilst his feet are to be winged, pointing out that he must be of quick intelligence and rapid in action. There are many other things worthy of observation in this curious volume, but I must hasten on to others.

I find a volume of original drawings by Carlo Fontana, formerly in the library of Paine, an eminent architect of the last century. It represents the state at that period of the Coliseum at Rome, and Fontana's supposed restoration of it, with his suggestion, certainly not a happy one, for the erection of a church within the area of the amphitheatre, to be dedicated to the Christian martyrs who suffered there. I need scarcely say that this monogram on the Coliseum is greatly inferior to that unpublished work on the same subject existing in the British Museum, to which I directed your attention last week. These drawings of the seventeenth century, by Fontana, are very neatly and ably executed, quite free from the dry, hard manner prevalent among architects at a later date. The lines are in brown, and the shadows delicately indicated with a cool, neutral wash, probably Indian ink, or some colour equivalent to it. This mode of execution was retained throughout the last century, for I find here a large folio volume, containing original drawings by Wren and others of his time, which are all similarly treated. Some also in the volume attributed to Inigo Jones are so executed.

The use of a brown outline with cool shadows was, I believe, pretty general among English as well as foreign artists, up to quite recent times; and it is perhaps doubtful whether the modern substitution of brown sepia shadows, with Indian ink outlines, can be regarded in any respect as an improvement.

Among the treasures which Sir John considered to be worthy of a place in the strong room of his museum, I find a Roman missal of the early part of the sixteenth century, illustrated with miniatures of the greatest delicacy by Lucas von Leyden and his scholars. It is worthy of remark that all the architecture and ornamentation with which these miniatures are elaborately enriched are throughout very distinctly Gothic in style; late, it is true, but without any admixture of Classic taste; and yet this artist died in 1533, and was therefore contemporary with Raffaelle and Giulio Romano. The co-existence of two schools so remote in character and spirit, yet geographically so near, as Flanders and Italy, shows how little social intercourse could have existed in Europe at that period. Whilst admitting his merits and superiority to others of his school, Lucas von Leyden is described by Fuseli as "ignorant of light and shade in masses;" and his forms are condemned as "lank, meagre, and ignoble;" and yet this artist was studying and painting within what is now a day or two's journey from the easels of Leonardo da Vinci, Michael Angelo, and Raffaelle.

There are, I trust, few here present who are not aware of the beautiful work preserved in this same strong closet, known as the 'Commentaries on St. Paul's Gospel,' by Marino Grimani, illustrated by the beautiful illuminations of Giulio Clovio. This work, certainly the gem of the collection, presents a curious contrast in its architectural accessories with that to which I have just adverted. The style is strictly Raffaellesque, with medallions and arabesques such as we see in the loggia of the Vatican. I cannot pass from this magnificent and almost priceless manuscript volume without adverting to the elegant character of the handwriting. When we look upon the beautifully uniform, clear, well-proportioned, deliberately shaped, and, I would almost say, dignified style of the lettering, and compare it with the caligraphy of the nineteenth century, in which the words look often more like the hasty unmeaning scratches of a bad pen than the expressions of a man's thought and sense, it must be admitted that the lapse of three hundred years has brought, in this respect at all events, no improvements whatever. Nor perhaps can this be wondered at, when we find, as that eminent scholar Mr. Panizzi has lately proved, the great Bolognese painter, Francia himself, did not think it beneath him to unite the study and practice of typography with the highest efforts of a most gifted pencil.

Descending now 100 years, we come to the sketch-book of Inigo Jones; not the original book, it is true, but an admirable fac-simile of it, presented to Sir John by the late Duke of Devonshire, the owner of Inigo's own handiwork. It is not for me to dwell on this sketch-book, as it consists exclusively of studies of figures and drapery. The book bears date at Rome in 1614, when the great architect was about forty years old. I cannot refrain here from adding that the motto which graces the first page of this sketch-book is "*Altro diletto et 'imparar' non trovo*" (I have no pleasure but in acquiring knowledge), a sentiment which does high honour to Inigo Jones, and one which should never be absent from the mind of an artist, be he young or old. When a man has reached the period at which he imagines that he has learnt his art, and needs no more teaching, he may rest assured that he has fallen fully into the sear and yellow leaf.

In an evening devoted to the literary bequest of Sir John Soane, it seems natural that I should not altogether abstain from touching, for at least a few minutes, upon that eminent professor's own peculiarities of architectural design. Although within these walls we very wisely abstain from the remotest criticism on the works of contemporary artists, that salutary limitation has long ceased to exempt Sir John's works from the free comment of the critic. Upwards of a quarter of a century has passed away since his death. I have, however, no inclination nor intention here to use the lash. I would but remark, generally, that a constant endeavour to seek out picturesque effects, especially in the design of interior architecture, seems to have led to much of that eccentricity of manner which most critics are inclined to condemn in his works; although it may be found to have resulted in some ingenious combinations, and perhaps occasionally in some original conceptions.

We are apt to attach too great value to that quality, "the picturesque." The application of the word is somewhat vague. It is a word of no very remote origin; for there exists, I believe, no word of equivalent value in any classic tongue; and, certainly, there is no trace of any word calculated to convey the idea in the written records of mediæval times,—a fact which is perhaps the more remarkable, as the quality which, probably more than any other, characterises mediæval art is this same picturesque. To the best of my belief, this word was the invention of the writers on art of the period of the Renaissance. Its primary meaning is clear, although its application is, as I have said, vague and indefinite. Whatever is especially well adapted for representation in a picture is said to be "picturesque." In that sense its special applicability to natural scenery is obvious; but it is also very properly applicable to those objects of art which, either from their form or colour, or from the combination of forms or colours that they may present, are particularly capable of being agreeably represented in a picture. Thus, an old or ruined building is usually more picturesque than a perfect and new one; for there is a hard dryness in straight lines and sharp angles, and a crudeness, and almost harshness, in bright colouring, which cannot by the exercise of any amount of ingenuity be made so pleasing to the picture-loving eye as those more undefined lines and blended tints which almost necessarily characterise a ruin. It is finely said by Byron—

> "There is a power
> And magic in the ruined battlement,
> For which the palace of the present hour
> Must yield its pomp, and wait till ages are its dower."

And a somewhat similar idea is expressed by another poet—

> "Time
> Has moulded into beauty many a tower,
> Which, when it frowned with all its battlements,
> Was only terrible."

There is also a fruitful source of the picturesque in those combinations or compositions of lines of which the result is an ensemble or group of forms pleasing, though we know not why they please. To dwell on the picturesqueness of mediæval art would be superfluous, and, indeed, trite; for picturesqueness is, as I have said, the special and appropriate quality of that style of art; the groups of towers and pinnacles, and gables and chimney-shafts, which characterise it, are the very embodiment of the picturesque.

I think it may be more useful to you to point out for your observation how that far simpler and less pretending forms are susceptible of this attractive quality when treated by the hands of an artist. It is impossible to stray over that land of art—Italy—without meeting at every turn with plain farm-buildings, ordinary lodges—nay, sheds and gateways, of high æsthetic interest. Not that they have been purposely so designed to please, but the old Italian mind seems to have been so thoroughly imbued with artistic feeling, that they could not help imparting it to every common object they touched. Vague and difficult of precise definition as this word "picturesque" is in the painter's art, when applied to architecture it is certainly still more vague. We may readily enough say that monotony, uniformity, and severity of outline are opposed to the picturesque; and that freedom and absence from restraint and variety of outline are circumstances favourable to, and consonant with, the picturesque. Yet to say that these latter circumstances are essential to its existence, or that the former are unreservedly incompatible with it, would be going a great deal too far.

Can we, for example, venture to say that the Doric temple of Minerva at Athens is not picturesque? Yet symmetry and severity of outline are its special characteristics.

So in an ordinary modern London street we may find entire absence from restraint, and a superabundant variety of outline; for every man builds as he likes, and so variety is carried even to excess; yet no one will quote Oxford-street or Fleet-street, on that account, as furnishing examples of picturesque architecture. In truth, I apprehend that this very favourite but somewhat unintelligible word must be classed with the adjectives, "grand," "beautiful," and such like; words which address themselves rather to the feelings than to the judgment. Hence it arises that in architecture picturesqueness is a very dangerous object of ambition; for, if it be sought for by those who cannot feel it, there would be imminent risk of their running into ridiculous conceits. Their abortive attempts at the picturesque seem to have the same relation to really and truly picturesque compositions that nonsense-verses bear to real poetry. Each may present the requisite combination of long and short syllables, and the legitimate number of them; but the one is empty and unmeaning, whilst the other may perchance be fraught with sense and genius.

Even among men who may really have some true feeling for the picturesque, there are those to be found who have a sort of maudlin love of it; leading them to an extravagant and morbid craving for it, to such an extent, I believe, as sometimes to affect even the religious faith of those who abandon themselves to it. There are those who can scarcely say their prayers with warmth and sincerity, unless assisted by such helps to devotion as the architect or decorator may be able to afford; "the dim religious light," the "storied window richly dight," and the hierarchy of gilt and painted saints. It may be uncharitable to doubt the reality of feeling of such devotions; and we are here all of us too well acquainted with, and too much alive to the influence of the fine arts upon the mind and heart of men, to doubt their power of fostering a genuine religious sentiment; such an influence is, indeed, one of their most legitimate and salutary effects. But every virtue has its sham,—there is the courage which needs a dram to call it into existence; there is the charity which owes its birth to ostentation; and there is, as I have already intimated, the religious sentiment which needs these external melodramatic appliances to stimulate it into active existence: its votaries need a picturesque architecture, and even a picturesque costume, for their sustenance; otherwise there is reason to fear that their pious zeal might wane and wax faint.

These, however, are but examples of a false and counterfeit feeling. Men's minds are curiously and variously affected. There are some more deeply affected by contemplating the lowly, unambitious village church, wholly wanting the attractions of sculpturesque art, than by gazing up at those vast petrifactions of religion which have awed so many generations of worshippers.

Still, I repeat it, there is no denying the wide prevalence of that influence which architecture exercises, be it evidence of human frailty, or of the potency of art; and it seems a very legitimate exercise of the witchery of art to practise those cunning devices by which she can be made to elevate the mind or touch the imagination. It is in truth the special province of the fine arts to do so. The kindred arts of poetry, of music, and of painting, have in all ages asserted their dominion over the mind of man; and have claimed to bring even his enlightened intellect within the sphere of their potent spells. Surely then, architecture neither abdicates its proper functions, nor forfeits its character for utility, when it aims at exercising over the mind the like mysterious influence.

But if it be true that such power belongs to our art, it behoves all who practise it to regard that power as a sacred trust, and not to risk its character by exercising its influences improperly. After all, I believe that the most legitimate and the most wholesome exercise of the power of art is that which is inspired by truthfulness of character. I do not mean that the brewhouse or the laundry, when unavoidably forming part of the landscape, may not most legitimately have their homely domestic uses veiled under some more pleasing forms than those afforded by the undisguised smoke-flue or the ventilator; but in buildings demanding architectural character I am confident in the opinion that, by giving to each the expression that most befits it, we secure for it at least the one great merit of truthfulness of character. The tale that is most truthfully told is usually that which most affects us; and although it is not to be desired that the conventional forms and structural necessities, which an architect has always so largely to contend with, render it vain and futile to attempt to give a building all the expression of which the painter's or the sculptor's work is susceptible; yet our art would little merit the position which it is admitted by all to hold as a fine art, were it unable to affect the imagination, and, to a certain extent, the passions. It is, I apprehend, more than a mere figure of speech to say that a building frowns on us or smiles on us, or that it appears to attract or repel us. There is in one building a majesty that subdues us, in another a levity that even amuses us. There are some buildings of so festive a character, that in their very aspect they appear to sympathise with us in our joy; whilst others, on the contrary, are of an aspect congenial with an opposite tone of mind.

These are the qualities which constitute character in architecture; and therefore, as I have said before, so do I repeat now, the character of his work should ever be one of the chief studies of an architect. But I perceive that Sir John's aspirations after the picturesque have led me into too long a digression.

There are other peculiarities in his works on which I need not especially dwell; for whatever may have been his faults, they have not been imitated by others, and have not therefore influenced his successors either for good or evil. There were so many of these peculiarities or eccentricities in his manner of designing, that I am inclined to believe that he was ambitious to found a style of his own. Without perhaps venturing to go so far as to condemn altogether any such attempt, I would at all events say, that to found an original style of design in architecture would be a task demanding a very high rank of genius; and it is an enterprise which I certainly counsel no man to undertake. I believe it was some vague and weak ambition of this nature which led Mr. Dance to conceive and execute so unfortunate a design as the front of the Guildhall of London. There is a tradition that such was his aim. He sought to produce a kind of cross between Gothic and Classic art; and the result was certainly not such as to tempt imitation, or to enhance his fame.

I am convinced that no novel manner of designing which has deserved to be dignified with the designation of a *style* was ever the production of any one artist. It has ever been from the force of circumstances that styles, in one art at least, have gradually taken their rise. I need scarcely point out to you how greatly collateral circumstances and accidental and local peculiarities have, at all times and in all countries, influenced the changes of style that have taken place in architecture. Of this, however, I took occasion in a former lecture to point out to you various notable instances, and many others might readily be adduced.

One of the ablest, as well as one of the most recent writers on the subject of the so-called Gothic architecture, M. Viollet le Duc, points to the use of small-sized stones as one of the special characteristics of that style; and nearly 200 years previously our own Sir Christopher Wren had made exactly the same observation. Both these writers point out how materially the style was modified and influenced by that practice. In the middle ages there were few good roads, and this rendered the cost of the transport of stone proportionately high; a cost still more seriously augmented by the inordinate tolls, private and public, then so often and so extensively, on some pretence or other, levied by the landowners, whether lay or ecclesiastical, through whose demesnes or territorial limits the stones had to be conveyed to their destination. These causes of expense operated to so great an extent as to render the materials used in a building usually much more expensive than the labour required in working and setting them. Moreover, the want of regular employment for men in those times, and the consequent low scale of wages, rendered labour a comparatively unimportant part of the cost of a building. From hence a state of things arose exactly the converse of that which exists at present, when the mason is often better paid than the clergyman; and when canals, railroads, and machinery have reduced the cost of getting and carrying heavy building materials to a small fraction only of that which prevailed in Mediæval times. The former state of things naturally led to, perhaps, nearly all the peculiarities of the prevalent style of building. There was a lavish expenditure of labour in deep undercuttings and perforations, and the intricacies of every kind which above all things distinguish Gothic work, and which are, in truth, essential to the full and complete development of it. At the same time, the cost and difficulties of the transit of freestone naturally caused the use of it in small blocks, as observed by Wren and Viollet le Duc,—a result which of course tended to encourage those very intricacies and delicacies which characterise Gothic carved work in general. Each boss and badge and crocket was usually a distinct stone; the capitals of the very largest pillars and piers were built up in courses of very moderate depth; each course of stone composing a distinct and independent band or tier of foliage or other ornamentation, whilst the shafts of columns, even in the largest structures, were for the reasons I have adduced usually of diameters measuring but a few inches.

In making these remarks I am very anxious not to be mistaken as making them with any view, in the slightest degree, to the disparagement of any special style. My aim is to show that, as the manner of building has always greatly depended on the particular circumstances of the time or the place, and as every phase of art has varied with the variation of circumstances, it seems as useless as, I think, it would be irrational to expect permanently to bring back architecture identically to any one past phase of the art, unless we can resuscitate and bring about again all the concomitant circumstances to whose influences that phase was due, and restore to it its special character,—a resuscitation which, I think, we may regard as of necessity impossible.

At all past periods of our art every style has, in short, been the type of its own age, the result of that particular period which gave birth to it. The Byzantine style, for example, was the result of the grafting of an Oriental element on the Classic stock at a particular period of its existence. Had Byzantium succumbed to the West at an earlier stage of Classic art, the resultant style would probably have assumed a very different aspect. Again, had not Peter the Hermit preached the Crusades at the particular period when a great æsthetic energy was developing itself in some parts of Europe, the aspect ultimately assumed by Mediæval architecture might, perhaps, have been very different from that which in fact prevailed. It is the stage of civilisation which a people may have reached, and the condition they may happen to be in, that determine the effect upon the arts of any great historical event. To expect, therefore, to revive successfully in its integrity any style of art, under circumstances wholly different from those which gave birth to that style, would be to entertain an expectation inconsistent with the experience of all past time.

We may very easily repeat to any extent the examples of any period we may fancy: but such repetitions, although it is occasionally,—indeed, far to often,—the fate of an architect to be called upon to produce them, are mere travesties, artistic whims, so to speak, the relish for which on the part of the public taste is by no means indicative of a well-founded or sincere love of art; but suggestive, rather, of the caprices of an unformed, puerile taste, which takes up or tosses away a style as a child would its toys, just as the fancy of the moment or the caprices of fashion may dictate. I have thought it well to say so much, even at the risk of being reminded, perchance, that I am but repeating what I may already in another form, and on some former occasion, have ventured to say.

I am anxious to urge upon you, with all the emphasis I can command, that the modern tendency to repeat and perpetuate old forms, and thus to live, as it were, upon the wits of our predecessors; or, I might say, to feed upon the *réchauffées* of the past; is a mischievous tendency when carried to excess, destructive of progress, and leading inevitably to debasement. I would not, then, have you to look with indiscriminating reverence on the architectural productions of past times: let those productions be ever judged with reference to their age, and to the contingent circumstances of their existence.

In many respects the present age with justice may lay claim to the merit of having advanced as time has advanced. It has with truth been said, that such has been the moral advancement of education and intelligence, that a poor child in a Sunday-school is in some respects better informed than the sages and philosophers of antiquity; and certainly much of what was called science by our forefathers has proved to be but foolishness. Nevertheless, we must admit that no such progress appears to have been made in æsthetical culture. Excellence in that branch of moral cultivation would seem to be independent of those circumstances on which excellence of most other kinds depends, and to follow some different law. On a former evening I adverted to the apparent anomaly, that in the twelfth century, at a time when all Christendom was wrapped in the grossest state of moral and social tyranny, at that very period there existed in France a school of art which was then commencing to produce works which may at the present day be regarded as equal to those of the best days of antiquity.

Again, sculptors, as well as architects, are now in the nineteenth century, endeavouring to rediscover the oldest principles of art; and to emulate, although *longo intervallo*, the works of artists who lived twenty-four centuries ago. We may seek illustration, too, in still another quarter. In Arabia a faith sprung up in the seventh century which deluged Europe with blood, and tended to inculcate a gross sensual system,—a faith which has raised the most formidable barriers against the moral improvement and civilisation of mankind; yet it was to the followers of that very faith of Mahomet that we owe some of the most graceful works that architecture has yet produced, as well as one of the most beautiful styles of ornamentation that human taste or ingenuity has yet devised. In short, we get bewildered in a labyrinth of contrareties when we seek to assign the sources from whence has arisen that perception of beauty which constitutes fine taste.

However charmed, therefore, we may be by those manifestations of genius which past times afford us, our reverence for them need not be indiscriminate. We should endeavour to search out what is beautiful and worthy of our admiration and study; uninfluenced, as far as as our weak nature will permit, by local, national, or sectarian prejudices.

It is from the high vantage ground of modern civilisation that we should pass in review before us the work of all preceding time, and of every creed and clime; not, however, by any means with a feeling of self-satisfaction or assumed superiority—for he must be, indeed, in a hopeless state who is not fully sensible of the inferiority of the present to the past in very many respects—so far, at least, as art is concerned; but rather let a due reverence for the works of past times be mingled with a sense of gratitude that so rich a storehouse of experience has been laid up by them for our use and benefit; and let us demonstrate our thankfulness by devoting all our energies, not to a dry, antiquarian, pedantic imitation, but to a painstaking endeavour to improve ourselves by searching out and studying those principles which may appear to have led artists of past times to so great excellence. Principles, remember, never change. To adopt, in conclusion, the language of a former eminent president of this Academy—language which, applied as it was to his own particular branch of art, seems, nevertheless, equally applicable to all art—"There may," he says, "be new combinations, new excellences, new paths, new powers, but there can be no new principles in art." It is to the exact understanding of these, therefore, that our best energies should be directed.

INSTITUTION OF CIVIL ENGINEERS.

March 18 and 25.—The paper read was *"Description of the Works at the Ports of Swansea, Silloth, and Blyth."* By James Abernethy, M. Inst. C.E.

The author stated that he proposed to give an account of the past and present history of these ports, so far as it possessed engineering interest, and to describe the works connected with them, rather with a view to the elucidation of general principles, than of entering into matters of detail.

The port of Swansea was situated in the centre of an extensive bay, at the embouchure of the river Tawe, up which the tide flowed for a distance of three miles; but as the ordinary flow of the river was trifling, the maintenance of the channel was chiefly dependent upon the ebb and flow of a large body of tidal water between the piers. Previous to the year 1791, there were only a few insignificant wharves near the mouth of the river, and there was a bar at the entrance over which the depth of water did not exceed from 16 to 17 feet at spring tides. The effect of the construction of the piers, which still remained as they were completed in the year 1800, from the designs of Captain Huddart, F.R.S., had been to lower the bar and to drive it further out to sea; so that in 1831 the depth of water had been increased to 20 feet. The eastern pier was 1340 feet, and the western was 580 feet, in length. The author then alluded to the report submitted to the Harbour Trustees by Mr. Telford on the 5th of February, 1827, in which he recommended that the old and a proposed new channel of the river should be converted into floats;—as well as to the opinions of several other engineers, including Mr. Jesse Hartley, who, in 1831, suggested that a new cut should be made for the river, which was to be "canalised" by the construction of a weir across the mouth, and that the town reach should be appropriated to a dock and half-tide basin. In the following year Mr. Hartley, in a further report, adhered generally to his former plan, but advised, in addition, the deepening of the harbour by dredging. Fortunately, in the author's opinion, the works for the "canalisation" of the river were not carried out. A new channel was, however, commenced in 1840, and completed in 1844, at an expense of £23,000. Its effect had been to lessen the risk to shipping, and, by giving a better direction and greater force to the outgoing current, to improve the navigation. In 1845, Mr. Rendel was consulted as to floating dock accommodation; and under his direction the construction of an entrance with a double cill was proceeded with, as a preliminary step to the conversion either of the river or of the town reach into a float; but of this work the masonry alone was executed.

In his first report to the trustees, in February 1849, the author proposed the formation of a dock on the site of the town reach, or old bed of the river. It was subsequently determined to construct a dock and half-tide basin, of the respective areas of 11 acres and 2¾ acres; with a lock entrance to the dock, 160 feet long and 56 feet wide, and an entrance to the half-tide basin, 60 feet in width, having a depth of water over the cills of 22 ft. 6 in. and 25 ft. 6 in. at high-water of ordinary spring tides. A small lock connected the Swansea canal with the float, and another, at the head of the float, communicated with the various works on the banks of the river above. A small dock leading from the float, with an extensive range of warehouses round its margin, was also constructed at the same time, for the Duke of Beaufort. The works for the lock and float were commenced in November 1849, and completed in December 1851; those for the half-tide basin were begun in 1856 and were finished early in 1861. The total cost of these works, exclusive of the quay walls, had amounted to £95,688. In addition, the lower portion of the river to the pier heads was straightened, and both it and the new cut were deepened by dredging. By these means the depth of the entrance channel had been increased 4 feet since 1850. There was nothing peculiar in the construction of the works, but their execution was attended with some difficulty, as a large portion had to be performed by tide work, with as little interruption as possible to the trade of the port. The foundations varied from hard concreted gravel to soft sandy clay, extending to a considerable depth.

The most important work connected with the port of Swansea was the range of floating dock accommodation called the South Dock, which was formed on the foreshore of the sea beyond high-water mark. An act was obtained, in 1847, for the construction of this dock, according to a design furnished by Mr. T. Page, M. Inst. C.E. In 1850, the author was requested to make the necessary plans for a trumpet-mouth entrance basin, having an area of 3 acres; for a half-tide or outer dock entrance, 70 feet in width, with a single pair of gates, having a depth of water over the cill of 24 feet; for a half-tide basin, or outer dock, containing an area of 4 acres, with a depth over the cill of 25 ft. 6 in.; for an entrance lock, 300 feet long and 60 feet wide, divided by intermediate gates so as to form a greater or smaller lock, with an average depth over the inner cill of 22 ft. 6 in.; and for a dock having an area of 13 acres, with a depth of 24 feet. Considerable progress had been made with these works, when they were suspended, in 1855, for want of funds. They were resumed in 1857, and were completed in 1859, at a total cost of £169,073. One of the first operations was the formation of an embankment to exclude the sea. Careful observations showed, that the main action of the sea and the set of the tides were to the eastward, towards the Mumbles headland. It was therefore decided to construct a series of timber groynes, at intervals of 1500 feet, extending from the shore to the line of the proposed embankment. Rough boulder gravel, found immediately under the sand and the made ground, was tipped between the seaward-ends of the groynes, until a shingle beach of great depth was gradually formed which served as a face to the embankment, and proved an effective barrier to the encroachments of the sea. The centre of the embankment was composed of the clay and peat found in the excavations, so that something like a puddle dyke was formed, and very ordinary means were sufficient to keep down the accumulation of water within the works. When the sea embankment had advanced some distance, the masonry of the dock walls was proceeded with. These walls consisted of rubble, with coursed rubble facework to a height of 2 feet below the general level of the surface of the water in the dock. They were faced in the upper part with ashlar, projecting 3 inches beyond the rubble facework. They were backed with the lightest and driest material that could be procured, in layers forming an angle from the wall; and rubble drains, with pipes for carrying off any spring or upland waters, were placed at intervals in the walls. In no instance had any failure taken place, although the walls were subjected to a severe test; inasmuch as they were nearly completed when the works were suspended, and on their resumption, the dock and outer basin were found to have become filled with water. Details were then given of the lock and entrance, from which it appeared that they were constructed generally with elliptical inverted arches of rubble, the quoins and floors or platforms being of sandstone ashlar, obtained from the coal measures in the neighbourhood. The pointed cill stones and the hollow quoins were of greenstone and syenite, from the Carling Nose and Barnton Mount Quarries, near Edinburgh. The cill stones were carefully toothed and bonded into the floor stones, so as to avoid a long straight joint. The recess and side walls were of rubble, with ashlar facework in the upper portion similar to the dock walls, but the wing walls were faced throughout with ashlar. The filling and discharging culverts were of brickwork. The sluice frames and paddles were of cast iron, faced with brass. In the lock and entrance gates, the heel mitre posts and the lower rib were of the best teak and English oak, and the ribs and planking were of pitch pine. Across the lock there was a swivel bridge in one leaf, consisting of two wrought iron tubular girders, with a superstructure fitted for railway or road traffic. There being no backwater, the waste from lockage was supplied by a steam centrifugal pumping engine of 24 H. P.

The successful application of hydraulic power for working the usual hand gear at the float lock, and at the lock at Newport dock, with much heavier gates, determined the author to adopt the same plan at the new dock entrance, as in case of any accident happening to the hydraulic machinery the usual means were then always available. As it was of the utmost importance in the shipping of Welsh coal, that as little breakage as possible should take place, the hydraulic drops, or hoists, were so constructed as to deliver the coal into the hold of any class of vessel immediately at the hatchway; allowance being also made for the difference in size of the broad-gauge coal waggons, the weight of which varied from 14 to 19 tons. The various machines employed for opening and shutting the gates, bridges and sluices, for working the capstans, for discharging ballast, and for loading coal, as well as for the shipping and discharging of general cargoes, were upon Sir William Armstrong's hydraulic system, having accumulators equivalent to an effective pressure of 750 lb. per square inch. High pressure direct-acting steam engines of 80, 30 and 12 horse power were used at the Swansea Docks; the distribution of power being regulated by self-acting arrangements in connection with the accumulators, apportioned in each case to the powers of the machines at present erected. At the float lock, each line of shafting was driven by a small water pressure engine placed near the middle, but owing to the length of the lock at the new dock, and other minor circumstances, the line of shafting was broken, and was driven by two separate hydraulic engines on each side of the lock. The time employed in opening or in closing the gates was about two minutes and a half, which was as great a speed as could be adopted with safety to the gates. The sluices were worked direct by a piston and plunger placed immediately above them. The wrought iron swing bridge was turned in and out by means of two hydraulic cylinders acting in opposite directions, and attached to a drum beneath the bridge by means of a chain. The bridge could be opened or shut in one minute and a half. The ballast cranes were each capable of discharging from 350 to 400 tons per day. Coal was brought up for shipping on two distinct systems. In one it was carried in end-tipping waggons, and in the other in wrought iron boxes with false bottoms, each holding 2¼ tons, and four being placed upon one truck. About 1000 tons per day could be shipped by each machine; and both could deliver the coal on board at a faster rate than the 'trimming' in the hold of the vessel could be accomplished. The machine for delivering the coal from boxes was placed above that for discharging the end-tipping waggons, and both were commanded by one man. By this combination, a cone of coal could be formed in the hold of the vessel, by lowering the boxes through the hatchway, and then, upon this cone, the remainder could be delivered from the shoot in connection with the waggon-tipping arrangement. Details were then given of the mechanism by which the hoists were worked, from which it appeared that when a loaded waggon was run on to the rails of the tipping frame, the cradle on which it rested was either raised or lowered to the level of the shoot, as might be necessary, having a range of 21 feet for that purpose. The catches of the waggon door were then knocked out, and the pressure applied to the tipping frame. The empty waggon was brought back to the point where the rails of the traverser on the cradle and the staith met. The catch securing the traverser to the cradle was then liberated, and the waggon was allowed to run down to the return line, on to which it was pushed. The traverser was next hauled back to the cradle by a ram, and lowered to the point defined by self-acting stops, where the full waggons were taken on. The system pursued in discharging from the boxes was then minutely described.

With respect to the work performed by the hydraulic machinery, and its cost, it seemed that, during the year ending October 1860, the actual expenditure for engine power had been £22 16*s*. 1*d*. per week, or at the rate of 0·26 of a penny per cubic foot of water used for pressure. The cost of working was, by the cranes 9-10ths,—by the combined drop 5-10ths,—and by the waggon drops 4-10ths of a penny per ton. But inasmuch as the engine power was never fully employed, this statement must not be received as conclusive, as regarded the capabilities of the machinery. With the 80 H. P. steam engine, it was believed that 100,000 cubic feet of water could be pumped per week, at a cost of £30, or at the rate of 0·072 of a penny per cubic foot of water; and that of this quantity 80,000 cubic feet would be available for working the cranes and the coal drops, at a cost for the hydraulic power alone of about one farthing and one-seventh of a penny per ton respectively.

The commercial effect of the construction of the dock works and of the general improvement of the harbour was shown by the great increase in the tonnage of vessels frequenting the port. In 1851, on the completion of the first, or north dock, this amounted to 269,454 tons only. In 1860 it was 582,355 tons, and during the year 1861 the foreign tonnage had increased 10 per cent., and the trade was likely to extend, owing to improved communications with the steam coal and the iron-producing districts, as well as with the heart of the kingdom.

As a detailed description of the works constructed at the entrance of the port of Blyth had already been communicated to the Institution by Mr. M. Scott, M. Inst. C.E., the author only alluded to the change which had taken place in the condition of the channel since the year 1854. It was then exceedingly tortuous, in many places dry at spring tides, and the entrance was obstructed by a spit of sand. As the channel ran for its entire length parallel with a lee shore, exposed to the direct action of north-easterly seas, scarcely a winter passed without vessels being wrecked on the beach on the southern side. To remedy these evils, an eastern breakwater, 4500 feet in length, and a western half-tide training wall, 4000 feet in length, had been constructed, and the channel had been straightened and deepened by dredging, at a total cost of £67,320. In designing these works, the author was guided by experience obtained at Aberdeen harbour, the entrance to which was similarly situated. The result of the construction of the works at Blyth was, that the outgoing current had been increased to a velocity of 5 knots per hour at its greatest strength, whereas formerly it was lost immediately on passing the line of the foreshore. The bar, or spit of sand across the entrance, had been entirely removed, and there was now a depth of 8 feet or 9 feet at low water immediately opposite the breakwater. The depth throughout the channel had been increased 4 feet, and vessels, after passing the breakwater, were effectually protected from the action of north-easterly, or onshore gales.

In the year 1854 an act was obtained, after considerable opposition in Parliament, for the construction of works at Silloth, on the Solway Frith, the general design of which was stated to be due to Mr. John B. Hartley, M. Inst. C.E., although the direction of their execution was entrusted to the author. The works comprised a pier or jetty, 1000 feet in length, on the seaward side of the dock entrance;—an entrance channel parallel with the jetty, 100 feet in width at the bottom, which was generally 16 feet below the level of the adjoining beach, with side slopes of 6 to 1, and a fall of 2 ft. 6 in. in its entire length;—an embankment on the foreshore, projecting 400 feet beyond high-water mark, and inclosing the entrance to the dock, which was 60 feet in width, with a depth of water over the cill of 24 feet at high-water ordinary spring tides;—and a dock containing an area of 4 acres, with a depth of 25 ft. 6 in. A general description was then given of the principal peculiarities of the tidal and other features of the estuary. The navigation at Silloth Bay had remained unchanged for a long time, and the anchorage within it afforded good holding ground, and was sheltered by sandbanks from the action of heavy westerly seas.

The objections which were urged against the scheme were then stated, and contrasted with the results which had followed the completion of the works. It was considered that the flowing current might be deflected to the English side, and would there form the principal navigable channel; and it was believed that, if a training work was constructed below Annan Point, accretion would take place on the upper part of Powfoot Sand, and a constant navigable channel would be maintained from Annan to Silloth. The works indicated that great care must be exercised in projecting solid moles from the foreshore of an estuary on any sandy coast, as an entrance to ports. The sea channel formed inside the jetty had proved successful, and its maintenance was no longer a matter of doubt, as the depth and the sectional area remained the same as on its first formation two years back. With respect to the construction of the docks, by the aid of wells sunk on the site of the works, and a moderate degree of pumping power, the sand and gravel of which the excavation consisted were drained, and by the aid of sheet piling and concrete no difficulty was found in making good foundations.

The entrance gates, cranes, and coal hoists were worked by hydraulic machinery, similar to that at Swansea and at Newport, except that the coal hoists were exceptional, and deserved special notice, as involving the question of the relative capabilities and advantages of a high or low level system for loading coal. The author believed, that although there might be situations where the former system must be carried out, yet that at such places as Silloth and Newport the low level system was superior, both for convenience and economy; as the cost of high level erections was avoided, siding accommodation could be afforded with greater facility and at less cost, while the quays were unencumbered, except by the spaces required for the hoists. The quantity of coal that could be put on board was only limited by the amount that could be trimmed in the hold of the vessel. The cost had been found to approximate to that at Swansea, one farthing per ton. The hoists, which were constructed to receive both tipping and hopper waggons, were then minutely described, and it was stated that the total cost of the works which had been executed at Silloth from 1856 to 1859, had amounted to £122,000.

April 1.—The first paper read was on "*Railway Accidents,—their causes and means of prevention, showing the bearing which existing legislation has upon them.*" By James Brunlees, M. Inst. C.E.

The author proposed to treat the subject by dealing with the facts as they were, the causes of accidents being in nearly all cases sufficiently apparent; he would not therefore attempt by theory to establish rules for their prevention. From the reports of the officers of the Board of Trade it appeared that, during the seven years from 1854 to 1860, the number of accidents amounted to 540, as the result of 1274 distinct causes. Of these accidents 11 per cent. were attributed to the permanent way, 7 per cent. to the rolling stock, and 76 per cent. to the management, including insufficient means for securing safety, leaving only 6 per cent. as not ascertained.

The accidents due to the permanent way were then referred to in detail, and it appeared that the general defects were most evident in the system of ballasting, of joint-fishing, of turning the rails, and of fastening the chairs to the sleepers. With regard to the ballast, it was argued that it would be found economical to have at least 6 inches, or 9 inches of rough gravel, or broken stone, as a free draining bed to the sleepers and to the "top dressing;" and that, during the months of September and October, an extra number of men should be employed to drain the ballast and beat up the road, in order that it might become consolidated before the winter's rains and frost set in, and thus avoid the evil effects of frost on wet ballast. It was urged that the plan now in general use, of placing the fish-joint between two sleepers was objectionable, as the ends of the rails were unsupported except by the fish-plates, which together were frequently only equal to two-thirds of the section of the rail. It was submitted that all the joints should be fished directly over a sleeper, or that a bracket chair should be used. The practice of turning the rails was condemned, because when a rail was so much worn as to require turning, its strength was generally so reduced as to render it unfit for main line traffic. With regard to the fastenings of the chairs to the sleepers, it was urged that it was desirable that iron spikes only should be employed on the outer side of curves, or else that the chair should be partially sunk into the sleeper, to lessen the strain on the treenail. The superior economy of steeled, or partially steeled rails, points, and crossings, was also incidentally noticed.

In reference to the accidents which had arisen from defective, or neglected rolling stock, it was found that many of the fractures had occured during the winter months, owing, possibly in some degree, to the rigid state of the "way" in frosty weather; whilst others were due to the use of bad iron, and some to defects either in the welding of, or in the mode of attaching the tyres of the wheels. Steel, or the partially steeled, tyres were now, to a certain extent, in use, and tyres formed of a continuous ring, or unwelded piece of metal, were also successfully employed. Several new methods of fastening the tyres had proved as fruitful of mischief as the ordinary plan of simply shrinking them on, though others had been found to be efficient; and it was said that on some lines the tyres had not failed to any great extent. The author hoped, that the importance both of the tyres and of the axles of wheels would lead to a useful discussion on this branch of the subject. The usual want of uniformity in the main features of the carriage portion of the rolling stock was then commented upon: and it was considered that this variety not only increased the cost of manufacture and of maintenance, but was often the cause of accidents, and frequently contributed to render them disastrous. The author thought that the carriages should be nearly uniform in size, and that the buffers should, in all cases, be the same height above the rails. The longitudinal beams should be in the same line throughout, be strong in themselves, and the framing securely braced. The present coupling in the centre should be increased in strength, and the whole attachment between the carriages should be such as to render a train in effect, as far as practicable, as one carriage, with a certain amount of flexibility; so that in the event of collision, the carriages should retain their position, instead of rising upon one another; and if an axle or a wheel broke, the crippled carriage should be partially borne up by the neighbouring carriages until the train could be stopped.

On the question of management, after some remarks upon the speed of trains, it was shown that by punctuality both in the time of starting and in the rate of running, safety, so far as human foresight was concerned, was ensured. The system of working the traffic of a railway by allowing an interval of time between the trains was deemed unsatisfactory, and far inferior to the system of an interval of space. The accidents arising from the irregularity of excursion trains were then alluded to, and it was remarked that if during the summer and autumn the ordinary trains were run at lower rates of fares, the traffic would be increased, as the public would feel greater security in travelling. The difficulty in running coal or mineral trains to a fixed time-table might be met by a more general use of the electric telegraph, and by a better system of signalling arrangements. During the seven years from 1854 to 1860 inclusive, eighty-eight accidents happened from inefficient signals, of which fourteen occurred in 1860. In some cases, especially at sidings, there were no signals; in others they were defective in form, or were improperly placed. It was desirable that junction signals and points should be worked simultaneously by one man, and at junctions separate main and distance signals should be provided for each line. If the system of working the traffic by the electric telegraph was generally adopted, and the line was divided into sections, so that a train should be prevented from entering any section until the preceding one had passed to the section in advance, collisions would be impossible, except those liable to arise from disregard of the signals, and a proper interval would be secured between the trains, in spite of unpunctuality. As the want of a means of communication between the engine-driver and the guard or conductor had frequently been experienced, and as plans were in daily use on several lines, there was no reason why it should not be adopted on all. To render it fully effective, the guard or conductor ought to start the train from each station by means of that machinery, so as to prove that it was in working order. Owing to the general high speeds and heavy trains, it was of the utmost importance that ample break power, capable of being applied in the least time, should be provided with each train. It was a question how far a regularly distributed retarding force acting at the same moment on all the wheels, might not be preferable to a concentrated force applied at particular points. By the system of "continuous breaks," the employment of several men with each train was unnecessary. It had also another advantage, that a train was more under control, and could be stopped in a shorter distance. The negligence of servants, arising from their ignorance or inefficiency, was next adverted to, and it was thought to be due to the pay being too low to command the services of men of intelligence, steadiness, and self-reliance. Frequently they were insufficient in number, leading to overwork, and instances were on record in which engine-drivers had been employed for seventeen hours daily, and in some cases for twenty-six and thirty hours continuously.

The author proposed leaving the bearing of existing legislation upon railways to be dealt with by Captain Douglas Galton. He would, however, observe that Government interference was not likely to render railways safer, or more available to the traveller; and that it would be better to rely on the consideration and calm reflection of those immediately interested in these enterprises, especially as, from the heavy expenses attendant on accidents, directors and shareholders would naturally desire to render this mode of travelling as safe as possible.

The second paper read was on "*Railway Accidents.*" By Captain DOUGLAS GALTON, R.E., F.R.S., Assoc. Inst. C.E.

It was stated that the length of railway communication opened in the British Isles at the end of 1860 was 10,433 miles, upon which 163,435,678 passengers were conveyed in that year. From official returns it appeared that during the seven years ending the 31st December, 1860 there were 116 passengers killed, and 2832 injured from causes beyond their own control. From the sums paid by railway companies for compensation it was calculated that an insurance of one twenty-fourth part of a farthing per passenger per mile would, on the average of all lines, cover the cost of railway accidents. It had been found impossible to obtain reliable information as to the number of coach accidents in this country. But the returns of the 'Messageries Impériales' showed that in a series of years the number of passengers killed and injured, from causes beyond their own control, was 1 in 28,000. From the latest comparative returns the number of passengers killed and injured was, on British railways 1 in 334,000; on Belgian railways, 1 in 1,600,000; on Prussian railways, 1 in 3,000,000; and on French railways, 1 in 4,000,000. The greater comparative safety of foreign railways was traced to differences in the conditions of the traffic and of the management, as well as in the habits of the people.

In endeavouring to elucidate the question whether any of the accidents which had occurred could have been prevented by reasonable precautions, the first point which arose was, the extent to which the amount of traffic on the several lines influenced the number of accidents. The general averages thus obtained showed that lines of small traffic were comparatively safe. But as traffic alone did not determine the number of accidents, it was necessary to analyse the causes in detail; taking first those which could not be guarded against; and secondly, those which were within the control of the managing or working staff. During the seven years before referred to, 534 accidents to trains had been reported upon by the inspecting officers of the Board of Trade, in which 2912 passengers were killed or injured. In many of these cases there had been more than one contributing cause, but the majority might be thus tabulated:—

	Number of Accidents reported upon.	Number of Sufferers.	Cases in which the Accidents could not be guarded against.	Cases in which the Accidents were due to Causes within the control of the Management.		
				Attributable to the Works or Rolling Stock.	Attributable to the system of Working.	Negligence of inferior Servants.
Accidents from Engines and Carriages leaving the Rails, or Fractures of Machinery	135	313	59	98	15	17
Collisions of every description..................	319	2532	16	222	219	183

These figures showed that a large proportion of the so-called accidents were due to preventible causes. Those arising from the fracture of axles and tyres, and from engines and carriages leaving the rails, were less than one-half of the number which could not have been guarded against. But out of the 319 collisions only 16 were attributable to purely accidental causes, whilst 183 were assigned to the negligence of inferior servants, and 120 to the manner in which the traffic was conducted, and which ought not therefore to have occurred.

With regard to the first class of cases, accidents which could not have been guarded against, the author remarked that the best form of tyre for a railway wheel had not yet been definitely settled. The wheels and axles could scarcely be said to be mechanically satisfactory; the form of break in use was also imperfect. Although simple negligence could not be entirely prevented, yet in several cases the negligence had been attributable to the defective arrangement of the company in permitting pointsmen and engine-drivers to be habitually over-worked. Those accidents which arose from trains passing on to a wrong line through facing-points, might not have occurred if an indicator had been attached to the points to show in which direction they were set. The comparatively small number of accidents from negligence alone afforded strong evidence of the efficacy of the direct responsibility of the inferior servants. A few instances were then cursorily alluded to in illustration of those accidents which were wholly or partially attributed to defects in the condition of the railway or the vehicles, or to the absence of the requisite auxiliaries to safety, such as signals, breaks, &c. It was observed, that it was not for want of good rules that accidents occurred, but for want of a continued enforcement of those rules, and a close examination into the details of the manner in which the traffic was worked.

The discussions which had taken place on this subject in Parliament, both in 1853 and again in 1857, were then considered, and the conclusion was arrived at that freedom from railway accidents was not to be obtained by Government interference, but by an effective and responsible internal management, which would enforce the greatest punctuality and care in working the traffic, and maintain the strictest discipline amongst the servants employed.

The existing law affecting railway companies as carriers was then alluded to; and attention was next called to the principle of compensation for injuries sustained, Lord Campbell's Act being specially cited as the parliamentary recognition of that principle. It was said that this act removed a technical difficulty in the way of recovering compensation, rather than gave a new right to compensation. The money payment thus provided operated as a punishment, and tended to prevent the commission of careless acts. Compensation might, therefore, be looked upon partly as a penalty upon the company for its corporate carelessness, and partly as a remedy to the sufferer for the injury received. If viewed as a remedy it should be such as to tend to prevent a recurrence of the act for which punishment was awarded. It should, therefore, depend on the degree of blame which attached to the management for the accident, and it should be equally certain and just in its operation. In its aspect as a remedy it should be easily recoverable by the sufferer. As at present levied it did not properly fulfil either of these conditions, for reasons which were stated. Assuming that such a maximum amount was fixed upon as would fairly compensate the generality of passengers, according to the class in which they were travelling; and assuming that it were made payable in the case of every accident which occurred beyond the control of the passengers, without there being any obligation to prove negligence, the author was inclined to think that the fine would be rendered more certain in its operation, but that as a preventive the effect of the alteration would not be appreciable. The true remedy against railway accidents lay, in the author's opinion, with the railway companies themselves. Improved management would be greatly assisted by placing at the head of each railway a director of adequate capacity, responsible to the board for the management of the concern, who should be required to devote the whole of his time to its interests, and be paid in proportion; by giving the chief officers of the railway control of, and making them responsible for, the several departments, so that they might be held answerable for the results; and by providing a gradation of responsibility throughout all the employés. Improvements in the machinery and system of working might be promoted by the formation of an association amongst railway companies, embracing the objects of the association between the German railway companies, and of the association between manufacturers near Manchester, for the prevention of boiler explosions. It was doubtful however, whether such an association could become of any practical utility in this country, unless it assumed the form of an association for the purpose of mutual insurance against accidents, managed by a board of railway officials, chosen from the associated companies.

THE OFFICIAL PROGRAMME FOR THE DESIGN OF THE PARIS OPERA HOUSE.*

Section II.—*Ballet.*

77.—(1) The room of the first ballet master.

(2) That of the second ballet master, and of the inspector.

PRINCIPAL MALE PERFORMERS (*Sujets hommes*).

(3) Actors (*mimes*) and dancers of the first class; six dressing rooms.

(4) Substitutes (*doubles*) and second-class dancers; six or eight dressing rooms.

(5) A store for dresses (about 15 to 20 metres); and, pertaining to this store,

(6) A place for the dressers (4 men).

(7) That of the hairdresser, as large as a small dressing room.

PRINCIPAL FEMALE PERFORMERS.

(8) Principal female dancers (*premières danseuses*) four rooms.

(9) Second *danseuses* of the first class, eight rooms.

(10) Second *danseuses* of the second class, twelve rooms.

(11) A store for dresses (about 25 to 30 square metres); and, pertaining to it,

(12) Accommodation for the dressers (6 women).

* Concluded from page 111.

(13) Accommodation for the hairdresser, of the size of a small dressing room.

(14) Accommodation for the shoemaker, which ought to be provided near the rooms of the principals and the ladies of the *corps de ballet*, and to be large enough to allow three or four persons to try on their shoes there.

CORPS DE BALLET.—MEN.

(15) A dressing room for eight leading dancers and actors (*danseurs coryphées et mimes*), or two rooms for four in each.

(16) A room for the eight dancers of the first quadrille.

(17) A room for the eight dancers of the second quadrille.

(18) A room for the sixteen pupil dancers comprising the third quadrille. The first and second quadrille may be united in one single room. The dressing rooms of the ballet dancers should have proportionately the same dimensions as those of the male chorus singers, and like them should be divided into boxes by partitions. These compartments should be a little more roomy in the case of the leading dancers, and should form a species of small room for each one.

(19) A dressing room for twelve pupil children, only casually and occasionally occupied, and consequently capable of being more removed from the stage, and more contracted than those in regular use.

(20) A store for dresses, placed as far as possible in the centre of the group of dressing rooms, and communicating readily with the central wardrobe: 20 to 25 metres.

WOMEN.

(21) A dressing room for 16 leading female dancers, or preferably two rooms for eight each.

(22) A room for 16 dancers forming the first quadrille.

(23) A room for 16 dancers forming the second quadrille.

(24) A room for 16 pupil dancers forming the third quadrille.

Like the chorus singers, the ballet dancers ought each to have a separate compartment, and for the leading ones this compartment should be large enough to form a kind of dressing room closed by a curtain. For this about 1·50 by 1·50 metres would be required. We only insist upon this arrangement for the leaders, so as to save space; but it would be highly desirable if possible to adopt it generally, should the public dressing rooms of the women, and even of the men, be large enough to allow it. We regard the habit which all these young girls are obliged to contract, of undressing and going through their whole toilette several times a day, in a common room, as an unfortunate cause of demoralisation. The mothers of most of the young female dancers accompany them to the theatre, and remain in their dressing rooms. These rooms will consequently require to be larger for a given number of persons than those of the female chorus singers, who come alone.

(25) A room for from 15 to 20 young pupils, children employed only occasionally, and who consequently may be accommodated further from the stage, and with less space than the regular dancers require.

(26) A store for dresses placed as near as possible to the group of dressing rooms appropriated to the female ballet dancers: of from 25 to 30 square metres.

FIGURANTES.

78. The walking *figurantes* (non-speaking) so called because they neither dance nor sing, will have their dressing rooms better placed in contiguity with the ballet department, with which their duties more directly connect them, than with the chorus. Their ordinary number is eighteen, inclusive of two directresses; but it often rises to twenty or twenty-four, and may amount to thirty; the dimensions of the apartments devoted to their use must be calculated for this last number. A large room for thirty women is therefore required; or, better, one for twenty, and an adjoining one for ten; also, a special store for dresses, 15 to 20 square metres: the whole in one of the upper stories, if there be no room nearer the stage. We do not require for the *figurantes* such roomy compartments as for the dancers, but at the least a dressing box of from ·80 to 1·00 metre would be required for each.

79. In the ballet department, as in that of the chorus, the male and female dressers of the *corps* remain in the common rooms, and consequently increase the number of persons to be accommodated in them; they do not however require, like the dressers of the principals, to have a special place allotted to them.

80. The dressing room corridors must be straight (an indispensable condition of rapidity of working and efficiency of superintendence) withour projections or corners, well ventilated, and lighted by daylight.

81. At several points urinals and well ventilated closets ought to be contrived, in numbers proportionate to the various divisions of the establishment to whose use they are appropriated. We have already said that the principals ought to have private closets adjoining their dressing rooms.

SUPERNUMERARIES (*comparses*).

82. The supernumeraries ordinarily number from forty to fifty; for many works the number is from eighty to one hundred, and for some, as for example *La Juive*, it reaches a hundred and fifty. As the future stage will be more ample than the existing one, the number of performers will necessarily increase proportionately to the enlargement. The same thing will be true of the bodies of chorus singers and dancers; for the latter, however, we have based our calculation of the requirements upon the numbers at present employed. There will therefore be needed—(1) A common room for from 50 to 60 supernumeraries, near the stage, so that this numerous and undisciplined troup may come on without introducing disorder into the other departments. (2) A similar room, which may be further removed from the stage or at a higher level, as it will only be made use of when more than 60 supernumeraries are employed. (3) Lastly, a third room of the same size, to be made use of only when works including great spectacles, such as *La Juive*, are played. Each supernumerary should have for himself and his dresses a box 0·70 or 0·80 met. wide by 0·50 or 0·60 met. deep.

83. In the arrangements for supernumeraries, and so far as possible in immediate communication with the principal room, should be included—(1) a room for the superintendent of the supernumeraries and his under-superintendent, from whence they can easily overlook the room and transmit their orders to it. (2) Accommodation (a stall or standing) for the hairdresser and his store of wigs, beards, &c. (3 or 4 square metres). (3) A long narrow store, a sort of gallery for arms and armour (10 to 12 metres by 2, or 2·50 metres). (4) A wardrobe, either single (and of from 100 to 200 square metres) or in three compartments, annexed to the dressing rooms; but in this latter case the first must be larger than the second, and that larger than the third, for the first dressing room will be used at all performances, the second for those where the number of supernumeraries is larger than usual, and the third for the rare occasions on which it reaches its greatest height. (5) Lastly, if possible, a small courtyard, with urinals and latrines for the use usually of from 50 to 60 men, often increased to 100 and at times to 150.

84. An excellent arrangement, and one very desirable with a view to the promotion of good order and of that supervision which becomes requisite in the employment of supernumeraries who are almost all strangers, and for the most part unknown, would consist in such an arrangment of this department that it should only have one communication with the stage, wide and direct indeed, but single, and that it should have none at all with any of the other departments. A separate staircase would afford access—starting from the vicinity of the room already referred to (No. 72), where, with the exception of the twenty-four regulars, the supernumeraries are enrolled each evening, and from whence they would go direct to their dressing rooms without any means of arriving at the stage except in costume. Their work done, they would get their pay as they left,—in exchange for a check given by the superintendent of supernumeraries,—from the hands of a doorkeeper stationed in a little office in the lobby at the foot of this staircase.

SALOONS FOR THE PERFORMERS (GREEN ROOMS.)

85. The green rooms (different from the rehearsal saloons, which will be described further on) ought to be as near the stage as possible, and on the same level. The following details apply to the principal performers' saloons:—(1) The saloon for vocalists. This is an elegant but quiet sitting room, where ten or twelve persons assemble to chat, and where the performers sometimes try over or rehearse a passage out of their part. The existing saloon measures about 6 metres by 8 metres: that space is almost enough. (2) At each side of the theatre, near the proscenium, and as far as possible level with the stage, is required a little saloon, so to speak a box (of 10 to 12 square metres), to admit of hasty changes of dress, and to shelter performers who are awaiting the moment for their going on to the stage (this is sometimes termed *foyer de réplique*). (3) Near the scene and the saloon, but a little higher or lower, a small room for the manager is necessary. (4) The side scenes would be relieved by the appro-

priation to the chorus singers of a saloon, much more simple than that of the principal singers, but of about the same dimensions, 30 to 40 square metres. This saloon however is not indispensable; the chorus can wait in their rehearsal saloon if not too far from the stage, or in their dressing rooms. (5) The dancers' green room (*foyer de danse*), the floor of which slopes like that of the stage, and which is surrounded by resting bars to assist in practising dancing (for want of space, rehearsals take place here, which should be carried on elsewhere), is not only intended for the use of the *chorégraphic* performers, it is an elegant saloon into which the director introduces all strangers of distinction who come to visit the opera. It is a place of meeting and entertainment for such of the subscribers as have the privilege of entry behind the scenes. It should be of large size, for all the members of the ballet meet there (a hundred persons and more); and it ought to be decorated in a style to correspond with its distinction as the opera reception room. It would be desirable for this saloon to be reserved for the ladies and the principal male performers, and that the male dancers of the *corps de ballet* should have a separate saloon similar to that of the chorus singers, and of the same size. That would be the small dancers' saloon. The dancers' saloon in the present Opera-house is 8 metres by 11·7 metres; it is a little too small. (6) Among the dependencies a saloon for strange musicians, who are sometimes employed to the number of 20 or 30 on the stage. But this room must not be near the scene, on the contrary, it must be so far removed that rehearsals of flourishes of trumpets, which ordinarily occur during the course of the piece, should not interfere with the performance (see No. 89).

THE ORCHESTRAL DEPARTMENT.

86. In all probability the orchestra will occupy the same position in front of the scene as now, since, notwithstanding the disadvantages of this arrangement, a better has not yet been found. The present orchestra contains eighty performers, it will require to be a little larger for the new house, and it will be advisable to lower its level to 0·60 or 0·80 metres below the present level. In the neighbourhood of the orchestra will be placed (1) A saloon for the performers to the number of ninety; around it closets for preserving the instruments. (2) The room for the conductor. (3) That of the deputy conductor. (4) A store for music, harps, double basses, &c., level with the orchestra, and if possible adjoining. The accommodation for the orchestra ought to be situated beyond the immediate dependencies of the scene, with which it ought to have no communication, except through a door which ordinarily remains closed.

ARRANGEMENTS FOR HORSEMEN ON THE STAGE.

87.—(1) A stable for from twelve to fifteen horses. (2) A harness room, with a store for caparisons and the various accessories of harness. (3) A station for grooms and stablemen (12 to 15 men). The horses all caparisoned should ascend to the stage and descend from it by a gentle incline, upon which they can go under cover to the very stable.

INSTRUCTION AND REHEARSALS.

88. The saloons intended for instruction and rehearsals may be remote from the stage, but must be near the manager and the superintendents. There are required—(1) a small saloon for singing lessons. (2) Two saloons for study and rehearsal of parts (suitable dimensions from 30 to 40 square metres. (3) A great saloon or rehearsal room. The dimensions of this room should be such that rehearsals of grouping, and effects either of dancing or singing can be made there as well as on the stage. For this it must have a width at least equal to the opening of the scene—say about 15 metres.

89. The dancing school, now conducted partly in the rue Richter and partly at the Opera-house, must be established entirely among the dependencies of the new Opera-house. It may be situated in an internal court-yard, if possible on the ground floor, so that the pupils may come for their lessons without passing through any of the dependencies of the stage. This school will include—(1) Two dancing rooms, each for from twenty-five to thirty pupils, one for girls, one for boys. (2) A waiting room for the mothers of young pupils. (3) One or two dressing boxes or dressing rooms for girls. (4) One or two dressing boxes for boys. (5) Two or three private rooms for the professors. The instruction of the two sexes ought to be separate, if however space fails, it might be sufficient to have a single dancing room (a square of from 8 to 10 metres on each side) where lessons should be given at different hours. These dancing rooms may also be turned to account in various ways. For example, they might be useful for musical rehearsals, and particularly—if they were far enough from the stage for rehearsals not to create disturbance—they would serve for those of strange musicians; in this case they would render unnecessary the room specified (No. 85) for those musicians.

WARDROBE.

90. The work rooms and general warehouse for costumes may occupy the upper stories of the buildings appropriated to the management. At the same time, they ought to be as near as possible to the dressing rooms of the performers, and to communicate by a wide and easy staircase with the appendages to the stage. The complete establishment should include the following :—

MANAGEMENT OF THE DEPARTMENT.

Three rooms opening out of one another. (1) Room for the superintendent of dresses (*chef de l'habillement*.) (2) Office for the deputy superintendent and servant. (3) Room for the designer, usually only one person, sometimes two or three; to be large enough and well enough lighted to permit of a large figure being dressed there, or, if necessary, a model being set.

SHOPS.—MEN.

91.—(1) Tailors' shop, for from 20 to 24 men ordinarily; 40 or more when work presses, that is to say as often as a great piece is got up: an area of 140 to 150 metres is desirable, well lighted, as much as possible sheltered from the rays of the sun, and with a ceiling lofty enough to prevent the atmosphere from becoming too much vitiated, when working at night, by the breath of the workmen, and by the 30 gas burners which light them. (2) The room of the foreman of tailors, small, and united to the two following. (3) The cutters' shop, to contain two or three persons and a great tailors' board (20 to 25 square metres), separated as much as possible from the large tailors' shop by a glazed partition. (4) A small store for new dresses in course of manufacture, and such as are not yet taken into use.

WOMEN.

92.—(1) Shop for seamstresses and embroiderers, from 30 to 40 women—the counterpart of the tailors' shop. (2) The room of the head seamstress, small, and united to the two following ones. (3) The work room of the chief seamstress and of the assistant seamstress and assistant milliner, separated from the large shop by glazing. (4) A small store for dresses in hand. (5) A small room, easily reached from without, for receiving, counting, giving out, and repairing linen and hosiery,

93. Easy communication and access between the two workshops, placed under the general direction of the superintendent of dresses, and the inspection of his deputy. The office of the latter should be so placed as to render superintendence easy and efficacious. No one ought to be able to enter or leave without passing under his eye. The superintendent of dresses, the foreman of tailors, and the chief seamstress, ought to be accessible without entering the workshops, which should be closed against all persons not employed there. Within reach of these shops, private closets for men and for women ought to be provided; and it would be very useful for a sort of refectory to be provided, with a cooking range, where the workmen and workwomen who are detained for urgent work, or are to work through the night, may warm-up their food, and take their meals without leaving.

STORES.

94. The central wardrobe includes two principal sections, themselves subdivided into several groups, namely :—

Men ...	Opera...	Principals.
		Chorus.
	Ballet...	Principals.
		Corps de Ballet.
	Supernumeraries.	
Women	Opera...	Principals.
		Chorus.
	Ballet...	Principals.
		Corps de Ballet.
	Figurantes.	

and there are required—(1) Two rooms of about equal area (each about 150 metres), communicating by one or several openings, and subdivided by closets and partitions of wood, to suit the requirements of each department. (2) A little store adjoining for the most valuable dresses, head dresses, feathers, flowers, jewels, &c. (3) An armoury, for from 50 to 60 complete suits of armour, a certain number of helmets, cuirasses, and other portions of armour, several hundreds of halberts, spears, dressswords, &c. (4) A little work-room adjoining this armoury, for cleaning and polishing. (5) A small store for fire-arms, with a bench for the gun-smith. (6) A small store, well ventilated and in the shade, for furs. (7) A store, from 20 to 25 square metres, for the hatter, with a furnace, and a bench for the repairs and brushing up of hats. Lastly, in an upper story, if need be in the roof, but near the general wardrobe department—(8) A well ventilated light room for beating and cleansing dresses. (9) A store for old disused dresses.

95. Further—on the same story as the shops, and in easy communication with the office of the superintendent of dresses and workshops, must be provided—(1) The store for materials, a room of from 30 to 40 square metres, fitted up with closets; with (2) An office for the warehouseman and his servant. (3) A dark room for examining the effect of materials when lighted up.

MISCELLANEOUS WORKSHOPS.

96. It has been considered that it would be well to have, in the buildings of the opera, painting rooms for the scenery. These painting rooms, which could be formed nowhere but in the roof, would be of but partial use. The difficulty of access and of working, the impossibility of setting up stages of scaffolding for want of sufficient height, would of necessity limit the use of them to repairs and touchings up. Now since there is little probability that the run of a piece would be stopped to allow its scenery to be touched up, and since there will hardly be room enough to allow of the scenery for all the works on the list being kept in the opera house, there would be no reason for transporting thither, merely for repairs, scenery which could be much more conveniently mended in the painting room, which ought to be annexed to the general store. These painting rooms cannot be counted upon for the preparation of new scenery. Space and height will always be wanting for that; besides there would be great disadvantage in mixing up the departments of the theatre, already so extensive, with painting rooms, which would bring in a number of persons, usually far from orderly.

97. The general scenery store, which cannot be dispensed with, and the painting rooms (for of these two or three at the least are needed), require ten times as great a space as can be spared for them at the opera-house. They must be transported into a remote district where, land being cheap, it will be easy to afford them that space which is wanting in the rue Richter. If the system of mounting scenes, which we have described (No. 48 and following sections) be adopted, they will only seldom have to be transported, and there will be no disadvantage in the store being remote from the theatre. This further advantage will accrue—in place of a warehouse representing a rent of a hundred thousand francs or more, a better one will be provided which will not cost a third of this sum.

98. The roofs of the house will be turned to very good account, if stores for cumbrous accessories, chandeliers, tackle, the preparations for balls, the general store of the house-upholsterer, and his workshop, the brushing room for dresses, &c., are placed there. A carpenters' shop for repairs can be also very suitably provided there.

99. Other workshops yet are essential, but the roof is not the locality in which they should be situated. In a court-yard near the stage should be found—(1) A smithery, and a forge. (2) The general store and shop belonging to the lighting department, and a station for those engaged in this department, (see Nos. 60 and 67). (3) The store and shop of the chimney sweeper. (4) The house carpenter. (5) The store for brooms, brushes &c. (6) Stores for fuel, goods, &c. (7) A cart-house, and even a stable for a cart-horse.

PRECAUTIONS.

100. The construction of the new house of incombustible materials, will very much lesson the danger of fire, and will render a general conflagration impossible. But wood and combustible materials must inevitably be sufficiently made use of in the formation of the stage, the scenery, and the internal fittings for these to remain in considerable danger, and for it to be indispensable that precautions should be taken against the possibility of accident. The existing movable iron grating, the object of which is to secure the retreat of the audience in case a fire breaks out in the direction of the stage, will therefore be retained. As at present, charged water mains would be provided in various parts of the theatre, supplied from enormous cisterns in the roof. A powerful hydraulic system, acting by compressed air, or under the force of ordinary fire engines, will afford the means of rapidly and successfully encountering such accidents as may arise. But the engines or any other motive power selected, must be established on the ground level in the neighbourhood of a court-yard, easily reached from without and from all parts of the establishment, so that in case of anything serious, the action of the engines should not be interrupted. The architect will avoid placing his fire engines as they are placed in the present opera house—in a cellar, which would in a short time have to be abandoned for want of air to breathe, should any fire of magnitude break out.

101. The station of the firemen (*sapeurs pompiers*), about fifteen men, and their store for appliances to aid escape, will naturally be established near the engines, and so that these firemen can quickly reach all parts of the stage and the house.

MANAGEMENT.

102. The offices of the management and adminstration will be so placed as to secure prompt and easy communication with the stage and with all departments. They must be easily reached from without, and foot passengers must as far as possible be sheltered up to the very door, which will open out of the principal court-yard (No. 68), and in such a way that carriages can approach it easily. The manager's department will include —(1) An ante-chamber. (2) A small waiting room. (3) The manager's private room. (4) A small room adjoining. (5) The room of the manager's private secretary. (6) The room of the general secretary. (7) A small room adjoining. (8) The strong room (*depôt des archives*), which requires two other rooms of together about 50 square metres of area. These rooms ought to have exit doors, allowing the officials who occupy them to leave them, and reach the stage and all portions of the establishment, without passing through the ante-chamber.

The administrative offices will comprise the following:—(9) The office of the principal cashier. (10) Offices for 3 or 4 assistants. (11) A room for the office clerks. (12) An inspector's office. (13) A clerk of works' office (*bureau des batiments et du matérial*).

103. The cashier's office ought to be readily accessible to the whole staff on pay days, and daily to the public. It will consequently be better placed on the ground floor than on an upper floor. It is desirable, in order to guarantee the safety of this office, that it should be so situated as to be always under the eye of the door-keepers and inspectors, and should have no opening into the public way. The cashier's department will consist of (1) An ante-chamber into which the pay window opens. (2) The cashier's room. (3) An office adjoining it for a clerk.

104. The library of the opera-house contains one of the most important musical collections extant. It possesses autograph and unpublished works by the greatest masters, the loss of which would be irreparable. All the separate parts of the choral and orchestral scores of the operas and ballets played at the opera house, are there in full, and in case of their disappearance could not be replaced without heavy expences and a very long delay, during which the performances at the opera would be of necessity interrupted. It will therefore be impossible to be too careful in preserving this valuable deposit. The leader of the orchestra daily sends for and returns to this library the scores necessary for the performance of the day. For the convenience of working it might be therefore desirable for this library not to be established too far from the stage, but it is above all things requisite for it to be placed in a dry spot secure from any danger in case of fire.

105. The library, and the store for scores attached to it, at present occupy five rooms, having a total area of 200 metres. More space must be allowed for the new house, inasmuch as the store receives some increase every year, and is already too small.

106. To the library should be annexed a copying room (for 6 or 8 copyists), and the room of the librarian, who is also superintendent of copyists.

RESIDENCES.

107. The principal officials employed at the opera are on duty day and night. None of them can leave the theatre before the end of the performance, and some of them remain for long after, notwithstanding which their functions recommence on the morrow at a very early hour: for example, the general secretary —who has the administration and superintendence under his care —and the principal machinist. The presence of the heads of departments is daily and at all hours essential. To prevent casualties, they must to a certain extent be permanently at the theatre. Even without any regard to the convenience of the

officials, it can be easily understood that, reaching their homes far from the opera house at an advanced hour of the night, exhausted by the fatigue of a long and laborious day, it is difficult for them to recommence their work early the following day, and that consequently a great relaxation of the preparations and the general work of management must ensue. The general secretary and the cashier are at the present day the only officials residing at the opera house. We consider, notwithstanding the silence maintained in the programme which served as a basis for the first competition, that the new opera house ought to include residences for the following officials and assistants: (1) The manager. The manager of the opera is at once a general who ought to be always at his headquarters, and the head of a vast establishment who cannot safely remain out of reach of his *ateliers*. (2) The general secretary, upon whom devolves the administration, the care of the property, and the permanent superintendence of all the different departments and of the building itself. (3) The stage manager, who is responsible for the scenic effects and the rehearsals (*marche des études*). (4) The superintendent (*régisseur*), his principal assistant, upon whom devolve all the details of the stage, notices, &c. (5) The cashier, accountable for heavy sums of money, and who ought neither to leave the charge entrusted to him, nor to carry it away with him. (6) The head machinist, who has the immediate command of all the workmen.

ON PICTORIAL MOSAIC AS AN ARCHITECTURAL EMBELLISHMENT.

By M. Digby Wyatt, Architect.

(Concluded from page 120.)

A few words will suffice to dismiss the sixth species of mosaic, which I have called "Italian Portable." By this term I would convey that the basis of the variety is not so much making portable mosaics, as, from the great weight of the materials, they can never be made easily portable; but rather making reproductions, in mosaic, of pictures in oil or other media, which may be really and readily transferable from place to place. This species is, in fact, little else than a revival of the fine *opus vermiculatum* of the ancients. It would be incorrect to say that the Greeks did not ever manufacture miniature mosaic pictures; because two noted specimens exist to my knowledge,—one at Florence, and the other, of extraordinary perfection and curiosity, in the Kensington Museum; but it may be safely averred, from the great rarity of such relics, that the practice was altogether exceptional. This, indeed, is not to be wondered at; since, with the quick drying cement ordinarily used for mosaic work, it must have been extremely difficult to execute these almost microscopic pictures, which bring within the compass of a few square inches subjects usually worked out in as many square feet.

This leads us to the conclusion that the ancients for their finest mosaic pictures must have used some retarding agent, such as honey or beer would prove, to keep their cement plastic longer than it would remain if mixed with water only. When, however, Giovanni Baptista Callandra applied, early in the seventeenth century, a mastic in lieu of an ordinary hydrate of lime, to unite the tesseræ, it became comparatively easy to copy the most elaborate pictures in mosaic. By this artist was executed the beautiful reproduction of Guido's St. Michael; which, with Raffaelle's "Transfiguration," and Domenichino's "St. Jerome," is about the best of all the celebrated mosaic pictures in St. Peter's.

In the marble incrustation which forms our seventh species, and which is best known as Florentine Mosaic, the tints and shades are given by the natural colours of the jasper, agates, and other precious materials of which the work is composed. The hardest minerals only are used; and as each small piece must be cut and ground to a pattern, and each thin veneer backed by a thicker one of slate, or some such material, in order to give it strength; so much labour and time are involved in its production that its high price has necessarily limited its use. Zobi, the principal writer on the art of pietra dura mosaic, tells us that he knows of "no existing example in Italy of marble pictorial mosaic executed during the first periods of the revival of the arts, excepting the specimen to be seen in the central nave of Siena Cathedral, said to be the work of Duccio di Buoninsegna, who lived in the fourteenth century." There can be no doubt, however, that the art was founded on the *opus sectile* of the ancients, and that it descended by regular tradition from classical times. I need scarcely recall to your recollection the extraordinary advance made in the pavement of the same cathedral upon the work of Buoninsegna, by that great master of the sixteenth century, Beccafumi. The art was greatly patronised by the Medici. The celebrated "Fabrica Ducale," of Florence was founded by Ferdinand I., Grand Duke of Tuscany, in 1588; and its reputation during the seventeenth century was kept up by the exertions of those artists to whom Florence owes the finest specimens of mosaic which enrich her palaces and galleries, and whose names are for the most part given to us by Baldinucci.

Before taking leave of this subject, we must not omit to notice the exquisite specimens produced in India of pictorial mosaics, representing the finest Arabesque and conventional ornament in pietra dura. That the Indians were early in possession of all the technical ability necessary for such a work is proved by the antiquity of some of their gem-cuttings, inlaying, polishing, and carvings in hard stones; but it is probable that their sovereigns owed much to Italy for assistance in that beautiful marquetry which ornaments the great monuments at Delhi and Agra; for in 1688 a passport was obtained from the King of Spain, by the Grand Duke of Tuscany, for four workmen, skilled in mosaic working in precious stones, whom he was about to dispatch to the Great Mogul.

This art is retained at the present day both in India and to even greater perfection in Italy; for the specimens contributed to the recent Exhibition at Florence, some of which may be even now on their way to this country, were quite equal to anything produced in the palmy days of the Medici.

It would take too long now to describe the practical processes adopted in this and other modes of mosaic working, and having already given them in a work I published in 1848 on the subject, and in a report to the Board of Trade made in 1855, it is better to refer you to those sources of information than to further detain you from entering upon what is, indeed, the most practically interesting section of our inquiry this evening. Before commencing, however, upon the second part of our subject, the theoretical basis upon which we should as architects aid in the revival of pictorial mosaic, it behoves us to take stock of the present state of the material conditions likely to affect any such revival. In Italy, as I have already said, the art has lingered on; maintained in its monumental form by the necessities of repairing old works, rather than by the desire to create new; and in its portable form by the incessant demands of foreigners to carry off with them, as pilgrims' marks, in the nineteenth century, slabs of what is generally known as "Roman mosaic." In France, under the first Republic, an effort was made to introduce this manufacture into Paris; and a "fabrica" was opened by the authorities, under the charge of a Signor Belloni, in the old College of Navarre, in the Rue de la Montaigne Ste. Généviève. At the "Exposition" of the year X., some products were contributed from this establishment; but as it altogether disappears from the catalogue of subsequent expositions, there is every reason to believe that the experiment was abandoned. With this exception I am aware of no attempt made by France hitherto to revive pictorial mosaic. I have not heard of any other efforts, making or made, in any of the other countries of Europe, excepting our own.

Before noting what we are doing in this direction, it may be well to record the progress making in Italy. There are now three establishments in "Italia" (supposing it to be "Unita"), at all of which I believe the *smalti*, or coloured vitreous pastes requisite for mosaic working, are made, and from which they may be procured. These are each attached to great structures, the mosaics of which require occasional repairs; viz., St. Peter's at Rome, St. Mark's at Venice, and the Benedictine establishment at Monreale, near Palermo. Of the products of these establishments, the Roman and Venetian are the best, and the Sicilian the cheapest. Through the kindness of Mr. Penrose, of whose exertions in connexion with the revival of mosaic I shall presently have occasion to speak, I am enabled to bring to your notice the following particulars of the relative cost of the products of these establishments. At the Roman Fabrica he was furnished with an estimate for the execution of mosaic (of course, in very fine work) for "*opere di decorazione*," at the following rates, reduced to English feet and English money:—For figure subjects or landscapes, at from 23*l.* to 38*l.* per foot superficial; for flowers or animals, at from 23*l.* to 31*l.* per foot; for Grecian, Roman, or cinque-cento ornaments, at from 19*l.* to 27*l.* per foot; and for Byzantine ornaments, at from 3*l.* 17*s.* to 11*l.* 10*s.* I cannot help thinking that there must have been some misunderstanding with respect to the above estimate; for such prices might justify the very minute work requisite for copying highly-finished pictures, but are altogether unreasonably high for ordinary decorative work. I am led to this conclusion because Ciampini tells us that, when Clement VIII., in the beginning of the seventeenth century, commenced the embellishment with mosaic of the dome of St. Peter's, the price offered for the labour was about 1*l.* 10*s.* per English foot. This was so profitable to the workmen, as to attract the labourers from all parts of Italy, "*fama tam immodici pretii.*" The consequence was that very speedily the price fell to about 7*s.* 3*d.* per English foot. This would be, of course, exclusive of the value of the material employed, which latter would be worth, then, probably about 15*s.* an English foot. Allowing for a great increase of value since Clement VIII.'s time, it is hard to suppose that similar work could be worth more than about 3*l.* sterling per foot at the present time. This would agree pretty well with what the director of the mosaic establishment at St. Mark's—Signor Moro—told Mr. Penrose; viz., that the cost of finished work, similar to the ordinary Byzantine, would be about 3*l.* 2*s.* per English foot.

With respect to the cost of the Venetian material, I have myself obtained from the Count Conaro the prices at which Signor Salviati, the practical manufacturer who makes for St. Mark's, will supply the smalti, viz., for gold and silver, 12*s.* per pound, cut into tesseræ; 6*s.* for the same quantity uncut. For varied colours, 3*s.* per pound uncut. Count Conaro states that it will take about 33 English pounds weight of gold and silver, or 50 pounds of coloured smalto, to do a French metre superficial of mosaic; the French square metre being rather more than an English superficial yard. Mr. Penrose remarks that, at Palermo the price is much the sane as at Murano for the smalto, but that the price for cutting it into small pieces is very much lower in the former than the latter place: thus the prices for cutting only, at Murano, are, for coloured smalti, 6*s.* 8*d.*; and for gold, no less than 15*s.* 6*d.* per English foot; while at Palermo, for 4*s.* 7*d.* per foot the manufacturers will cut up into tessaræ golden and coloured smalti indiscriminately. Mr. Penrose's object in making these inquiries was to ascertain how far it was practicable to enlist foreign assistance in carrying out some of his proposed decorations in St. Paul's in mosaic, of a more pictorial nature than we had at the date of his last visit to Italy succeeded in producing.

The notes he made become now, happily, of less importance than they then were; owing to the fact that with the exception of the gold ground mosaic, which our manufacturers have not yet, so far as I am at present informed, been very successful with, all the foreign pastes may be with advantage replaced by home produce, and the work done by English workmen. The actual purchases made by Mr. Penrose for the purpose of experimenting upon were as follows:—1200 cakes of gilt smalto, sufficient when cut up and wrought to cover about 80 feet English, 63*l.*; 332 lbs. avoirdupois of coloured smalto, sufficient to do about 128 feet, 35*l.*

In the recent Italian Exhibition the Florentine and Venetian mosaic workers alone were well represented. Salviati, the manufacturer, and Vincenzo Redi, the mosaicist, both of Venice, combined in contributing a fine figure of St. Nicholas, taken from Sta. Sofia, at Constantinople; and an equally good one of our Saviour, copied from an original in St. Mark's. Both of these left nothing to be desired in the way of material or workmanship. Antonio Gazetta, also of Venice, exhibited a very good head. I saw nothing, however, at Florence in these works which, with the exception, perhaps, of the good quality of the gold ground smalto, we could not I believe now rival in this country. It remains for us to see by what steps this newly-acquired faculty has been obtained.

The revival of mosaic in this country as an architectural adjunct may be considered to have begun in 1839-40; about which time Mr. Blashfield endeavoured to produce decorative pavements by means of inlaid asphalte, coloured cement, and Venetian pisé works, assisted by the clever inventions of Mr. Singer, of Vauxhall, by his ingenious assistant Mr. Pether, and also by Mr. Prosser's mode of producing a tile of great density and closeness of texture, by subjecting powdered China clay to strong mechanical pressure in iron moulds, and in this way obviating the shrinking caused by evaporation, which is unavoidable when the clay is used in a moist state. Mr. Prosser's invention was first applied to the manufacture of buttons, in which for some time a large trade was carried on. Recently the Messrs. Maw have invented a process by which they obtain tesseræ with the close texture and consequent hard surface, only to be attained by aqueous shrinkage, and hitherto only approached by subjecting the materials to extraordinary pressure.

Mr. Minton, I believe, at the suggestion of Mr. Blashfield, turned his attention to the application of Mr. Prosser's patents to the production of tesseræ suitable for the formation of pavements similar to those of the ancients. Many beautiful geometrical combinations for this purpose were suggested by Mr. Owen Jones; and the result of Mr. Minton's spirited efforts was the speedy introduction to the market of excellent tesseræ in all colours.

In 1844, when I went abroad to study my profession, Mr. Blashfield gave me a commission to obtain for him anything which I considered likely to render these tesseræ (the manufacture of which Mr. Minton had then just entered on) of more general utility. In Italy and Sicily I found much material, of which I believed little notice had at that time been taken; and this induced me to make a series of drawings, which I afterwards published in the 'Geometrical Mosaics of the Middle Ages.' These drawings were shown to Mr. Minton by Mr. Blashfield; and, on my return to England in 1847, Mr. Minton applied to me to assist him in his views with respect to encaustic tiles, and their combination with tesselated work in general. For some time I rendered him what aid I could; and, but for other and more pressing professional engagements, I should probably have continued to do so. On Mr. Minton's retirement from active business, Messrs. Maw and Co., determining to add the execution of mosaic to their encaustic tile manufacture, sought my co-operation, which has been given, at such intervals as have suited our mutual convenience, up to the present time. Feeling their strength quite equal to the production of pictorial as well as geometrical mosaic, Messrs. Maw requested me, on the announcement of the intended Exhibition of 1862, to design a pavement of that character for them. Some of the working drawings for that commission I now exhibit; and do not doubt that, on seeing the work done from them in the Exhibition, you will admit that Messrs. Maw and Co. have fully proved their capability to rival any antique mosaic yet exhumed in this country. To have attempted successfully such an experiment, involving the production of an indefinite number of tesseræ of about one hundred different tints—many never previously got up in England—and the application of skilled labour as it had never before, I believe, been employed in this country since the last Roman quitted it,—is, I do not hesitate to say, highly honourable to them as manufacturers; and it is a source of gratification to me to have been associated with them in this the first practical endeavour to revive the pictorial mosaic amongst us. That we shall soon have many rivals is not to be doubted; since already, through the energetic and most laudable prompting of Mr. Cole, a scheme has been set on foot to which no one amongst us can, I think, fail to give hearty sympathy and support. Some prospectuses, one or two of which I have laid upon the table, give the detail of a scheme, which, if carried out successfully—as I have every reason to think and believe it may—will give a rare impetus to the development of pictorial mosaic. Those details I do not dwell on; for the double reason that time will not now permit of my doing so, and that they will, I believe, form the subject of a paper hereafter at the Society of Arts. I may, however, point to two most hopeful features of progress certainly made:—1st, that already the practical co-operation of many of the most celebrated artists in this country has been secured; and 2nd, both Messrs. Minton and Messrs Simpson (Messrs. Maw and Co's London agents) have proved, that if artists will only make good designs, they possess all the requisite power to realise their designs successfully. To prove this, I need only point to a specimen produced by Messrs. Simpson, which has been kindly lent me by Mr. Cole.

Such being the actual conditions of the manufacture at the present moment, I think it will be admitted that it is really incumbent on the studious architect to endeavour to grasp the theory of the right application of pictorial mosaic; and it is in the endeavour to either aid him by my advice, or to aid myself by eliciting a rectification of my views, that I put before you, as the second and concluding part of this paper, a few convictions on the subject, with respect to which I see my way at present pretty clearly.

The combined action of the moisture and severe frost of our climate is such as must always, I fear, render but little durable any extensive application of mosaic in small tesseræ as external decorations; to a great extent, therefore, architects will have to look upon it as an internal embellishment. It is, of course, a coloured incrustation, applicable to any structural surfaces which it may be desirable to enrich; and its appropriate design must be strictly determined by very nearly the same laws which should govern the distribution of polychromatic decoration, executed through any other medium upon similar surfaces. The rationale of these laws has been by no one better illustrated than by Sir Charles Eastlake, in his invaluable reports to the Fine Art Commission; and it is better that I should refer you to what he has so well written in those documents, than attempt to give you now any paraphrase of my own. The chief exceptional conditions are, firstly, its expense, which entails simplicity; secondly, the extremely vivid way in which it reflects light, and exhibits local colour partially, demanding judgment to adapt the design to the mode of lighting; and, thirdly, its limitations, under ordinary circumstances, as a means of artistic expression, which lead to the prudent avoidance of many of those pictorial elements, such as perspective, foreshortening, lively action, or complicated chiaroscuro, which are proper and agreeable sources of effect in mural paintings executed with more tractable vehicles. That which the designer will probably at first feel to be his greatest difficulty, the arrangement of the cement joints which attach the tesseræ to one another, will, when once he has mastered the principles upon which they should be disposed, prove a ready and most essential means of heightening his effects. The jointing is, to a mosaic designer, exactly what the lines and reticulations of an engraving or etching are to an engraver; and the rules of taste which apply to the one apply equally to the other. For instance, as the engraver's lines by convexity or concavity express the undulations of drapery, and the modelling of surfaces advancing to or retreating from the spectator's eye, so precisely should the directions of the jointing of a piece of pictorial mosaic. Again, as the regular ruling or cross-latching of an engraved half-tint is made to give value to the broken lights and shades of the leading figures, to which by their vivid contrasts attention has to be attracted; so precisely should the uniformity of the jointing with even-sized tesseræ diminish the brilliancy of a mosaic background; breaking up the light which would otherwise be so strongly reflected from, say a white or golden background, as to quite kill the effect of the figures or ornaments to be relieved upon it.

Another point which should be carefully attended to in arranging the jointing, is to allow a row of tesseræ of the same colour as the ground to always follow every leading contour profiled upon the background. The use of this rule, which was invariably followed by all good mosaicists, is to prevent the directions of the generally horizontal and vertical jointing lines of the background from cutting awkwardly against the profiles, which the eye should be allowed to follow without being led off into other channels, or distracted by the occurrence of irregularly shaped tesseræ next to leading forms. This reduplication, as it were, of mosaic outline has almost the effect of the lead line in stained glass, and is not much less essential to good effect. It is highly gratifying to observe the degree of judgment with which the mosaicist has emphasized the designer's intention, by a judicious treatment of the jointing in Messrs. Simpson's specimen head now exhibited. It is always to be remembered that, at the distance from the eye at which mosaics are usually likely to be placed, mechanical defects disappear, but that artistic mistakes betray themselves, despite the most perfect mechanical execution. Hence it is far better to spend time, thought, and money, in getting really first-rate cartoons, than in endeavouring to bring the tesseræ to fine joints or microscopic minuteness. In mounting to the summit of the great dome of St. Peter's, glimpses are caught from time to time of the nature of the mosaic work; and the observer who from below may have fancied the whole to have been wrought with great exactness, will find that the work is of the coarsest description, with joints in which often a good-sized pencil might be laid. From its judicious design, however, the effect of the whole is eminently satisfactory, when viewed from the floor of the cathedral.

It may be well to remember also that although mosaic is, as it were, painting, it is something more in its relation to the structure it decorates; it has become "bone of its bone," and in virtue of its intimate and permanent union is especially bound to live in peace and harmony. As a good wife should make conspicuous the virtues of the husband she adorns, should hide his faults, and screen his defects; so should a well-devised system of mosaic give, by predominant vertical lines, height to a structure in which height is wanting, and, by predominant horizontal lines, length where length is needed. Brilliancy may be wrought out of darkness by allowing gold grounds and luminous colours to prevail; while the eye in another building, "faint with excess of light," may be refreshed by a preponderance of cool and quiet tones. String-courses and borders, archivolt and impost bands and friezes, should be treated as permanent frames to permanent pictures; essential, by their rectangularity or other simple geometrical character, to afford the eye a ready means of testing all adjoining and more complex forms by contrast. Need I say that where the skeleton of the picture's composition is tossed about in lively action, a stronger boundary of more vivid and contrasted hues must enclose it as a corrective, than when the motive power of the picture is of a quieter and simpler structure? That is the reason why the great Venetian pictures demand such massive framing; while the more serene compositions of the early Florentine and Siennese schools look best when separated one from another by little else than narrow bands of flat and softly-tinted ornament. In the same way, in mosaic, the rigid saints of the early Byzantine school, with their evenly-balanced limbs and perpendicular draperies, need little else than vertical palm-trees or inscriptions, or even upright staves placed between them, to keep them architectonic; while the later corresponding figures of the Italian school, with their swaying lines, require often actual insertion into niches to keep them even reasonably quiet.

Such are a few of the most important theoretical points which have occurred to me; but had time permitted I would willingly have entered this evening upon—what I have indeed partly prepared—an analytical sketch of the different artistic conventions which form graduated stages between the crudest mode of, as it were, symbolising nature, and the most highly perfected form of imitative art. While an intimate acquaintance with the specific conditions of each of these stages—which are to the designer what keys are to the musical composer—will be a great assistance to the mosaicist; an ignorance of or an indifference to them will lead him into great trouble and confusion.

In bringing this paper to a close, I may be permitted to say a few words with respect to specific style, as affecting pictorial mosaic. We have seen that, as a decorative art applicable to monumental structures, it has survived every fluctuation and vicissitude which have affected architecture from the Christian epoch to our own time: as certainly will it outlive the little differences which split us into Goths and Greeks—"big and little endians" of the professional golden eggs. We are now probably on the eve of introducing a new element into our national art; and happily one which may, with precedent, and therefore with a good conscience by those who lean heavily on precedent, be used alike in buildings of whatever historic style we may any of us peculiarly affect. Let me then express a hope that it may not be considered necessary to retain the defects and mannerism either of too much or too little academic knowledge, peculiar to ancient, mediæval, or modern times; but that we may rather concur in doing the very best we any of us can with this art, without pedantry or a slavish deference to the past. The whole history of monumental and industrial art has shown us, that never is perfection attained in any product in which the material conditions, and the processes by which those conditions may be best enhanced and developed, have not formed the basis of the theory of construction, manufacture, or application of any such product. This has held good of glass, stone, wood, marble, and of all the metals; and assured am I that, if we are to make this art of pictorial mosaic a credit to the nineteenth century, a similarly "objective" spirit must also direct and determine the specific mode in which, under every varying condition of style and historical association of ideas, we would endeavour to rival the great masters of old in their use of this time-honoured embellishment.

THE ECONOMIC ANGLES IN PARALLEL OPENWORK GIRDERS.

(*Continued from page* 98.*)

We have hitherto spoken of each pair of braces as having to convey a certain vertical component=V, towards one only of the piers, say to pier Q, so that the first individual of the pair is always a strut or tie, while the other is always a tie or a strut. But there are some cases in which a pair of braces may be required to transmit a vertical component at one time in the direction of pier Q, and at another (from changes in the distribution of the loading) in the opposite direction, or towards pier P. This occurs in the central pairs of long girders when a large portion of the loading is moveable, and still more strikingly in the case of the longitudinal stiffening girders applied to suspension bridges, the duty of which is to distribute as uniformly as may be over the span the effect of a concentrated or irregular loading.

When the amount of action of the pair, or the value of V, is as great when directed towards one pier as when towards the other, the economic angles will evidently be each equal to 45°, whatever the ratio of a_1 to a_2. And many of the pairs in the stiffening girders of a suspension bridge will approximate more or less nearly to this condition. On the other hand when the secondary value of V is less than $\frac{a_1}{a_2}$ times the first value (supposing ties to be the most economical braces, and $\frac{a_2}{a_1}$ times when struts are the most economical) then the secondary action may be neglected, since the angles θ_1 and θ_2 being calculated with reference to the greater value of V, there will nevertheless be sufficient material in the parts to carry the less value of V in the opposite direction; care must however be taken to give a suitable form of section to that brace which is in the first instance a tie, to fit it for acting as a strut under the less value of V.

The Application to Actual Structures.

The general conclusion arrived at in a previous paper, that, when one uniform value of a is adopted for both booms the sum of all the numbers representing the weights of every bay of both booms, is unaltered by changes in the inclinations of the braces —so long as the distribution of the loading remains the same—is practically applicable, with an approximation to accuracy, to very few structures. The most important are the longitudinal stiffening girders of suspension bridges, whose booms act alternately as struts and ties. There are some other structures that may be mentioned, the loadings or pressures on which may at different times act in opposite directions, but to which the investigation is scarcely applicable; such are the piers of viaducts, the longitudinal stengthening girders in some ships, horizontal girders to resist the wind, &c.

When a for the upper boom is taken greater or less than a for the lower one, the above conclusion would no longer hold good. And we might therefore very properly go on to investigate the economic angles for various girders having one uniform value of a for the top boom, and another uniform value of a for the bottom boom, this would lead us somewhat nearer to the truth, particularly in the case of structures having long spans in proportion to their depths; we will not however, at least at present, enter upon this part of the subject, but proceed at once to the practical consideration of the general and much more interesting questions connected with the construction of complete girders in an economical manner.

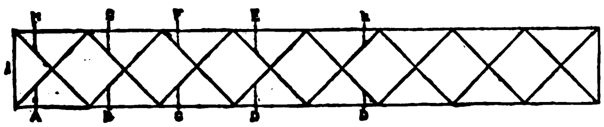
THE ECONOMIC CONSTRUCTION OF GIRDERS.

As the above title is a very comprehensive one (and indeed includes the subject we have just left) it is necessary to state that we do not intend at present to treat on the general subject of the economic construction of girders, but only employ the heading as an appropriate one under which to classify what follows in this, and also, it may be, in some future papers.

We purpose discussing certain girders in a thoroughly practical manner, taking no uniform value of the factor a for a boom, or for the struts of the bracing, or other parts, but adopting such a value of it for each particular bay of the booms, and for each particular brace, as shall be derived from executed structures, or dictated by constructive as well as theoretical considerations. It must be apparent that such a treatment of the subject removes it at once from the grasp of the higher forms of mathematical analysis; and our course of procedure will therefore be to tabulate the results of the separate calculations, based upon actual working data, of all those forms or varieties of any given structure which have any chance of being adopted; so that their respective merits and peculiarities may become obvious at a glance. Of course such a mode of investigation is both tedious and cumbrous, but it will be appreciated by a much wider circle of readers, and have a more direct bearing upon practical construction than any other mode; and we think it right to give the calculations in considerable detail, since the values of the factor a are taken somewhat arbitrarily, and as the forms of girder that will be made the subjects of discussion are such as will probably be employed in bridge construction to a very great extent indeed.

So long as the question of the economic angles is confined to cases in which the depth is less than or only one-sixteenth of the span (like the Newark Dyke Bridge, and many others which fol-

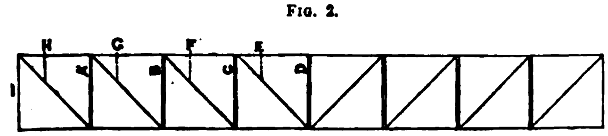
Fig. 1.



low in this respect the proportions of the Britannia Tube) as well as to suspension bridge stiffening girders, it is of very considerable importance; and the economic angles for the whole structure will approximate pretty nearly to the values given in Tables I. or II., on page 98. But when we accept the option which openwork construction offers us, of making the proportional depth twice as great as that of the Britannia Tube, with the highly economic advantage of a diminution of the stresses in the top and bottom of the girder by more than one half, we shall find that the effect of variations in the value of θ is very much complicated with and overborne by the influence of other elements that enter into the question.

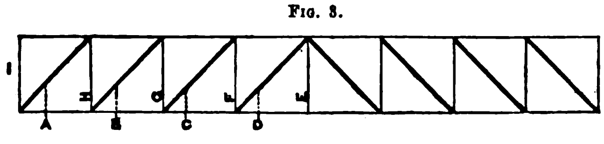
This point of depth of structure in proportion to span, is that on which must chiefly rest the comparison of plate with openwork girders; yet in a discussion, which extended over two

Fig. 2.



evenings, at the Institution of Civil Engineers, London, on the relative merits of these different modes of construction, it was altogether overlooked. In the letter already referred to (Vol. xviii. p. 236) the writer had the honour of being the first to draw attention to the matter, and further of advising the adoption for openwork girders of a depth equal to at least one-eighth of the span; and to this proportion he has very uniformly adhered in his practice as a consulting engineer, with the most gratifying economical results. Fig. 1 shows the girder of a viaduct constructed according to his drawings and calculations, two girders being employed to support two lines of railway; these girders have a depth equal to one-eighth of the span; and two series of braces, all placed at an angle of 45°, so that the span is divided into eight equal bays or sub-spans. We purpose now giving the

Fig. 3.



calculations of the quantities of material required for the construction of all the marked varieties of such a girder, under various conditions of loading and attachment to the piers, so that by tabling the results, their respective costs can at once be ascertained, and hence the most economical form for the purpose in view made choice of.

The varieties of the pattern of the girder itself which we shall consider are *four*, viz. :—1st. The regular form shown by Fig. 1, in which all the braces are inclined at 45°. 2nd. A modification of Fig. 1, in which all the braces, the inclinations of which

* The equivalent of x as given in equations (5) *ante* should be multiplied by c.

can be altered without affecting the distribution of the loading, will be placed at the economic angles calculated by formula 2, p. 97, for the case of the bracing alone being considered. 3rd. The form shown by Fig. 2, in which all the struts are placed perpendicularly, and the ties at 45°, the number of series being reduced to one; and 4th. The analogous form shown by Fig. 3, in which all the ties of the bracing are vertical, and the struts at 45°. The loading will be considered as applied in *two* different ways, 1st, as concentrated at the level of the upper boom; and 2nd, as wholly at the level of the lower boom. The modes of attaching the girder to the piers will be *three*; viz.:—1st. By the extremities of both booms, so that no end pillar is required. 2nd, by suspension, the attachment being at the extremities of the upper boom, and therefore the end piece acting as a tie; and 3rd, by direct support at the extremities of the lower boom, the end pillar being then a strut. There will therefore be results for twenty-four different arrangements or combinations, in all of which the span S, the depth D, the bays of the roadway, and the amount of the loadings, are the same; the only changes being in the values of θ. The loadings we will suppose to consist of a moveable loading equal to one ton per foot run of the girder, and a fixed loading or dead weight, equal to half a ton per foot run. Were other values of the dead weight assumed, the number of combinations would be so many-fold increased, but the estimate we have adopted is pretty well suited for ordinary railway bridges of certain spans.

The values of a employed in the calculations are as far as found suitable drawn from the completed viaduct already referred to, the whole being of wrought-iron. The values of a are taken so great as to make a liberal allowance for joint-plates, for excess of material rendered advisable or unavoidable; for excess of length of parts above the calculated length between the points of intersection of the central lines; for rivets in the case of struts, required to build them up; and for loss of strength in the case of ties, from rivet holes, supposing these to be judiciously placed; these extras have been taken so liberally, that in some structures as much as 10 to 15 per cent. might be safely abstracted from the values of a. No general rule can be given for the value to be assigned to the factor a for struts: regard must be chiefly had to the unsupported length compared with the amount of stress to be conveyed, as this in a great measure determines the proportions of length to least width. Again, in girders, the form of section of the bracing struts will very properly be chosen with respect to the first or strongest, marked A in the figures; and as all the struts must, for constructive reasons, be of somewhat the same pattern, the shape determined upon will necessarily be very ill-suited for the central struts, and consequently the values of a for these should on this account as well as from their diminished stresses in proportion to their lengths, be greatly increased.

The depth D will be assumed as the unit of length, and one-twenty-fourth of the whole load on the girder will be taken as the unit of weight or stress; one-half only of the length of each girder will be calculated, and the weight of each part made = stress × length × a = V $\sec^2\theta$ a.

The details of the calculations for the case of the girders being of wrought-iron are so fully given, that little trouble will attend the calculation of results for other materials or circumstances, since the requisite substitution of the appropriate values of a are rendered by such detail as clear as possible.

Calculations of the Weight of Iron in the Bracings and End Pillars.

1. In Table I. are given the elements and results of the calculations for the first or regular form, Fig. 1, when the roadway is situated at the level of the upper boom.

TABLE I.

Brace.	a.	V.	$\sec^2\theta$.	Weight.
A	0·00060	6	2	0·00720
B	0·00067	4·5	2	0·00603
C	0·00077	3·25	2	0·00501
D	0·00090	2	2	0·00360
E	0·00120	1	2	0·00240
F	0·00045	2	2	0·00180
G	0·00045	3·25	2	0·00292
H	0·00045	4·5	2	0·00405
				0·03301
I as a tie	0·00045	6	1	0·00270
I as a strut	0·00060	6	1	0·00360

Table II. is for the girder as above, but with the roadway at the level of the lower boom.

TABLE II.

Brace.	a.	V.	$\sec^2\theta$.	Weght.
A	0·00065	4·50	2	0·00585
B	0·00076	3·25	2	0·00494
C	0·00090	2·00	2	0·00360
D	0·00120	1·00	2	0·00240
E	0·00045	2·00	2	0·00180
F	0·00045	3·25	2	0·00292
G	0·00045	4·50	2	0·00405
H	0·00045	6·00	2	0·00540
				0·03096
I as a tie	0·00045	6·00	1	0·00270
I as a strut	0·00060	6·00	1	0·00360

In the first of the above tables, the values of a are taken in excess of, but as nearly as possible in proportion to those for the actual viaduct. It will be observed that strut A in the second table has the same value of V as strut B in the first; but a better form, of section may be chosen for the former, a, for it is therefore taken somewhat less than for B: the other values of a are assigned from similar considerations.

2. The elements and results of the calculations for the second form, or that with the economic angles as already explained, are given in Tables III. and IV.; the first being for the case of the loading being at the level of the upper boom, the second for the loading concentrated at the lower level.

TABLE III.

Brace.	a.	θ.	V.	$\sec^2\theta$.	Weight.
A	0·00060	45° 0	6·00	2·0000	0·00720
B	0·00067	38°47	4·50	1·6457	0·00496
C	0·00077	36°25	3·25	1·5442	0·00386
D	0·00090	33°41	2·00	1·4442	0·00260
E	0·00120	45° 0	1·00	2·0000	0·00240
F	0·00045	53° 8	2·00	2·7782	0·00250
G	0·00045	51°37	3·25	2·5937	0·00379
H	0·00045	50° 7	4·50	2·4321	0·00493
					0·03224
I as a tie	0·00045	0	6·00	1·0000	0·00270
I as a strut	0·00060	0	6·00	1·0000	0·00360

TABLE IV.

Brace.	a.	θ.	V.	$\sec^2\theta$.	Weight.
A	0·00065	39°17	4·50	1·6691	0·00488
B	0·00076	36°39	3·25	1·5536	0·00384
C	0·00090	33°41	2·00	1·4442	0·00260
D	0·00120	45° 0	1·00	2·0000	0·00240
E	0·00045	53° 8	2·00	2·7782	0·00250
F	0·00045	51°29	3·25	2·5786	0·00377
G	0·00045	49°46	4·50	2·3970	0·00485
H	0·00045	45° 0	6·00	2·0000	0·00540
					0·03024
I as a tie	0·00045	0	6·00	1·0000	0·00270
I as a strut	0·00060	0	6·00	1·0000	0·00360

3. Tables V. and VI. are for the third form of the girder, or that in which the struts of the bracing are vertical, and the ties at an inclination of 45° (Fig. 2). The first of these tables is for the case of the load being at the upper, the second for the load being at the lower level.

TABLE V.

Brace.	a.	V.	$\sec^2\theta$.	Weight.
A	0·00060	10·50	1	0·00630
B	0·00067	7·75	1	0·00519
C	0·00077	5·25	1	0·00404
½ of D	0·00090	1·50	1	0·00135
E	0·00045	3·00	2	0·00270
F	0·00045	5·25	2	0·00473
G	0·00045	7·75	2	0·00697
H	0·00045	10·50	2	0·00945
				0·04073
I as a tie	∞	0·00	1	0·00075
I as a strut	0·00060	12·00	1	0·00720

TABLE VI.

Brace.	a.	V.	$Sec^2\theta$.	Weight.
A	0·00065	7·75	1	0·00504
B	0·00076	5·25	1	0·00399
C	0·00090	3·00	1	0·00270
½ of D	∞	0·00	1	0·00075
E	0·00045	3·00	2	0·00270
F	0·00045	5·25	2	0·00472
G	0·00045	7·75	2	0·00698
H	0·00045	10·50	2	0·00945
				0·03633
I as a tie	0·00060	1·50	1	0·00030
I as a strut	0·00060	10·50	1	0·00690

4. The calculations of the weights of the various parts of the fourth form, Fig. 3, having vertical bracing ties, the struts being inclined at angles of 45° therewith, are given, for the two cases of the load being concentrated at the top and the bottom booms, in Tables VII. and VIII. respectively.

TABLE VII.

Brace.	a.	V.	$Sec^2\theta$.	Weight.
A	·00060	10·50	2	·01260
B	·00067	7·75	2	·01038
C	·00077	5·25	2	·00809
D	·00090	3·00	2	·00540
½ of E	∞	0 00	1	·00030
F	·00045	3·00	1	·00135
G	·00045	5·25	1	·00236
H	·00045	7·75	1	·00349
				·04397
I as a tie	·00045	10·50	1	·00473
I as a strut	·00120	1·50	1	·00180

TABLE VIII.

Brace.	a.	V.	$Sec^2\theta$.	Weight.
A	·00060	10·50	2	·01260
B	·00067	7·75	2	·01030
C	·00077	5·25	2	·00809
D	·00090	3·00	2	·00540
½ of E	·00045	1·50	1	·00068
F	·00045	5·25	1	·00236
G	·00045	7·75	1	·00349
H	·00045	10·50	1	·00472
				·04764
I as a tie	·00045	12·00	1	·00540
I as a strut	∞	·00	1	·00200

TABLE IX.

Results for the Webs complete.

	Without I.	With I as a tie.	With I as a strut.
1st Case: Load at Top.			
1st Form of Girder	·03301	·03571	·03661
2 ditto	·03224	·03494	·03584
3 ditto	·04073	·04148	·04793
4 ditto	·04397	·04870	·04577
2nd Case: Load at Bottom.			
1st Form of Girder.	·03096	·03366	·03456
2 ditto	·03024	·03294	·03384
3 ditto	·03633	·03723	·04263
4 ditto	·04764	·05304	·04964

Calculations of the Weight of Iron in the Booms.

The lengths of the bays, except in the second form, are all equal to unity. In Figs. 2 and 3 it may be observed that in certain cases the first bay of one of the booms may be omitted along with the end pillar: two additional combinations thus produced will be noted in the table of final results.

It is impossible to make the estimates of the booms with minute accuracy, as for this purpose the nature of every detail of construction would have to be specified. All we can attempt is to give values to the factor a just so great as to cover liberally all extras to which judiciously-designed girders may be liable. Thus, for instance, the boom at the level of which the roadway is situated, will generally demand an excess of material to counterbalance any cross strains brought upon it, or augmentations of its longitudinal stresses from the action of the principal horizontal bracing: but no special change in the values of a for the boom on account of this will be made in the calculations; it will be understood that to meet it a small portion of the values of a may be abstracted from the one boom and transferred to the other, the latter being the one at the level of the roadway.

TABLE X.

1st Form of Girder. Estimate of the Weight of the Booms when the load is all at the upper level.

	a.	Stress.	Weight.
Upper Boom.			
1st Bay	·00180	4·5	·00810
2	·00070	13·5	·00945
3	·00060	19·5	·01170
4	·00055	22·5	·01238
			·04163
Lower Boom.			
1st Bay	·00067	6·0	·00402
2	·00045	15·0	·00675
3	·00045	21·0	·00945
4	·00045	24·0	·01080
			·03102

TABLE XI.

1st Form, with the load at the lower level.

	a.	Stress.	Weight.
Upper Boom.			
1st Bay	·00140	6·0	·00840
2	·00070	15·0	·01050
3	·00060	21·0	·01260
4	·00055	24·0	·01320
			·04470
Lower Boom.			
1st Bay	·00080	4·5	·00360
2	·00045	13·5	·00608
3	·00045	19·5	·00877
4	·00045	22·5	·01012
			·02857

TABLE XII.

2nd Form of Girder, with the load at the upper level.

	a.	Stress.	Length.	Weight.
Upper Boom.				
1st Bay	·00170	5·3838	1	·00915
2	·00070	15·1707	1	·01062
3	·00060	20·7869	1	·01247
4	·00055	23·0000	1	·01375
				·04599
Lower Boom.				
1st Bay.	·00067	6·0	1·1964	·00481
2	·00045	15·0	1·0659	·00720
3	·00045	21·0	1·0710	·01012
4	·00045	24·0	0·6667	·00720
				·02933

TABLE XIII.

2nd Form, with the load at the lower level.

	a.	Stress.	Length.	Weight.
Upper Boom.				
1st Bay	·00140	6·0	·8182	·00687
2	·00070	15·0	·9256	·00972
3	·00060	21·0	·9229	·01163
4	·00055	24·0	1·3333	·01760
				·04582
Lower Boom.				
1st Bay.	·00095	3·6819	1	·00350
2	·00045	11·9133	1	·00536
3	·00045	18·2314	1	·00820
4	·00045	22·0000	1	·00990
				·02696

Had the above two tables been calculated with one uniform value of a for both booms, the total results would have been the same as for the regular form similarly calculated.

TABLE XIV.

3rd Form. The estimates of the Booms for the two cases of a load at the upper and at the lower levels, may be made alike for this girder.

	a.	Stress.	Weight.
Upper Boom.			
1st Bay	·00081	10·5	·00850
2	·00065	18·0	·01170
3	·00058	22·5	·01305
4	·00055	24·0	·01320
			·04645

Lower Boom.	*a*.	Stress.	Weight.
1st Bay	∞	0·0	·00360
2	·00045	10·5	·00473
3	·00045	18·0	·00810
4	·00045	22·5	·01012
			·02655

TABLE XV.

4 Form. Estimate of the Booms for both cases of the load being at the upper and at the lower levels.

Upper Boom.	*a*.	Stress.	Weight.
1st Bay	∞	0·0	·00800
2	·00080	10·5	·00840
3	·00060	18·0	·01080
4	·00055	22·5	·01238
			·03958
Lower Boom.			
1st Bay	·00045	10·5	·00473
2	·00045	18·0	·00810
3	·00045	22·5	·01012
4	·00045	24·0	·01080
			·03375

TABLE XVI.

Summary of Results for the Booms.

1st Case: Load at Top.	Top.	Bottom.	Total.
1st Form of Girder	·04163	·03102	·07265
2 ditto	·04599	·02933	·07532
3 ditto	·04645	·02655	·07300
4 ditto	·03958	·03375	·07333
2nd Case: Load at Bottom.			
1st Form of Girder	·04470	·02857	·07327
2 ditto	·04582	·02696	·07271
3 ditto	·04645	·02655	·07300
4 ditto	·03958	·03375	·07333

TABLE XVII.

GENERAL SUMMARY OF RESULTS FOR THE GIRDERS COMPLETE (composed from Tables IX. and XVI., &c.)

1st Case: Load at Top.	Without end pillars.	With end pillars as ties.	With end pillars as struts.
1st Form, Fig. 1.	·10566	·10836	·10926
2nd "	·10756	·11026	·11116
3rd " Fig. 2.	·11373	·11448	·12093
4th " Fig. 3.	·11730	·12203	·11910
2nd Case: Load at Bottom.			
1st Form, Fig. 1.	·10423	·10693	·10783
2nd "	·10302	·10572	·10662
3rd " Fig. 2.	·10933	·11023	·11563
4th " Fig. 3.	·12097	·12637	·12297

3rd Form, with load at top, and with end pillar and 1st bay of bottom boom omitted = 0·11013.

4th Form, with load at bottom, and with end pillar and 1st bay of top boom omitted = 0·10297.

This table of results offers many interesting and instructive points worthy of attention, but we will only say a few words thereon. The most remarkable general conclusion is, that the weights vary in a much less degree than could have been expected; this arises from the ratios of Table IX. being in a great measure overborne by the reverse action of those in Table XVI. We must not however be misled by this into undervaluing the importance of a consideration of the inclinations of the braces, for were the spans in proportion to the depths much increased, we should get other results.

The most important arrangement is that wherein the end pillar acts as a strut; and for this, when the load is at the lower level, the results are, as regards economy, in the order in which we would have expected; when however the load is at the upper level, which will generally form the cheapest arrangement for a bridge, it appears that the regular form, Fig. 1, ranks first in order of economy. With the end pillars as struts, both the heaviest and lightest constructions occur when the load is at the lowest level, the heaviest or that for Fig. 4 being 15·33 per cent. in excess of the 2nd form; when the load is at the upper level the heaviest, No. 3, exceeds the lightest, No 1, by 10·7 per cent.

It should be noted, however, that the absolutely most economical structure is not included in the table; but it is obvious that the results for it would differ very slightly indeed from the least of those for the two first forms, and from this and constructive reasons the first or regular form, Fig. 1, should always be preferred.

That modification of the fourth form, in which the end bays of the top boom and the end pillars are done away with, appears at first sight to possess economic merits, but it would demand a considerable addition of material to be devoted to steadying the top boom in a lateral direction.

We will now show the use of the tables in calculating the actual weights, in tons, of any girder, suited to bear a working load consisting of one ton moveable and half a ton fixed per foot run of the span.

The unit of length is $= S \div 8$ feet, and the unit of weight or stress is $= 1\frac{1}{2}\, S \div 24$ tons; and as the quantities in the tables are calculated for the halves of the lengths of the girders, we have for the whole weight—

$$\text{Weight of girder} = \text{tabular number} \times \frac{S}{8} \times \frac{1\frac{1}{2}S}{24} \times 2 =$$

$$\text{Tabular number} \,.\, \left(\frac{S}{8}\right)^2 \text{or} = \text{Tabular number} \,.\, D^2.$$

Let us take examples of the regular form Fig. 1, with end struts and the load at top. The tabular number for these will be $= 0·10926$, and we have

Span for Calculation.	Weight of Girder complete.
120 Feet	24·58 Tons.
130 "	28·85 "
140 "	33·46 "
150 "	38·41 "
160 "	43·70 "

These weights will appear to many engineers to be very light for such spans (the girders being *double ones*, or each suited to carry a whole line of railway); this lightness arises from the depth of structure. To show that there is really an excess of strength, we may calculate the stress per inch of section in the various parts. The weight of a prism of good rolled iron, one foot long and one inch in sectional area, weighs very nearly 0·0015 tons, and as *a* in the tables represents the weight of that fraction of such a bar required to convey one ton of stress, the number of tons of stress per sectional inch of the part will be $= 0·0015 \div a$. Now applying this formula, we get the following stresses per sectional inch, on the supposition that all the material of any bay or brace is available as though spread over the calculated length.

Upper Boom.	Stress in Tons.	Brace.	Stress in Tons.
Bay 1	0·833 Comp.	A	2·5 Comp.
2	2·143 "	B	2·239 "
3	2·500 "	C	1·948 "
4	2·727 "	D	1·667 "
Lower Boom.		E	1·250 "
Bay 1	2·239 Tensive.	F	3·333 Tensive.
2	3·333 "	G	3·333 "
3	3·333 "	H	3·333 "
4	3·333 "		

To arrive at the actually efficient sections, and the corresponding stresses per sectional inch of metal, certain percentages would have to be deducted from the values of *a*, given in Tables I and X. These deductions would be much less in the case of struts than for the ties, on account of less weakening from rivets, and less material required for joint-plates. And it will hence be seen that the strength given to the struts is very considerably in excess of that very frequently, but the writer thinks, with danger, allotted to them.

The gross weight of the ties in proportion to the weight of the efficient portion depends so much upon the lengths of the plates used, that no satisfactory rule can be given for estimating the extras; the two principal items are—1st, the part of the section cut through or away by the rivet holes; and 2nd, the joint-plates. Now we may readily diminish one of these, but by increasing the other, so that, for plates of a given length, there is some degree of uniformity in the sum of these two additions of, in a certain sense, useless material. As an approximation we may estimate the various portions of *a* thus:—

Solid metal in section of Tie	=	100	or	69·0
Metal rendered useless by rivet holes	=	25	"	17·2
Extra metal in Joint Plates, rivets, extra length, &c.	=	20	"	13·8
		145		100·0

In the case of the bays of the lower boom, there will be no extra length, but long joint-plates; in that of the diagonal ties there may be no joint-plates, but the length may exceed that used in the calculations. According to the above estimate we should take only 69 per cent. of a, in calculating the true stress per solid inch of section: thus when $a=0\cdot00045$, the stress so counted will be $=0\cdot0015 \div 0\cdot69a = 4\cdot83$ tons.

For a double girder with a span for calculation equal to 144 feet, the weight is 35·4 tons, or in detail as follows:—

		Tons.		Per Cent. of whole.	Approx. Ratios	
Top of Girder	=	13·488	or	38·10	 4	2
Bottom of ditto	=	10·050	,,	28·39	 3	
Web and Pillars	=	11·862	,,	33·51	.... 3·5	1

Here we find that when the depth of our openwork girder is made one-eighth of the span, the weight of the web complete is just one-half of that of the booms taken together, or one-third of the whole. If the depth be made only half of this, or one-sixteenth of the span, the weight of the booms may be roughly estimated at double, or say = 4; whereas, as explained in a former paper, the weight of the web would not be materially altered—that is, it will still remain nearly equal to 1, and the weight of the whole girder will be represented by 5. Now in the best examples of plate girders constructed with a depth equal to one-sixteenth of the span, the booms may be set down at the same as for an openwork girder of equal depth,—that is, their weight will be represented by 4, while the web is generally one-third of the whole, or=2. So that, were we limited to such a depth of structure for both descriptions of girder, the openwork one should possess an advantage in point of economy of weight in the proportion of 5 : 6. When however the depth of the openwork girder is made one-eighth, and that of the plate one-sixteenth of the span, the ratios will be as 3 : 6; each part of the openwork girder, viz., top boom, bottom boom, and web, being then about half the weight of the corresponding part in the plate girder. This is a very rough comparison to make on such an important point, and may therefore be allowably objected to by the advocates of the plate form of web; it is, however, offered by the way, and we shall probably treat on the subject more fully at some other time.

Edinburgh. R. H. B.

THE ARCHITECTURAL EXHIBITION

(Continued from page 96.)

Mr. E. B. Lamb, in his "Proposed Restoration of the Church at Mellis, Suffolk (37), does not employ flint-work in those chequered patterns so common in that part of England. The tower, too, appears unduly heightened for its width, and we remark upon this point under the impression that its upper part is to be entirely new, the present tower having long been a ruin. Mr. Lamb has a whole succession of pictures arranged together, to which we can scarcely do more than direct attention. Most of them are small, and sketchily done; but one and all, whether based on Italian or Gothic principles, are treated in that free and artistic manner in which their architect so much excels, and which causes one almost to overlook the venturesome anomalies which are occasionally introduced. Thus, "Hodnet Hall" (33), is a capital specimen of a plain half-timbered residence, with simple overhanging gable-rafters and eaves; in (34) we have a pretty "Villa to be erected at Kingston-on-Thames," and a clever "Study for Schools at Shobdon;" (35) is a frame containing six subjects, all happily conceived and expressed; (38) contains a "Lodge," with stepped gables, effective in the extreme; also an "Interior of a Private Chapel, erected at Carnsalloch, N.B.," which is noticeable for its stone roof, and curious scheme of partite groining, by which the main ribs diverge, so as to come down on each side of a window—an idea which Mr. Lamb has reproduced in his wood ceiling to the "Interior of a proposed Church" (18), in the next frame. In (40), among other excellent conceits, Mr. Lamb gives two characteristic drawings of "Warehouses for the Consignment and Store Company;" (41), in his "Sketch for a Public Library," essentially pure Classic in its treatment, and ably handled, there is a flat segmental dome over the centre, which conduces much to the completeness of the design. Mr. Rushforth, in his "House now building in the West of England" (16, 17), has not ventured beyond a careful and correct reproduction of Mediæval forms and details, and this is hardly to be commended.

Messrs. Willson and Nicholl, in (59), exhibit some excellent "Studies" of Gothic detail, as applied to subjects which, to be treated properly, require the nicest discrimination and taste, viz., the "High Altars" of Roman Catholic churches. The two herewith given are models of their kind. Very little can be said in praise of Mr. North's "Competition design for the Oswestry Cemetery" (56), which appears based on thoroughly mistaken notions of Gothic principles. Nor will Messrs. F. and H. Francis's attractive frame of photographs (57) bear a close scrutiny, for a similar reason. But if there be occasion to object to these, what shall be said to the next picture (58), in which Mr. F. G. Lee seems to have endeavoured to heap a mass of absurdities without a single redeeming feature. It is called "Meopham Court, Kent," and its crudeness of forms is only equalled by the poverty of its details. A plinth is considered an all but indispensable, as well as useful, feature in Gothic architecture, but Mr. Lee apparently thinks otherwise. The entrance porch is of wood, but of so odd a shape, and so pinched and feeble, that it looks more like the skeleton of a summer-house than anything else.

It is refreshing to turn to (63) in which Mr. Truefitt gives one of his characteristic modern residences—that erected at Hornsey Rise—showing what may be done with economical materials when rightly handled. The only other contribution by this gentleman is (55) a slight but cleverly tinted sketch of a homely village church—Blakemere, in Herefordshire. Mr. R. W. Edis's two "Chimneypieces," in (64), display correct feeling, and are boldly conceived. That for Mr. Woolner's studio is of the plainest possible design, in red and black bricks, while that for the drawing-room of the Poet Laureate is proportionably elegant, in stone and marble, with inscriptions along the sloping top. (65*a*, 65*b*, 65*c*) we may mention in passing, as containing a selection of the "Illustrations" which have been recently given in this Journal. Mr. G. Baxter's sketches from Arbroath Abbey, and Glasgow Cathedral (68), may be instanced as rough but effective renderings of their respective subjects, without that painful labour which is generally bestowed upon pencil drawings.

Among the designs for "Drinking Fountains," that by Mr. J. Johnson (77) presents a few good features, while there is an over-ornateness as well as loftiness which appear to be unnecessary. In the "Family Memorial" about to be erected in Brighton Cemetery, and designed by Mr. Burnet, the arrangement of the parts is as novel as it is pleasing, and the several parts are made subservient (as they should be) to the general outline, which is gracefully pyramidal. The style is the Early Gothic, and it would be unexceptionable, but that some of the supporting piers *look* scarcely equal to bearing the superincumbent mass. The "Piazza del Popolo," at Florence, is well shown (80) in an oil painting, by Mr. Shoubridge. The building is a grand and simple study of Northern Italian art. Mr. C. N. Beazley's "Sketches in France and Italy" (81), are ten in number, and among the best of their class,—clear, sharp, and correct. No effort has been made to indicate the shaded effect, but just so much only is jotted down as to denote the architectural proportions and details—in fact, they appear to be transferred from the author's sketch book, precisely as finished on the spot.

In (86) Mr. C. H. Smith exhibits what he calls a "Design for an Octagonal Vestibule, with four porticoes to the principal Government Offices," a scheme unquestionably destined to remain *in nubibus*, for anything so extravagantly absurd it has seldom been our lot to encounter. The enormous scale on which such a building would have to be erected is, of itself, a sufficient barrier to its ever being carried out, nor do we see the slightest counter-advantage proposed to be secured. The site is probably intended to be not far from the spot where the Mediæval gateway at Whitehall formerly stood, but this latter, beautiful as it was, would shrink into insignificance, were the present idea to be ever realised. Mr. Goldie sends, as usual, several clever drawings, including (90), "Studies for portions of new buildings, Arundel Castle," and a "Design (156) for the Hull Town Hall." In the former of these, especially, (for the frame includes several sketches) the author's appreciation of Gothic principles is unmistakeable, and that knowledge has been judiciously exercised.

Passing by the visionary scheme (91) designed to commemorate the exhibition of 1851, and whose "Internal relievos, frescoes, and stained glass, illustrating the objects for which great medals were awarded, surrounding the central stair, would (somehow or other) carry the datum line of the world's science and art at this period into future time," we come to a matter-of-fact "design for the Birkenhead Workhouse," by Mr. R. Griffiths (92), which at once levels our thoughts again to stern realities; while the adjoining selection of admirable lithographs, by Mr. J. B. Waring (93), consisting of "Sculptural and Architectural Studies from Miraflores, Castile," it is truly delightful to contemplate. The infinite resources of these designs are no less remarkable than the skill with which they are here delineated, as every one must know who has looked over the sumptuous work from which they have been culled. The cast-iron and steel goods designed for Messrs. Longden and Co., of Sheffield, as shown in (94), are a marked improvement upon the majority of such articles, the manufacturers having had recourse to the professional assistance of Messrs. Walton and Robson in preparing the designs. The drawing before us embraces an elaborate Gothic grate, fender, and fire-irons, another of a plainer kind, and some staircase railing and metal work. The principal grate is made in cast-iron, and so designed that it can be ground upon a grindstone, and all its outer surfaces brought to a Sheffield polish; burnished brass mouldings surround it, and brass ornaments, as finials and angle-coverings, are added. The electro-bronzed architrave is studded with small convex mirrors and lesser enrichments, while a considerable portion of the front surfaces is covered with diaper work. The grate proper is supported on standards, being an adaptation of the "dogs" of Mediæval times. The fender is simply an electro-bronzed plinth, on which are standards carrying a steel rod. An ashpan is fitted under the bars of the grate, and it follows the shape of the fender; the slopes of the internal bars in the ashpan are so arranged that the spaces are wider at bottom than at top, and thereby ashes do not so readily lodge. The fire-irons comprise several novelties, all devised so as to be practically useful. Notwithstanding these improvements, we learn that this grate can be procured at the ordinary price for articles of this class. Several photographs from drawings of works executed by Mr. E. Hadfield will be observed with interest in (99), particularly his additions to a Convent at Leeds.

(To be concluded in our next.)

THE BELL ROCK LIGHTHOUSE.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—Sir John Rennie, in his 'Account of Plymouth Breakwater,' published in 1848, says that the late Mr. Rennie 'designed and built the Bell Rock Lighthouse,' while he withholds even the name of Robert Stevenson, the engineer of the work. This groundless statement, made for the first time thirty-seven years after the completion of the lighthouse, and twenty-four years after the publication of Mr. Stevenson's 'Account' of the work, was fully refuted in the correspondence of 1849 between Sir John Rennie and Mr. Alan Stevenson, which is to be found in the thirteenth volume of the *Civil Engineer and Architect's Journal*. Mr. Smiles in his 'Lives of Engineers,' just published, took his notice of the Bell Rock from Sir John Rennie; and I am happy in having this opportunity of acknowledging the courtesy with which Mr. Smiles at once agreed to delete certain passages and alter others in the second edition of his book. As it still, however, contains much that is erroneous regarding the Bell Rock, I shall feel obliged if you will permit me through your columns to state the following brief *résumé* of the facts of the case:—

1st. In 1800 Mr. Stevenson, in his capacity of engineer to the Commissioners of Northern Lighthouses, reported (23rd Dec.) his opinion that the erection of a stone tower on the Bell Rock was not only practicable, but that it was the only suitable structure for that situation.

2nd. In 1800 Mr. Stevenson made drawings and a model of a stone tower, and in that design he introduced the peculiarities of construction which constitute the difference between the Bell Rock and the Eddystone,—in particular, the improved form of floor to obviate outward thrust, and render the chain bars used at the Eddystone unnecessary.

3rd. Acting solely on Mr. Stevenson's advice and on his design and estimate, the Commissioners of Northern Lighthouses applied for a bill in 1803, which passed the Commons, but was thrown out in the Lords, on mercantile and not on engineering grounds.

4th. Subsequent to this Mr. Telford reported; and afterwards, in 1805, Mr. Rennie, at Mr. Stevenson's own request, was called in to confirm Mr. Stevenson's opinion.

5th. In 1806 the Commissioners applied for another bill to carry out Mr. Stevenson's plan of 1800, which was the only design before the Parliamentary Committee. Mr. Stevenson, as engineer for the work, was first examined before the committee, and explained his plan and estimate, and Mr. Rennie was next called in, and "*confirmed*" his views. This bill passed.

6th. The Commissioners thereafter proceeded with the work, appointing Mr. Rennie as chief, or, as now termed, consulting engineer, as fully stated in Mr. Stevenson's book; and it would appear that founding on this circumstance, and utterly ignoring the facts of the case, Sir John Rennie assumes that his father designed and built the Bell Rock Lighthouse.

7th. The only drawing furnished by Mr. Rennie was a *pictorial* sketch of a tower, with clouds and shipping in the distance, which sketch was not adhered to in the execution of the work. *He never furnished any section, nor any working-plans or specification of the Bell Rock Lighthouse.* The only working-plans were those made by Mr. Stevenson.

8th. Mr. Rennie, in his correspondence with Mr. Stevenson, and in his reports and sketch, named for consideration alterations on only five of the dimensions of Mr. Stevenson's original design; which alterations Mr. Stevenson did not approve of, and did not adopt. These were: that the diameter of the base should be 52 feet, and afterwards 45 feet, instead of 42 feet; that the height of the solid part of the building should be 50 feet instead of 30 feet; that the hollow or habitable part of the tower should be divided into four instead of five compartments; and that the height of the tower should be 85 feet instead of 92 feet. In determining the first three of these important dimensions, Mr. Stevenson adhered to and executed the work in exact accordance with his original design; in the fourth—viz., the height of the tower—instead of reducing it to 85 feet, as Rennie proposed, he increased it beyond his original height of 92 feet to 100 feet. The fifth suggestion of Mr. Rennie was, that the part with the central stair should be 30 feet, and the solid masonry only 20 feet; but as this would have made the solid only 4 feet above high water, Mr. Stevenson rejected it, and wisely adhered to his own design; and, from what I know of the building, I can with positive certainty affirm, that had Mr. R nnie's suggestion been adopted it would have proved fatal to the structure.

9th. Mr. Rennie, in his correspondence and in his reports, disapproved of the deviations from the construction of the Eddystone which Mr. Stevenson, in his original design, suggested in the formation of the floors, and the means of tieing the walls together; but Mr. Stevenson in this also adhered to his own design, and dispensed with the use of chains for binding the building even at the upper floor, where Mr. Rennie regarded them as indispensable.

10th. Mr. Stevenson therefore acted independently and on his own responsibility as an engineer, in determining the diameter of base, height of solid, internal arrangements, and dispensing entirely with the safety chains; and executed the work, in these vital and all important respects, in accordance with his original design of 1800. This he did in direct variance with the views of Mr Rennie, whose real responsibility in connection with the work was his confirmation of Mr Stevenson's opinion as to the practicability of a tower of masonry. The Bell Rock Lighthouse has now withstood the winter storms of half a century. Had it failed, or were it to fail now, no responsibility could have rested with Mr Rennie, whose suggestions as to the important matters refered to were not adopted.

11th. The amount of responsibility may be judged of from the fact, that while Mr. Telford was paid for his advice £77—Mr. Rennie, for his advice, including supporting the bill in Parliament, £420—Mr. Stevenson was paid £4052 16*s*., of which £315 was for preliminary work, including his original designs, which were made out before either Mr. Telford or Mr. Rennie had been consulted.

12th. Mr. Rennie never arrogated to himself the credit of the Bell Rock. On the contrary, in writing to Mr. Stevenson on 7th Sept. 1807, he designates it as "*a work which will, if successful, immortalise you in the annals of fame.*" Stronger language could not have been used had he been speaking of Smeaton and the Eddystone; and, coming as it did from Mr. Rennie's own pen while the operations were in progress, it convincingly disproves the statement made thirty-seven years after by Sir John, who, in his 'Account of the Plymouth Breakwater,' not only says that his father "designed and built the Bell Rock Lighthouse," but, as already stated, actually suppresses Mr. Stevenson's name—a significant fact, which, I submit, is fitted to disqualify Sir John as an authority, and to render utterly valueless his assurance given to Mr. Smiles that his account was "perfectly correct."

13th. The late Mr. Charles Cunningham, who was secretary to the Commissioners of the Northern Lights while the Bell Rock was being erected, and who at the same time held the office of clerk to the Leith Docks, writes to Mr. Alan Stevenson on 29th May 1849, in the following terms: "I had frequent opportunities of being with Mr. Rennie during his periodical visits to Scotland. The wet docks he planned and executed under the superintendence of a resident engineer, appointed by himself. The Bell Rock was planned by your father, and after having been sanctioned by Mr. Rennie, was executed entirely under your father's personal superintendence; and in all my communications with Mr. Rennie, which were not unfrequent, I never heard him lay claim to that work."

14th. The Commissioners of Northern Lighthouses, under whose auspices the work was initiated and carried out—who visited it repeatedly during its progress—to whom Mr. Stevenson reported directly on every point, from the selection of the foundation to the manufacture of the lantern—completed their part of the business by acts the most significant and unmistakable. They instructed Mr. Stevenson, at the conclusion of the work, to write an account of the Lighthouse; they appointed a committee of their number to superintend the publication, the expense of which was defrayed by the board; they placed Mr. Stevenson's bust in marble in the Lighthouse; and, at his death, they recorded in their minutes that to "Mr. Stevenson is due the honour of conceiving and executing the great work of the Bell Rock Lighthouse."

Thus we have opposed to the *recent* unsupported statement of Sir John Rennie, the deliberate opinions of the *only persons who were officially connected with the work*—viz., the late Mr. Rennie himself; the late Mr. Charles Cunningham, who was secretary to the Lighthouse Board at the time; and the Commissioners of Northern Lighthouses.

In conclusion it may be asked, since the example shown by Smeaton, who himself saw every stone of the Eddystone laid, what credit can be due to any engineer in connection with the Bell Rock Lighthouse which is not included under one or more of the three following heads?—viz.

Either, The original proposal to erect a tower of masonry in an exposed situation 16 feet under high water;

Or, The proposal of any improvements on Smeaton's design and mode of carrying on the work;

Or, The personal execution of the work, involving so much fortitude, zeal, self-denial, and knowledge of engineering.

Which of these sources of credit does not belong to Mr. Stevenson *alone*, in connection with the Bell Rock Lighthouse?

I am, &c.

84, George Street, Edinburgh, April 1862. DAVID STEVENSON.

THE ALBERT MEMORIAL.

THE last number of this Journal contained an investigation of some of the general principles which ought to regulate the design and character of the monument which it is proposed to erect to the memory of the late Prince Consort; and we endeavoured to show briefly, that the monuments known as "crosses" in mediæval architecture satisfactorily embodied those principles. At the time when these remarks were written it was generally understood that a very different kind of monument would be adopted; but it has been found impracticable to carry out the contemplated design; and at present the form of the monument appears to be altogether undetermined.

In resuming the subject, it may be well to advert to the exceedingly great diversity of forms which have been chosen by different nations in different ages for their memorials of the dead. Almost every nation which has attained to wealth and power has left examples of such memorials. The first and most elementary type is the monolith, of which the obelisk is only one of many varieties. Next in simplicity of design, although in many instances far more remakable for their stupendous magnitude, were the pyramids, which, according to generally-accepted conjectures, were immense monuments of the dead.

As architecture advanced the form of monuments became more complex and very different in different countries of Europe and Asia. Oriental monuments we may at once dismiss from our consideration, for notwithstanding the grace and magnificence of many of them, they are obviously unfit to be adopted as models in this country. Of the rejection of Classic models we are by no means so secure. There is a powerful class in this country who have personal interests in advocating the merits of Classic architecture, or rather the debased styles which adopt its forms without its principles, and who would doubtless be dissatisfied with any building which did not illustrate one or more of their favourite Five Orders. Without, however, entering into a general discussion of the reasonableness of this taste, we may advert to one reason which, as it seems to us, is conclusive against the adoption of Classic forms in the Albert Monument. The monument ought to be lofty, in order that it may be visible from a great distance. It ought at least (we suppose) to be higher than the surrounding trees of the Park in which it is to be placed. Now this requisite is not attainable with Classic forms without resort to contrivances which violate the principles upon which those forms were originally designed. The most common of these contrivances have been the piling of columns one upon another, as in the western façade of St. Paul's—the outrageous exaggeration of the original size of columns, as in the Nelson Monument at Charing-cross—or by an incongruous superstructure or substructure above or below the columns. Are we premature in expressing a hope that the day for repeating these absurdities is gone by?

The only definite suggestions for the Albert Memorial which have been made since the design of an obelisk was abandoned, are memorial windows, and buildings to be dedicated to some charitable purpose in the name of Prince Albert. Both these plans appear to us very objectionable. Glass is not a sufficiently durable material for a monument which ought to be designed to endure many centuries. How much remains of the ancient stained glass of our cathedrals and churches? Abundance of fragments, no doubt; but scarcely a complete window more ancient than the Tudor period. Besides, memorial windows are not sufficiently conspicuous; for instead of being visible from a great distance, as we have said the intended monument ought to be, their effect is not visible except from the inside of the building which they decorate.

Moreover, the proposal of a memorial window is liable to this objection, in common with the other proposal, just mentioned, for a charitable institution, viz.: that in either case the memorial would not be exclusively commemorative. It would be made to serve two purposes; and the purpose of commemoration, even if always regarded as the primary object, would lose much of its importance and dignity by association with a secondary object. For instance, in the case of the charitable institution—either the institution is not really wanted, in which case the erection of it is a positive evil; or it is really wanted, in which case the feeling of charity ought alone to suffice to secure its erection. The contrivance of combining the two objects which have no necessary connection—a work of charity and a memorial—savours too much of thrift; looks too much as if there were not sufficient zeal for either object alone. Of course it may be objected that a mere monument is of no use, and that therefore its erection is a waste of money. The objection is—Why was all this money wasted and not given to the poor? This objection is not, however, likely to proceed from those who reflect that memorials of public benefactors are natural benefits, because they encourage efforts to promote the welfare of the community.

If we reject the proposals just mentioned, what are the alternatives? Surely we are not to repeat the frequent blunder of erecting isolated columns or uncanopied statues. The objections to monuments of this kind are so manifest that their adoption ought to be regarded only as so many proofs of utter debasement of architectural taste in the times which tolerated them.

In advocating the adoption of a monumental "cross," we are not advocating the revival of an obsolete idea. If our method of reasoning on this subject has been correct, we simply wish to revert to a natural and reasonable mode of designing monuments, which has never become obsolete in the sense of becoming unsuited to our times, but which fell into disuse when architecture became debased. The merits of these crosses are of many distinct kinds. They are susceptible of great variey of design, size, and magnificence; they may be so constructed as to be very durable; and they are in a peculiar degree characteristic of English art. There have been, it is true, some crosses of great beauty erected in Northern France during the Mediæval period, but they were never so abundant there as in England. In this country, as Britton well shows in his essay on "Ancient Stone Crosses," in the first volume of his 'Architectural Antiquities,' they abounded in every county, and scarcely any great town was without its market cross, preaching cross, or memorial cross. Why the name of crosses was given to these structures is by no means clear, for the symbol of the Cross does not appear on the majority of them; and it is not a principal object in any of the beautiful, and interesting illustrations of the volume cited.

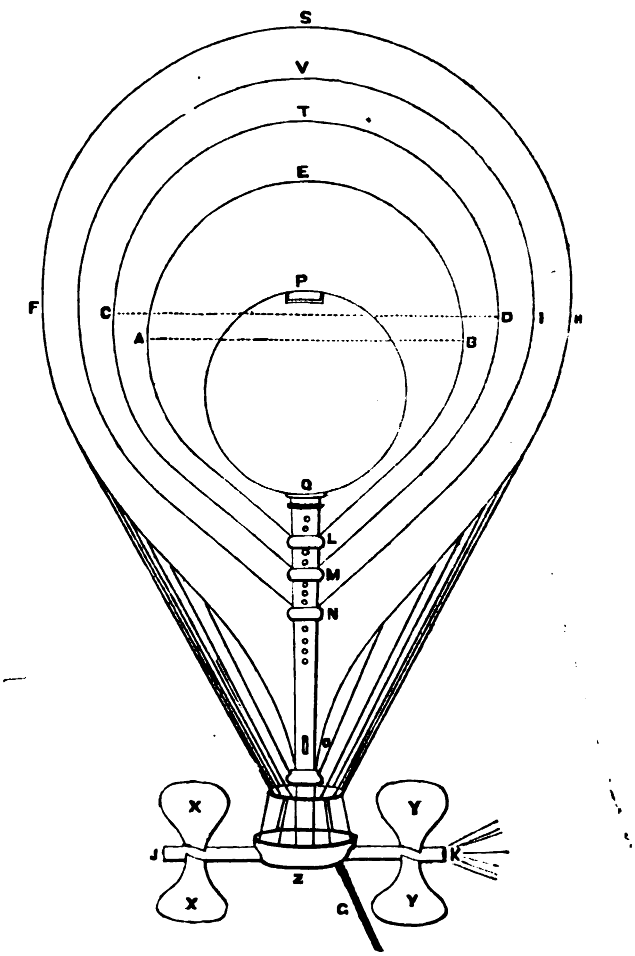
THE SAFETY CONCENTRIC BALLOON.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—The actual state of aerostation at the present time is far from being perfected; as an art it is incomplete. The supposed impossibility of guiding the balloon according to a given direction, oblique to the wind, has been the long-contested question of aerial navigation, and the want of this important mechanical desideratum has hitherto obstructed its advancement as an art applicable to useful purposes. Another impediment exists which has continued to oppose its adoption as an adaptation to the wants and occasions of human life, namely, the dangers considered inseparable from the practice of the art. The mechanical guidance of the balloon can be effected to a serviceable extent by my invention, which I have named the Safety Concentric Balloon, and which it is the object of this communication to describe. As a source of recreation, aerial navigation stands unrivalled; in this sense it is that I consider its present merit entirely to consist; but our exertions must be limited, and our pleasure curtailed, when we do not consider ourselves moderately safe, whether we travel over the water, through the air, or upon the land. By my method of constructing a balloon I remove all danger while in the air, and extend the relations of the art by a new guiding principle. Aeronauts have dangers quite inseparable from the present practice of constructing a balloon; all attempts to give direction to a balloon have failed hitherto, and great difficulties have been experienced in remaining in the aerial regions a sufficient time to insure the attainment of a given distance. My invention overcomes many existing difficulties. I propose to form a balloon of a series of concentric interior balloons—viz., one balloon inside another, *the centre one* to be made of sheet steel, iron, copper, or other strong material, *permanently* charged with gas, and *solidly*, but *not stiffly* connected to the car, to support and give effect to the steering and propelling apparatus. When gas is discharged from the upper valve of a balloon, the cover is (in the present mode of construction) often rent, not from bursting, but by *collapse*, caused by the pressure of the atmosphere on the partial vacuum created. In the balloon that I propose, any portion of the gas between the first and second covers may be discharged without chance of accident. When necessary, the gas inside the second cover can be discharged in the same way, and when all the gas between the consecutive covers is discharged, the central metallic or permanent balloon, *and the balloon that contains or immediately surrounds it*, will descend to the earth gently and safely, delivering up the voyagers without damage or shock. It will easily be seen that the metallic balloon being filled, and surrounded outside with gas, sustains very little pressure.

It may be argued that the material employed in all the covers would make a balloon stronger and safer with a single cover, than my balloon of balloons; this is not the case; for a cover composed of ⅜ boiler-plate, which would be twenty times stronger than all my covers put together, would give way if only a partial vacuum were created inside by suddenly discharging the gas. All that is required of a cover is the power to sustain the difference of the pressures of the atmosphere and of the gas inside. In my balloon no mistake can be made in discharging the gas between the first and second covers, for the gas between the second and third covers maintains the required equilibrium, when the space between the first and second covers are empty, or partially so; besides, the exit of the gas from between the first two covers is not accelerated by the great body of gas contained in the other covers, which do not require the strength of the outer cover. Mr. Charles Green's ingenious discovery of the guide-rope should not be dispensed with—viz., a rope varying in length from 2000 feet upwards, according to the exigencies of the case, the connection with the earth by its means need never be entirely dissolved. It might be long enough to allow for any necessary increase of the altitude of the balloon in the higher currents of air which exist in the atmosphere; this guide-rope should also be of a mass proportioned to the weight against which it is intended to provide, and lowered from the car by means of a windlass, and passing through a pulley attached to the hoop above, allowed to remain freely suspended in the air. As soon as any alteration takes place whereby the specific gravity of the balloon is increased, and it in consequence begins to descend, the lower extremity of this rope becomes gradually deposited on the ground, and acting in this case like the discharge of so much ballast, keeps constantly abstracting from her weight below in the direct proportion of the augmentation which it is receiving above; until, the latter having reached its maximum, and an adequate compensation having been effected by means of the former, her further descent is eventually checked, and she either continues to advance upon the level to which these vicarious alternations have reduced her, or rising again under the influence of the first change that occurs sufficient to produce such a tendency, and reversing in her ascent all the proceedings that attended her depression, she gradually becomes charged with all her former weight, and ultimately quits the earth in the same condition with regard to her resources in gas and ballast, as she was before circumstances had interfered to disturb the equilibrium of her previous course.*

My concentric balloon may be constructed of almost any size with perfect safety, as the weights of the envelopes of similar shaped balloons increase as the squares of the diameters, or of similar dimensions, while the solidity increases as the cubes; hence the quantity of gas between two consecutive covers may be made to assume any fixed relation to the area or weight of the outer cover. Suppose the inner balloon A E B to have a diameter AB=20 feet, a surface=1250 square feet, and a solidity



=5000 cubic feet; and let CD=29 feet be a diameter in the balloon C T D, then the surface of the balloon C T D = 2628 square feet nearly, and the solidity=15,243 cubic feet nearly; therefore, 10,243=the cubic feet of gas between the covers, and the ratio between the solidity and the surface is maintained. That is, 5000 is 4 times 1250; and 10,243 is not far from being 4 times 2628. G represents the guide rope, invented by Mr. Charles Green, and may be paid out of or taken into the car by means of machinery attached to the hollow shaft QZ. FSH

* See Monck Mason's 'Aeronautica,' page 17.

is the outer cover, provided with a stuffing-box at O, so that the gas when it expands may be discharged through apertures in OQ, through the hollow shaft JK. VIN represents the second cover inside OHSF; CTDM the third balloon cover inside VIN, and so on. As many balloons as we please may be introduced inside the other, fitted to OQ by loose bands LMN. The gas as it expands may escape through the hollow shafts OQ, and JK, by means of apertures in OQ.

PQ is the inner balloon, and may be made of copper, steel, india-rubber, or gutta-percha, and may be easily moved up and down inside the balloon AEBL, so that JK connected to OQ by a crank inside the car gives a forward motion to the whole machine, by means of screw sails X, X, and Y, Y. P is a valve to allow the air to escape from PQ, while itself and the inner cover AEB immediately next are being inflated; it may then be closed during the voyage. The upper valves of the rest of the concentric balloons may be operated upon in the usual manner; the balloon A E B enclosing PQ is not furnished with an upper valve, so that when the ballast and the guide rope are all out, and the gas of all the balloons outside of A E B is discharged, the machine may descend quietly to the earth.

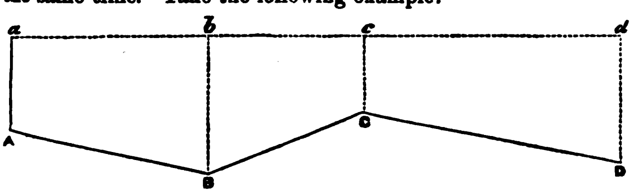
I have other methods of applying my system to practice without altering the combinations that constitute the invention.

ELEANOR RUGG BYRNE.

21, Tollington Road, Holloway, N.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—Notwithstanding all that has been written on hydraulics, I think a simple formula is needed for cases which frequently occur in practice; for instance, it is often necessary to determine accurately the velocity with which water will flow from a given pipe, say at D, after having passed through several other pipes of different dimensions, lengths, and inclinations from the reservoir or main; and the case becomes more complicated when side branches are flowing from some of these pipes, as at B and C at the same time. Take the following example:—



ad, Permanent level of water. AB, Pipe 500 feet long, 24 inches diameter. BC, Pipe 600 feet long, 18 ins. diameter. CD, Pipe 800 feet long, 12 inches diameter. Aa=25 feet. Bb=30 feet. Cc=20 feet. Dd=40 feet.

And suppose moreover that a very short side branch pipe 6 ins. diameter was flowing from B and C at the same time. Then required the velocity of the water through each of the pipes AB, BC, and CD, and especially the velocity of discharge at point D. If any of your correspondents would elucidate this example by a simple formula, I think they would confer a general favour.

Referring to the letter of "Observer," page 375 in your Journal for Dec. 1861, there is some mistake, as the formula quoted is not to be found in your Journal, vol. xv., p. 353. Allow me also to suggest the great convenience of always giving the value of the letters when quoting formulæ, rather than of referring to the works in which they appear at length; for many persons cannot without great trouble consult these works, and in consequence of the various signs and numerous authors it is impossible to carry formulæ in the head. Your valuable assistance in solving this problem will much oblige.

ENQUIRER.

Iron and Concrete Pavement in the City.—The roadway of the Poultry, commencing at the corner of Charlotte-row, Mansion House, and extending about 100 yards westward from that point, is being laid with Knapp's patent pavement, which consists of hollow iron blocks, divided into small compartments, the latter being filled up with concrete level with the surface. Four of these blocks will make a square yard. On each side of the road, close to the edge of the footway, are being laid hollow cast-iron tramplates, 6 feet in length and 18 inches broad, which are first filled with concrete, and then turned over, leaving the indented iron face upwards, thus forming solid tramways. To keep the paving level at each end, iron girders, 18 ft. 9 in. in length, will cross the roadway. The blocks lock into each other, and form a solid mass of iron and concrete.

AUSTIN'S BILATERAL DOUBLE OFFSET PLOTTING SCALES.

WE have on our table specimens of Mr. Austin's scales. The principle is simple, and the arrangement ingenious and remarkably convenient. The ends of the scale have brass cross-pieces, with "Station Pointers." By placing the scale so that the Station Pointers are upon the Base Line, the zero of the offset scale is made to coincide with this line. The offset scale being graduated right and left from zero, the offsets on either hand can be plotted with facility as fast as they are read off from the field book. The trouble and delay of either shifting the scale or going over the survey twice (once for right offsets and once for left offsets) is thus done away with.

In each cross-piece are two steel spring points, which are worked by a screw with a milled head. By these the ends of the scale are fixed down to the paper and drawing board, so that the draughtsman has only the care of moving the set square forward as the plotting proceeds; the right hand is thus left at entire liberty for the use of the pricker, or the pencil or pen, so that the delineation can be carried forward at the same time as the plotting.

The scales and offset scales can of course be graduated as desired, the essential principle being the graduation of the offset scale right and left from a zero point at a fixed distance from the guiding edge. Each of the patterns before us has two scales upon it. In pattern No. 1, the the two scales are separated by a clear interval of at least 6 chains, and connected at the top and bottom by the brass cross-pieces, the "Station Pointers" being placed in the central line. The middle space is just wide enough for the offset scale to be set in it so as to slide along between the scales, the left-hand scale being read from. By this arrangement at least 3 chains on either side of the base line can be plotted. In pattern No. 2, one scale is given, graduated on either edge. The brass cross-pieces form T heads, so as to give a pair of "Station Pointers" for each side of the scale. This arrangement is stated to be less costly, and capable of being more readily fitted to existing scales.

In a third pattern, the "Station Pointers" can be set at a considerable distance from the edge of the scale, as they are on a brass bar, which slides either way by a rack and pinion movement. This is intended to fit the instrument not only for surveys, but for plotting sections, for which, no doubt, it affords some advantages. The racks must of course be marked so that they can be set to suit the length of off-set scale, for which they are intended. They ought to work true and rather stiff; and if not furnished with steel points to pin their ends down to the board, should be clumped by the same movement that pins down the scale. Attention to these details will, we doubt not, render pattern No. 3 extensively useful. The other patterns are perfect.

Mr. Austin's method affords marked facilities for plotting in all cases where the off-sets do not exceed a certain limit; and it will not fail to commend itself to many, as it effects a considerable saving of time, both in plotting from a field book, and in plotting to a reduced scale.

The instruments are sold (by the inventor) at Blackwell's, 9, Cranbourne-street, Leicester-square, W.C.

Trial of Steam Fire Engines.—A trial of the steam fire engines belonging to the London Fire Establishment was made on the 16th ult. at the distillery of Mr. Hodges, Lambeth, in the presence of a numerous company of visitors. The new steam fire-engine recently made for the London Fire Engine Establishment is of nearly the same dimensions as the one so long located at Watling-street, now removed to Chandos-street station, to give place to the new one. Steam was got up in 15 minutes from the time the fuel was lighted, with 100lb. pressure of water and 120lb. pressure of steam. Though a brisk wind was blowing, a jet of water from a 1¼-inch nozzle was thrown perpendicularly 160 feet high, and upwards of 200 feet horizontally. A tank of water holding 459 gallons was emptied in one minute and a quarter, thus doing as much work as four hand brigade-engines at their ordinary rate of working. Mr. Hodges then manned one of his hand engines (weighing, when mounted with complement of men, &c., two tons), and threw a 1¼-inch stream a horizontal distance of 190 feet. The large hand-engine made by Messrs. Merryweather and Son for the London and North-Western Railway Company was next tried. It required fifty men to work it. The playing of this engine fell short of Mr. Hodges'. It is fitted with quick pumps, with a 9½-inch stroke.

CLASSIFIED LIST OF PATENTS SEALED IN APRIL 1862.

2581 Felt, C. W.—Improved machine for setting up and distributing printers' type—October 10
2698 Ryder, W.—Improved machine for fluting rollers—October 28
2611 Fearnley, J.—Improved steam hammers—October 19
2552 Nelson, H.—Machine for punching washers—October 12
2588 Clark, W.—Apparatus for bending iron rails (com.)—October 16
2686 England, G.—Improved planing machines—October 22
2877 Loomes, E.—Improved machine for moulding bricks—November 15
3101 Mennons, M. A. F.—Improved Jack machine for moving heavy bodies (com.)—December 11
2678 Gibson, H.—Improved slate dressing machine—October 25
2762 Worsham, S. W.—Improved machine for cutting wood
2912 Johnson, J. H.—Improved wood carving machine (com.)—November 20
2480 Knox, G.—Improved paper machine—November 20
2599 Streather, W.—Improved wind engine October 18
2663 Dicks, W.—Improved water meters—October 24

231 De Boulteville, J. D.—Improved machine for spinning—January 29, 1862
2624 Holdfield, E.—Improved self-acting mules for spinning—October 21
2584 Robertson, W.—Improved mules for spinning and doubling—October 26
2585 Smith, R.—Improved apparatus for winding yarn—October 17
2685 Sidebottom, J.—Improved machine for making spindles of spinning and other machines—October 26
590 Tongue, W.—Improved scutching machine—February 18, 1862
596 Tongue, W.—Improved machine for preparing silk, flax, and other fibrous materials—March 3, 1862
2490 Rowan, W.—Improvements in scutching machines—October 5
2650 Morel, A.—Machine for combining all filamentous materials—October 23
2510 Simpson. W.—Improved twist lace machine—October 23
2604 Johnson, J. H.—Improved braiding machine—October 18
2530 Mould, W., and Hall, J.—Improved machine for manufacturing healds—Oct. 10
2549 Ramsden, J. C.—Improved healds for weaving—October 12
2628 Fenton, F.—Improved means for treating and obtaining fibrous materials—Oct. 21

2487 Lansley, J.—Improved ploughs, drill, &c.—October 5
2505 Willscher, J. C.—Improved combined thrashing and dressing machine—Oct. 7
2594 Goucher, J.—Improved beaters and drums used in ditto—October 18

2598 Holt, C. H.—Improved steam engines and boilers—October 18
3221 Newton, A. V.—Improved means for reducing the friction and wear of slide valves of steam engines (com.)—December 24
2625 Calvert, J. A.—Improved engines—October 21
2455 Davies, J.—Improved steam engines—October 2
2749 Henry, M.—Improved steam engines (com.)—November 1
354 Macnab, W.—Improved steam engines—February 11, 1862
2780 Fanshawe, J. A.—Improved steam generators—October 31
2496 Improved tap for regulating the flow of steam—October 5
2502 Improved condensing apparatus October 7
2671 Green, E. and E.—Improved apparatus for generating and condensing steam—October 25
196 Johnson, J. H.—Removal of incrustation from steam generators (com.)—Oct. 25
2567 Ross, W.—Improved taps or valves—October 15
2568 Gilbert, J.—Endless railways—October 15
2668 Wharton, W.—Springs for railway and other vehicles—October 25
2660 Campbell, F. A.—Railways
2616 De Bergue, C.—Sleepers and chairs for permanent railway—October 19
3009 Ellis, J.—Rails for permanent ways—November 29
2680 Lamothe, B. J.—Railroad car and other vehicles—October 25

2606 Cheyne, C.—Railway signal apparatus—October 18
2464 Henley, T. W.—Electric telegraph apparatus—October 3

2720 Leigh, E.—Improvements in sailing ships—October 30
2492 Collins, J. S.—Apparatus for reefing and furling sails of ships—October 5
2633 Toward, J.—Armour plates for ships, and securing the same to the side of a vessel—October 21
3182 Tate, W.—Armour plates—December 19

2579 Lister, J.—Hoisting apparatus—October 16
3038 Duchemin, W.—Improved blocks for hoisting—December 3
2675 Moore, T.—Improved windlasses—October 26

2584 Welch, W.—Marine screw propeller—October 17
36 Bousfield, G. T.—Improvements in propelling water craft—Jan. 4, 1862

2522 Curtis, F.—Fire-arms—October 9
2514 Sievier, R. W.—Batteries for war
2619 Bloxam, H.—Sight for rifles and ordnance—October 19
2703 Bayliss, O.—Double rifle guns October 29
138 Winans, W. L.—Improved manner of mounting, and apparatus for manœuvring cannon or ordnance on ships or vessels—January 18, 1862
2601 Robertson, P.—Manufacture of cartridges (com.)—October 18
2786 Thomas, L.—Rifle ordnance and projectiles

2478 Brooman, R. A.—Manufacture of coloured fabrics (com.)—October 2
2462 Hill, C. G.—Manufacture of cap fronts and trimmings—October 2
2506 Ford, A.—Method of forming waterproof fabrics—October 8
2573 Baker, F. B.—Improvements in stiffening lace—October 16
2728 Topham, A. J. and B.—Manufacture of lace—October 30
233 McKean.—Dressing yarns or textile materials—January 29, 1862
2447 Scott, J. W.—Leather washers and laces—October 1

2459 Thompson, W., Stather J.—Hydraulic presses—October 2
2638 Ward, F. O.—Hydraulic presses—October 22
3191 Westwood, J.—Hydraulic presses—December 30
3041 Newton, W. E.—Pumps (com.)—December 4
226 Newton, W. E.—Pumping-engine (com.)—January 28, 1862
2727 Norton, J. L.—Apparatus for raising water—October 30

2700 Gilbert, G. M.—Preparing liquid blue—October 28
2855 Balmin, W. H.—Manufacture of flowers of sulphur—November 13
3255 Laurent and Castehlas.—Colouring matters—December 24
2525 Tidmarsh, J.—Artificial manure—October 9
2710 Gibbon, R.—Preparing grain for brewers—October 29
2843 Birchbeck, J. H.—Improved method of extracting silver from lead (com.)—October 23
2561 Mackmeikan, H.—Smelting gold or other ores—October 18
2574 Forster.—Reworking waste vulcanised india rubber—October 16
2637 Muschet, R.—Manufacture of a certain metallic alloy—October 22
2609 Muschet, R.—Manufacture of pig metal—October 19
2694 Smith, W.—Preparing stone, &c.—October 26

2473 Malam, W.—Manufacture of gas—October 3
2516 Smith, W.—Regulating the pressure of gas—October 9
2623 Smith, J. I.—Collecting gases evolved from blast furnaces—October 21
3282 Newton, W. E.—Apparatus for containing gaseous liquids—November 9
217 Hunt, J.—Gas and other chandeliers—January 28, 1862
2580 Smith, W.—Apparatus for increasing the illuminating power of gas (com.)—October 17
2795 Wigham, J. R.—Apparatus for manufacture of gas—November 7

2514 Flinn, J.—Watches—October 15
2544 Stram, N.—Watches—October 11

2559 Distin, H. J.—Metal musical wind instruments—October 14
2674 Alexandra, R.—Pedal-box for small organs—October 25

2528 Palmer, W.—Lamps and lamp-wicks—October 9
2591 Croome, W.—Lamps—October 18
2620 Lamplong, H.—Means for igniting the wicks of lamps—October 21

2595 Peyton, E.—Frames of metal bedsteads—October 18
2640 Fox, H. B.—Metallic bedsteads—October 22
2783 Norman, G.—Mounting cradles.—October 31

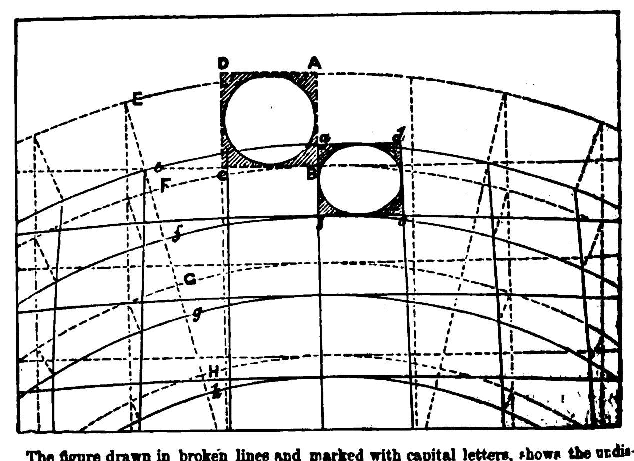
2281 Howell, J. B.—Chain cables—September 18
2534 Browne, B.—Improved spring (com.)—October 10
2760 Lockie, T.—Wrought-iron wheels—November 2
2743 Mitchell, B.—Scissors and shears—November 1
2614 Browne, J.—Metal tubes—October 19
2538 Cristophe, L.—Cast-steel and other metal tubes—October 10
2583 Weston W. J.—Screw wrenches—October 17

2470 Evans, I.—Manufacture of boots and shoes—October 3
3202 Bousfield, G.—Machine for attaching soles to the upper leather (com.)—Dec. 20
2786 Bradt, H. D.—Machine for pegging shoes (com.)—November 6
2907 Godfry, B. D.—Improved boot or shoe with a wooden shank—November 19
2639 May, H.—Goloshes—October 22
2642 Archer, G.—Sewing boots and shoes—October 23
162 Tozer, W.—Boots and shoes—January 21, 1862

2649 Deliry, J. F. V.—An improved kneading trough—October 23
81 Ramsay, I.—Improved manufacture of coke—January 11, 1862
273 Hibbs, J.—Improved portable chairs, &c—February 1, 1862
381 Ebbutt, A. C.—Improved easy and other chairs—February 13, 1862
223 Morgan, G. H. and E.—Improved carriages—January 28, 1862
2621 McDoughall, C.—Improved means for connecting the ends of covered steel or other materials for crinolines—October 21
2610 Lepeinteur.—Improved fastenings for gloves, belts, &c.—October 19
2488 Edwards, J.—Manufacture of buttons—October 5
2564 Taylor, B.—Improved dress suspenders—October 14
2431 Smith.—Improved umbrellas—September 30
2841 Newton, W. E.—Improved skates (com.)—December 12
2646 Brison, C. and Chavame A.—Ovens, &c.—October 23
2578 Clark, W.—Securing mail bags, &c. (com.)—October 16
2808 Johnson, J. H.—Treatment of carpets (com.)—November 8
2565 Wynants, C.—Chase for presses—October 15
2666 Boyde, R. A.—Fire-place for singeing pigs—October 24
2821 Loysel, E.—Match-boxes—November 9
2965 Willis, A. W.—Pencil holders—November 26
2657 Lord, W. B.—Plug or socket for closing and opening passages for flow of liquid—October 23
3012 Perry, R. C.—Infant's feeding-bottle—November 29
2592 Aytoun, R.—Improved apparatus for chimneys—October 17
2683 Mennons, M. A. F.—Improved apparatus for ascertaining the degree of vitality in the human body (com.)—October 26
2771 Ashley, J.—Improved apparatus for attaching horses to carriages—November 4
2959 Johnson, J. H.—Improved apparatus for preparing oval picture frames (com.) November 25
2477 Husson C.—Improved process of silvering looking glasses—October 4
2478 David A.—Improvements in fixing letters on metallic plates—October 4
2494 Mares G.—Improved method of effecting communication by means of a kite and an apparatus connected therewith—October 5
2521 Coathorpe H. B.—Improved means of obtaining and applying embossed metal—October 9
127 Thompson N.—Improved apparatus for stopping bottles—January 17, 1862
2586 De Groote, C.—Improved instrument for corking bottles—October 17
23 Eschwege H.—Improvements in treating wool—January 23, 1862
2661 Morris, J., Ware, R., Monckton, E. H. C.—Improved electro-magnets—Oct. 24
2656 Pulvermacher, T. L.—Improved electro-magnetic apparatus—October 23
2784 Bousfield, G. T.—Improved electro-plating—November 5

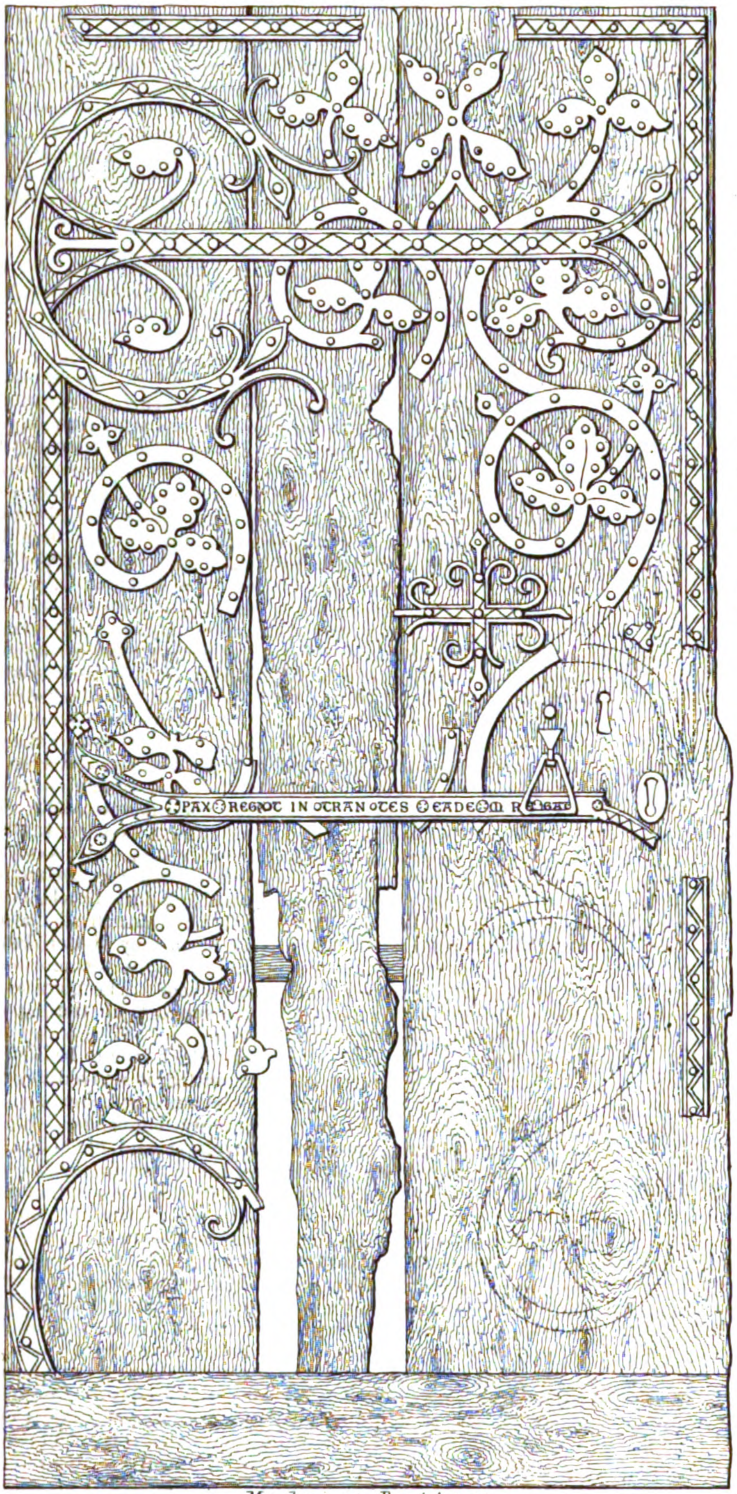
ERRATUM.

"PHOTOGRAPHIC DISTORTION."—The woodcut, *ante* page 86, being somewhat faulty, we here reproduce a part of it on a larger scale, which will give a clearer idea of the marginal contractions.



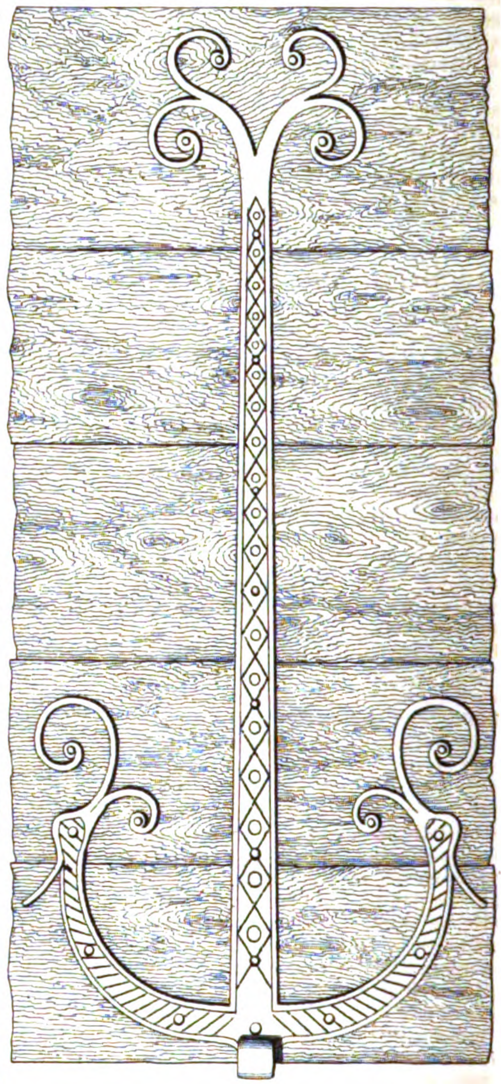
The figure drawn in broken lines and marked with capital letters, shows the undistorted form; the distorted image being shown by the figure drawn in continuous lines and marked with smal letters.

EASTWOOD CHURCH, ESSEX.



Iron-work on Inner Door of South Porch.

Scale 1 In. to a Foot.



Hinge to Door.
1/6th Real size

INNER DOORWAY OF PORCH,
SUTTON CHURCH, ESSEX.

ANCIENT IRON WORK.

(With an Engraving.)

From the Church of St. Lawrence and all Saints, Eastwood, Essex (a good specimen of Early English work), we obtain the accompanying specimen of ancient ironwork, which still exists, in a somewhat dilapidated state, on the inner door of the porch. The church is said to have belonged to the priory of Prittlewell, in the time of Henry II., at which period it was called a chapel, but in 1390 it became a rectory, presentative by the prior and brethren of the before-named monastery, this being done through the power of the pope, without the king's consent or the knowledge of the bishop of the see. The superior and brethren of the monastery in consequence were compelled to obtain a license from Richard II. in 1394 to appropriate this church with that of North Shoebury to their own use. On the middle cross-bar upon the door are the remains of the following inscription:—"Pax Regat Intrantes eadem Regat." Upon the same plate we also exhibit a fine old hinge from the inner door of the Church Porch of Great Sutton, a village about 1½ miles south east of Rochford. The sacred edifice is small, and is of the Early English period, it has a tower at the west end, in which are a good peal of bells.

ARCHITECTURE AT THE ROYAL ACADEMY.

It may, with reason, be asked, what is to become of architecture in connection with the intended purposes of the Royal Academy? The latter part of this sentence, it is true, might be construed as referring to either the past or the present, and this precisely accords with the idea in our mind when penning it. The institution of the Royal Academy, now nearly a century ago, contemplated the patronage and encouragement of architecture *no less* than that of painting and sculpture, and for a time, when Chambers, Soane, and Cockerell were the great rulers of the art, its annual displays at Somerset House and in Trafalgar Square, were such as to entitle and secure for it a due share of attention and respect. But this state of things has, comparatively, long passed away, to the disgrace and blame of all parties concerned, while the two other arts—painting especially—have not only maintained their ground, but actually profited, as it would seem, by the neglect exhibited towards their less favoured sister. In days gone by, yet many years after the location of the Academy in its present abode, architecture possessed a room within its walls specifically and exclusively devoted to the exhibition of its own and kindred works; by degrees the thin wedge was introduced, and the space became encroached upon, next reduced to half, afterwards to still less, and last year when the alterations in the plan of the building involved a re-arrangement of its rooms, the architectural drawings were notoriously overpowered by their more numerous and showy rivals in the same apartment. This season, however, matters look still worse, so that what may be their future lot, how much longer they are to be suffered thus to dwindle, or whether they are destined to a speedy and utter extinction, is a problem which we cannot pretend to solve, but which unquestionably depends for its solution on the energy or the continued apathy of the profession itself.

The number of drawings is this year, we believe, much fewer than usual, and these are unceremoniously grouped in the ante-room immediately opening upon the entrance stairs, sharing the wall space with sundry crayon and other drawings of a general kind. Of very attractive architectural subjects, there is certainly a lack, in spite of the very fine picture, among one or two others (875), of Mr. T. Page's "Design for the New Bridge at Blackfriars, as approved by the Bridge Committee." With the principal features of this design our readers are familiar; suffice it therefore to say, that these lose none of their importance or beauty by the way in which the artist has treated them, which renders this drawing at once the largest and one of the most perfect in the room. Below this is perhaps the second most important drawing (882), "The New Town Hall, Halifax," one of the late Sir Charles Barry's last professional works, and by no means one of the least important, though, in point of design, it is much below the standard of many buildings designed in the same style by that accomplished architect. In carrying out the work some modifications have been introduced by Mr. E. M. Barry, on whom the superintendence involved, but he has not, it appears, interfered with the strange looking tower which Sir Charles had planned as its crowning feature, but which, besides being apparently quite unnecessary, is decidedly, as part of the composition, inharmonious and unsatisfactory.

In (825) Mr. T. Vaughan gives a tinted view of the interior of the celebrated cathedral at Pisa. The point selected for delineation is a happy one, as it enables the draughtsman to show the combination of bold arches, and their banded and radiating enrichments; these being, for the most part, in structural material. The view is taken across the transept looking north. Malines and Antwerp Cathedrals furnish Mr. E. S. Cole with subjects for two charming pictures (827, 828), the former being an interior, powerfully treated, especially in the grouping of the crowds of people, and the truthfully substantial effect of the building itself. The latter is an exterior, as seen down a narrow street, which displays the towers and a portion of the lower part of the west front to considerable advantage, so that its partial obscuration is of little moment. In spite of Mr. Spiers' delicate and pretty drawing, we cannot bring ourselves to admire the "Chimney-piece for the chateau of Blois, Touraine" (830), which besides being in the most extravagant style of Renaissance, has not even the merit of good outline to recommend it.

We miss Mr. E. Falkener this year, but his place is worthily filled by Mr. F. P. Cockerell, who in (831) gives a delightful restoration of the "Street of the Tombs, at Pompeii." In this drawing every detail has been well studied and expressed, even to the arrangement and dress of the mourners and others attendant on the funeral procession, which is seen in the foreground approaching through the city gate. The colouring is excellent. From dreams in Classic Italy we next come to the stern realities of England, and observe in (832) a very plain but satisfactory dwelling house, of red brick, erected in Berkshire from the design of Mr. J. Brooks. (833) is a step in advance, in so far that it is a mansion rather than an ordinary house, but though evidently founded on one of the most characteristic of our ancient Elizabethan residences, Charlecote, there is a degree of tameness, resulting from over-uniformity, which would have been better avoided. The architect is Mr. Gibson. We pass by Mr. Smith's "Memorial Church, Hereford" (835), so greatly overlaid with cuspings and pretty enrichments, to notice a little "New Church at Sutton, Kent," by Mr. Ashpitel (847), which is in the now almost exploded Norman style, and withal so truly simple and faithful to some scores of old ones, that it might (with the exception of a very paltry bell turret) pass muster for an ancient one itself. The plan, it will be noticed, is unusual, except in some early example of this period: it consists of a semicircular apse attached to, but not continous with, what appears to be the ordinary rectangular chancel. "Christ Church, Pentonville," by Mr. Brock, is unmistakeably founded upon Mr. Street's new church in Garden-street, Westminster. The tower is all but a copy of this, but its effect is disguised, yet by no means improved, by the addition of a lofty spire with dwarf pinnacles at its base. The piers at the lower angles do not look equal to the support of the superincumbent mass.

The Thames Embankment question, which it is to be hoped is at last on the eve of being practically settled, is revived in drawings by one or two exhibitors. (834) shows the scheme as proposed by Mr. Henman, jun., and "highly commended" by Her Majesty's Commissioners. However clever and ingenious this plan may be, the elevational appearance is far from being prepossessing. The continuous repetition of ill-shaped, poorly-designed blocks of building is monotonous in the extreme, and would contrast most disadvantageously with the varied outlines of the existing buildings, which, however irregular and absurd in many respects, have at least the charm of unceasing picturesqueness. Mr. Henman's plan may be practically a well-digested one. He contemplates securing a clear water-way, averaging at least 700 feet wide, a quay along the banks of the river, with shallow floating-docks for wharfingers, a roadway 80 feet wide for water-side traffic, and a continuous range of fire-proof warehouses adjoining. There would also be an upper roadway 60 feet wide on each side of the river, at the level of and connecting each of the bridges, from Westminster to Southwark, with a glazed promenade. In the construction of the houses it is proposed that each story should be provided with its separate staircase and a lift, and that each dwelling should be isolated from the one adjoining by vertical and horizontal fire-proof and sound-proof construction. (889, 890) is another version of the same scheme by Mr. H. R. Newton, who, it will be remembered, exhibited another drawing of the same series last year. The primary intention of their author is to urge that the highest metropolitan requirements, and particularly those relating to street traffic, demand medium level embankments of an uniform height, and consequently his drawings have been studied more with a view to the elucidation of this feature than the display of any special architectural compositions in the erection of new buildings.

A "Suggested Design for a National Memorial to the late Prince Consort" (842), by Mr. Bellhouse, is shown to a rather small scale, with plan, and a lengthy description complete; but the drawing is hung so absurdly above the eye, that nothing whatever can be made out beyond the general form, which is that of an obelisk. Mr. F. Mew, who sends a similar "memorial," for Newport Church, Isle of Wight (853), has been more fortunate, and the drawing he exhibits is in many respects as meritorious as it is original. It may be briefly described as showing a mural tablet, between two windows filled with painted glass, the whole being inclosed by a border of incised and inlaid work, enriched with monograms, scroll-work, figure outlines, inscriptions, &c., bearing reference to the general subject. The composition is on the whole a pleasing one, much of this effect being due to the well-selected materials and colours of which it is composed. In another different class of works (Cemetery Chapels), the selected designs for those at Rugby, by Mr. Bidlake, are unusually good, and are well shown in the four perspectives, and a plan comprised in (846). The best portion is the lodge, which, if it has a fault, is that rather too much has been attempted. (848 and 868) are two views, interior and exterior, of the "New Garrison Chapel at Woolwich," as being erected from the designs of Messrs. T. H. and M. D. Wyatt. It is in the Byzantine style, but without any particularly striking features externally. The interior is more original; it has galleries, and slender iron columns are employed to carry the roof, which to our mind is the poorest and least successful portion of the design. A little more apparent strength, in the construction generally, would have improved the perspective effect. In Mr. Bidlake's "Design for the New Markets, Chester," he has taken a step in advance of the majority of his usually clever productions. It is a very simple composition, relying more upon its outline and materials (red and blue brick) than sculpture or carved enrichments. The tower in the centre may especially be cited as presenting some admirable points. We regret that we cannot speak so favourably of Mr. M. D. Wyatt's "Monument," erected to the memory of the late Mr. J. M. Rendel, the celebrated engineer. It is of granite, and from the nature of this material the chief thing to be aimed at in the design should have been a suitable expression in forms and proportion only; in both which respects, according to our judgment, the author has sadly failed,—nor is there throughout a display of anything beyond mere commonplace ideas, and these are awkwardly arranged. Mr. Goldie has but one drawing (855), which is a better specimen of his bold pen-and-ink drawing than of his powers of design. It is an exterior view of "St. Wilford's Roman Catholic Church at York," and among many very good features are interspersed several doubtful ones, at least such as to tend greatly to mar the effect as a whole. The next drawing (856), a "Cemetery Chapel," erecting by Mr. J. P. Jones, is a shade still lower in merit. The design has, if we mistake not, been exhibited before. The single picture exhibited by Mr. Truefitt (857), is a characteristic one, and shows an exterior of one of the numerous villa residences which he is now erecting. Mr. Truefitt's especial forte in adapting his designs to his materials is in this instance happily evidenced; while that over-quaintness, which is noticeable in some of his designs, appears only in a subdued degree.

(To be concluded in our next.)

MACHINERY IN THE INTERNATIONAL EXHIBITION, 1862.

The Western Annex.

In our time, that nation which applies the sciences to the arts to the best advantage and most economical effect obtains the highest position, and the greatest amount of influence and wealth, and will keep the lead in the march of civilisation. The development of steam-power has much to do in the application of the arts. Boilers, the generators of steam-power, are little improved since they were first invented. We have an infinite variety of boilers of different arrangements, the subjects of patents, utilising but a comparatively small amount of the developed heat. It is to be regretted that steam-engines in the International Exhibition are not accompanied by either a model or working drawings of the boiler adopted. The engines in the annexe are put in motion by steam-power obtained from a nest of boilers constructed by Messrs. Hick, of Bolton, and placed in the rear of the conservatory of the Horticultural Gardens. Boiler-makers and those interested in the generation of steam should read Charles Wye Williams' work 'On Heat in its relations to Water and Steam; embracing new Views on Vaporisation, Condensation, and Explosions.'* The classification of the machinery is good; and the collection contains many admirable specimens of mechanical skill. For workmanship, and, if we may use the term, *mechanical cunning*, the examples exhibited by John Penn and Son, of Greenwich, certainly stand first. In the British end of the annex Messrs. Penn exhibit a pair of marine engines (No. 1955), excellent exponents of their skill. They are on the direct-action principle, and are intended for a screw steam-ship. The engines are of 600 horse-power, manufactured for the Spanish Government. The cylinders 78 inches diameter, and 3 feet 6 inches stroke. The connecting rods are 9 feet long. Each condenser is provided with a double acting air-pump 23 inches diameter and 3 ft. 6 in. stroke, being the same as that of the piston. Messrs. Penn are masters of the science of balancing their machinery at all speeds, so that the motion of the crank is nearly uniform at high as well as at low velocities. These engines are of the same kind as the engines being constructed by them of 1250 horse-power for H.M.S. Achilles, one of the cylinders of which is also exhibited in this department; it is a clean casting, well bored out, weighing 18 tons; diameter, 42 inches; stroke, 4 feet. Near the cylinder is a massive wrought-iron crank-shaft and connecting-rod, fitted complete, with brasses for the same engines. The Warrior and Black Prince were furnished with engines of which those of the Achilles will be duplicates. Messrs. Penn are also engaged in making two pair of engines for the new iron-sided ships Minotaur and Northumberland. The marine engines (1891), exhibited by Humphrys and Tennant are very compact and neat. This firm, by whom engines were supplied to the British, Brazilian, and other governments, have successfully studied two of the most important points in connection with engines for war purposes and for screw propulsion in general, namely, the compression of the greatest amount of power into the least possible compass, and have contrived that the engine should be placed as much out of harm's way as possible. The pair of 400 horse-power engines (1926) by the firm of Maudslay, Son, and Field, for H.M.S. Valiant, is well calculated to maintain the high reputation which this firm has so long deservedly enjoyed. Tod and McGregor hold a high position as engine builders, yet their direct-acting inverted cylinder marine engines (2009) show a very poor arrangement for sea-going vessels. However, the workmanship and finish of these engines are excellent.

George Rennie and Sons, of London and Greenwich, exhibit a pair of marine screw engines (1964) for H.M.S. Reindeer, of 200 horse-power, and similar to those of H.M.S. Perseus. These engines possess great strength, and are well calculated for effective hard work and long voyages. The Messrs. Rennie are represented in other classes to be referred to hereafter. Messrs. Fairbairn and Sons, of Manchester, exhibit a locomotive constructed for the Midland Railway Company. The boiler is composed of thick edged plates, double rivetted; no angle iron is used, the barrel of the boiler being flanged where attached to the tube plate. This engine was designed by Mr. Kirtley, Engineer of the Midland Railway Company. The Lilleshall Company, Shiffnal, Shropshire; the London and North-western Railway Company, together with a locomotive engine and tender, bring forward an ingenious apparatus, invented by Mr. Ramsbottom, for supplying water to tenders whilst in motion. The plan has been in daily operation on the Chester and Holyhead Railway since it was first adopted in the winter of 1859-60. Various quantities of water, from 1200 gallons downwards, can be fished up at speeds ranging from 22 to 50 miles per hour; the arrangement has the effect of reducing the dead weight of the tender about 6 tons, equal to the weight of a loaded carriage. We must not pass the little locomotive engine of Manning, Wardle, and Co., of Leeds; it is designed for mineral traffic at iron works, collieries, &c., and will go round any curve where an ordinary railway waggon will pass. It is also well adapted for contractors' purposes; the wheels being small, it will ascend steep gradients. The wrought engine and carriage

*See reviews of this work in the volume of the *Journal* for 1860, page 378, and volume for 1861, pages 29 and 82.

wheels, stamped, of William Owen, of the Phœnix Works, Rotherham, we purpose noticing specially hereafter. Although the locomotives placed in the Exhibition are admirable specimens of the progress and improvements that have been made in railway economy during the last 10 or 12 years, and reflect credit on the companies and firms who have manufactured and sent them to the Exhibition, yet the lug principle is not fully carried out in any of the locomotive engines exhibited. The proper disposition of permanent lugs or stops to relieve the strains and shocks on the bolts, and to sustain the action and reaction of the working parts, should be attended to with great care by locomotive contractors. In the boilers exhibited there is scarcely an improvement worth mentioning. The models of Harvey and Co.'s single acting condensing engine (1880) on the Cornish principle, and of a safety-balance valve invented by W. Husband, although not new, deserve attention; the engine was erected by Harvey and Co., Hayle, Cornwall, and the Haymarket, London, for the East London Water-works Company, at Lea Bridge. The cylinder is 100 inches in diameter; working stroke, 11 feet. The pump is a plunger, 50 inches diameter and 11 feet stroke. This engine, when working full power, pumps 9000 gallons of water a minute, usually 140 feet high. In 1858 Harvey and Co. erected for the Southwark and Vauxhall Water Company at Battersea a pumping-engine, the cylinder of which is 112 inches diameter, weighing 36 tons. It is said that the total quantity of water pumped for the supply of London daily amounts to 115 million gallons. Of this large amount it is stated that 79 million gallons are pumped by single-acting engines. Harvey and Co. have had great experience in the manufacture of machinery for stamping and crushing ores. Among the hydraulic machines, the steam fire-engines in the western annexe hold a high place. These machines are unfortunately placed in corners where it is difficult to observe their merits. The American steam fire-engine, forwarded by Mr. Hodges of Lambeth Distillery, is very complete. Messrs. Shand and Mason, Messrs. Roberts, and Messrs. Merryweather, stand well in this department. The experience of the managers of the fire-brigade of the metropolis for the past year or two, and the recent report of a select committee, clearly show that the engines, stations, and staff of the London Fire Brigade are totally inadequate to the efficient protection of life and property from fire.

Mr. Martin's patent rocking furnace-bars, for land and marine purposes, are exhibited in No. 1925. A furnace fitted with these bars is easily managed; the bars are easily moved by a lever, and clinkers and impurities are removed. We cannot see what object W. and A. McOnie, of Glasgow, have in view in exhibiting one of their 30-horse power high-pressure steam-engines. We are unable to find anything novel in either their sugar-cane mill or steam-engine. Mr. Macord exhibits (in No. 1922) machines, tools, and utensils used for bottling wine, spirits, and beer. Macord's apparatus for bottling wine is the best in use: the syphons are fitted to the cistern with hinge-joints, one pin forms the centre of all, they may be removed and replaced without unscrewing or screwing; they are also made so that one set will answer both for pint and quart-bottles. We cannot pass without remarking C. A. Preller's machine driving-belts (No. 1959), for transmitting power, made of leather prepared in a peculiar manner, combining strength with suppleness. By experiments made in Woolwich Dockyard, it has been ascertained that Preller's leather belt is at least 50 per cent. stronger than tanned leather; and hence superior to all substitutes for leather.

Ravenhill, Salkeld and Co., of Ratcliff and Blackwall, exhibit some very fine models of engines. The first (1962) is a model of the engines of the Holyhead mail packets, Leinster and Connaught, each of 720 nominal horse-power. This model shows an application of the oscillating cylinder to the largest class of marine steam-engines; each cylinder 98 inches internal diameter, weighing, when finished upwards of twenty tons; the condenser 22 tons. The engines were fitted with 8 tubular boilers, having 40 furnaces and 4176 tubes, giving a total length of four and three-quarter miles of tubing; and the vessels attained an average speed at the official trial in Stokes Bay of 18 knots, or 21 miles an hour; the engines exerting an indicated power of 4751 horses. The second is a model of engines of 500 nominal horse-power, with horizontal cylinders and double piston-rods, for screw propellers, such as are fitted by Messrs. Ravenhill, Salkeld and Co., for Her Majesty's 90-gun line-of-battle ships. The third is a model of engines of the same power as the second model, but arranged for surface condensation. The fourth model shows a marine steam-engine, with inclined oscillating cylinders, designed for vessels having a small section with considerable rise of floor. Engines on this plan have been constructed by the exhibitors up to 240 nominal horse-power. No. 1964 is a working model of a marine condensing engine for screw propeller, high and low-pressure, with surface condenser, by Messrs. George Rennie and Sons. We have no doubt that these engines will work well; they are fitted with improved centrifugal pumps for circulating the water in the condensers. Messrs. Rennie state that engines on this principle, fitted with boilers in proportion, apparatus for superheating the steam, and feed water heaters, can be made to consume not more than 2 lbs. of coal per indicated horse-power; however, the mode of obtaining this result does not appear. Mr. J. Scott Russell gives (1976) a three cylinder marine steam-engine, of 100 horse-power, working expansively, with variable cut off surface condensers, with india-rubber packing; diameter of cylinder 30 inches, length of stroke 3 feet. Captain Fowke's patent military fire-engine, made by Shand and Mason, for Her Majesty's War Department, is an unpromising affair. B. D. Taplin and Co., of Lincoln, manufacturers of steam fire-engines, and of traction engines in general, would do well to employ Fisher's elongated springs now applied to the New York steam fire-engines of Messrs. Lee and Larned. We step aside to notice the feed-water regulator, indicator, and alarm for steam boilers (2028) of Francis Wise, of Buckingham-street, Adelphi. If foaming and scale did not interfere, this simple arrangement, with a float within the boiler, and without the use of stuffing-boxes, cocks, or other complexities, would regulate the action of the feed pump, indicate the water level, and, should the latter fall below a certain line, sound an alarm. We cannot see how Mr. E. T. Wright (No. 2032), gains forty per cent. additional strength by constructing a boiler with diagonal seams.

The iron semaphore railway signals and compensating signal wire apparatus of Messrs. Stevens and Son, Darlington Works, Southwark, answer every purpose for which they are designed. They are complete, and may take their place in the front rank of modern improvements in railway appliances. One of these signals acts for both 'up' and 'down' lines by day and night. They are the most durable and effective signals in use; and, although invented recently, are now adopted on many of the lines in the United Kingdom, India, and Australia. Being made of open ironwork, they are not affected by violent gales, while the strong cast-iron base renders these signals secure, and not subject to decay, unlike timber signals. The patent wrought-iron distant signal of Messrs. Stevens and Son, fitted with Brydone's candle signal lamp, are fixed in many instances 1800 yards from the railway stations, and worked at that distance with ease and certainty. The compensating pullover level, with ratchet weight and chain, are employed to work the auxiliary signals at a distance from the station, the lever being fixed on the junction platform. The advantage of these over ordinary levers is, that by means of the ratchet balance-weight and rack fitted to the lever, the expansion or contraction of the wire through the variations of temperature is compensated for. It is desirable to have an efficient apparatus to show when the shifting-rail or point is open or shut; the indicators of Messrs. Stevens show most distinctly by day or night the state of the points. By day the disk divides, and by night the lamp placed at the back of or between the disk or disks, shows a red, green, or white light.

At present we are compelled to pass, in the western annexe, many effective machines, which we shall take an early opportunity of describing. Cotton machinery is extensively represented by Messrs. Dobson and Barlow of Bolton, and by Platt Brothers and Co. of Oldham. The cotton working machinery of these firms reflects great credit upon the proprietors, who must have gone to great expense to set their machines to work in London, and to support a numerous staff to work and attend to them. The cotton machinery of Messrs. Hetherington, of the Vulcan Works, Manchester, is not inferior to that just mentioned. There are also exhibited a large number of engineering tools, drills, planers, slotting, sparing, chipping, trimming, and turning machines, nut and bolt machines, wheel cutting machines, lathes, file and rasp machines, &c.

(To be continued.)

ARCHITECTURAL DRAWINGS AND OBJECTS AT THE INTERNATIONAL EXHIBITION, 1862.

The objects and drawings of interest to an architect are of necessity widely dispersed in various parts of the building. Of the raw materials which he employs, some are to be found in the "Mining and Quarrying products" of Class 1, others among the "Vegetable Substances used in Manufactures" of Class 4, and others again among the glass and pottery of Classes 34 and 35. The building and engineering contrivances form a class of themselves, the architectural drawings and models are again separate; and lastly, when these various objects have been hunted up and examined on the British side, the visitor will find throughout the foreign side similar objects scattered about in various localities and among the contributions of various countries.

We propose in the present notice to refer to some of the more prominent articles on the British side showing architectural design, leaving out for the present the specimens of tiles and stained glass, the building materials and contrivances, and the foreign contributions. Of these articles some are situated in the nave and east transept, some in a "Mediæval court" on the north side of the nave, mixed up with and catalogued among articles of furniture in Class 30, and the remainder in a series of bays east of the south-east transept. They include specimens of upholstery work, hangings, stone carving, and metal-work, and taken together exhibit a remarkable degree of productive skill in these departments. The place of honour must undoubtedly be given to Mr Skidmore's screen for Hereford Cathedral, this, which is entirely of metal-work, Gothic in character, and executed from Mr. Scott's design, is fixed in the centre of the transept, and forms almost, if not quite, the most artistic single object in the whole Exhibition. The skeleton or ground-work of the screen is simple and bold enough, an arcade of five pointed arches, the centre one wider and loftier than the others, and surmounted by a pediment finished by a cross, having a horizontal cornice running over the side arches which is broken through by the central pediment. The lines of the features here described are strongly and firmly defined, and the eye grasps them in a moment—notwithstanding the almost endless elaboration of the ornamental details superadded; and in the good proportion and simplicity of these leading forms, and the vigour with which they are marked, lies the source of a great portion of the beauty of the work. The large arches are subdivided each into two smaller ones by intermediate shafts carrying a cusped filling-in of open-work. The lower parts of the openings are filled up with an elaborate grille; the capitals, cornice, traceries, finials, and crockets, are elaborated with the most perfect workmanship and design, and as a crowning finish there stand, supported on corbels above the main capitals, exquisite figures of angels, while the central gable is enriched by a figure of our Saviour occupying an open panel of the vesica piscis form. The materials employed are principally iron, bright brass enriched by coloured inlaid work, and beaten copper; and the beauty of the work is enhanced by the judicious colouring given to the parts which are painted, in which a refined variety and contrast is carried out to a very great extent without destroying the harmonious effect of the screen as a whole, but on the contrary contributing to it. This is justly a work to be proud of, as showing a capability for production of works of metal work such as has been lost since the middle ages. There is, however, one cause for regret, in the fact that the endless variety found in ancient work of the same sort is not to the same extent present here; true, the repetition of the same flower, or the same panel, time after time, in a work of this sort enables its expense to be brought within the compass of comparatively ordinary outlay; and to carry out to the full the utmost amount of variety and novelty of design in small parts as might have been possible, would have added greatly to the cost of the work, and doubled or trebled the time of producing it, without increasing the effectiveness of the screen taken as a whole; still, this was wanted to make the Hereford Screen as perfect as most examples of the same nature executed in Mediæval times.

Near the screen are a very fine gas corona and two gas standards, executed to accompany it. The corona is hung so high as to defy scrutiny, in fact almost to escape observation, its general form is very good, and its enrichments seem equally successful with those of the screen. The standards are noble and simple, but rich.

The next most important piece of ornamental metal work exhibited consists of a fine pair of park gates, fixed in the nave; they are manufactured by Messrs. Bernard, Bishop, and Co., of Norwich, but the name of the designer is not stated. These gates are not Mediæval in character, but are almost, if not quite, as perfect in workmanship as the screen just referred to; they are however exhibited at every possible disadvantage as regards colour, for not only is there no variety in material, or variation in tone of colour, but that colour itself is a very inappropriate inky tint, singularly ill-chosen to show off a work of art. The design of this work is not so masterly as in the last instance, but still it shows an intimate acquaintance with the properties and capabilities of iron, and its carrying out shows the existence of a remarkable body of skilled workmen. The thistles in the upper part of the work may be instanced as specimens of beaten work of the highest class.

Near Mr. Skidmore's work stands a sort of trophy, occupied by the contributions of Messrs. Benham, Hart, Feetham, and Bailey. In the varied displays by these four eminent manufacturers a large amount of taste and executive skill may be traced, and especially is this the case in the Mediæval work sent by Messrs. Benham and Messrs. Hart. Altogether this part of the display of metal-work is most admirable, and belonging as it does to varied styles, and especially to those best periods of Gothic art which can never fail to retain their hold upon all refined minds, these specimens will probably receive, as they in fact seem to deserve, more observation than many of those which yet remain for us to notice.

Passing now to works executed in other materials, we find unquestionable indications of great skill in the artificers, and originality on the part of the designers. The works in the Mediæval Court already referred to, and which was under the especial care of the Ecclesiological Society, present an aspect which strikes a visitor as contrasting strangely with his recollections of the mediæval court of 1851. The objects exhibited are to a great extent cabinets, buffets, book or organ-cases in wood, and portions of the carving or sculpture of such features in churches as a reredos, pulpit, or font in stone or alabaster. The art seems in the eleven years that have elapsed to have gone back almost half that number of centuries, not in execution but in style, so that the forms here exhibited are many of them really archaic, while the inspiration of nearly all of them has been drawn rather from continental than English sources. That this has for some time past been the tendency of English Gothic has been obvious enough, but the strangely uncommon, we had almost said uncouth, aspect of much here impresses the fact very forcibly on the beholder. Whether all our Gothic work will turn to Romanesque of the most primitive type might be almost a subject for speculation to a spectator of this court, were it not for his recollection of such objects as the Hereford Screen, and of such drawings as those, for example, of Mr. Scott's Foreign Office, or Mr. Waterhouse's Assize Courts.

It will interest lovers of art to examine the painted cabinets of Mr. Burges, and the inlaid ones of Mr. Shaw, Messrs. Prichard and Seddon, and other similar works; but it may be fairly regretted that all the works in this court are so similar to one another in type, and that that type is neither the noblest nor, we venture to think, the most commonly employed and appreciated by those who love and follow pointed art.

Leaving for the present these articles, which are not however by any means exhausted, the British architectural drawings seem to claim a moment's attention. Of these there is a noble collection, very few architects of distinction being unrepresented, while the collection gains very much in importance from the fact that the majority of the drawings represent executed works.

We have here the drawing by Sir Charles Barry, showing improvements in connection with the Government Offices, which attracted so much attention at the time of the great competition. This drawing is understood to have been executed entirely by his own hand, and it and a series of sketches in the East, also exhibited, will show how well deserved was the reputation for consummate draughtsmanship that he possessed. A modest selection from his executed works, including the Palace of Westminster and Bridgwater House, is also exhibited.

Sir Charles's sons are large exhibitors. Mr. Edward Barry sends his fine Schools in Endell Street, and his Leeds Grammar School and other drawings. Messrs. Banks and Barry exhibit, with other works, their fine but unsuccessful design for the Manchester Assize Courts, and their design for the Government Offices, to which the second premium was awarded. Mr. Scott exhibits his designs for the same work, which, unhappily, he has been obliged completely to modify. These are, perhaps, the finest architectural drawings shown, though they are possibly not the best designs among the series sent by Mr. Scott, a series which includes his Hamburgh Church and Hotel de Ville, his Doncaster Church, a restoration of the Chapter House, Westminster, and several other works.

Another series, remarkable for beauty of drawing and for fine colouring, is that exhibited by Mr. Owen Jones. His Palace of the People, designed for Muswell Hill, his St. James's Hall, and his design for the Manchester Exhibition, are all works that show a powerful and fertile imagination and a profound knowledge of colour, while as specimens of masterly drawing they are worthy of all attention. Special interest attaches to the "Design for the Decoration of the Great Exhibition Building, 1851," as a record of what had been his intentions had they been fully carried out, and as a contrast to the dull commonplace effect of the building in which the drawing itself is hung.

Mr. Digby Wyatt, who has been associated in many works with Mr. Owen Jones, sends a somewhat similar contribution. His drawings are more numerous, but smaller for the most part. They mostly represent executed works, and some of the best are the Fine Art Courts, and the Screen from the Crystal Palace. The studies, sketches, and designs for decoration here given are most valuable.

Professor Smirke sends but one drawing, it is, however, a work of great beauty, showing the application of various descriptions of coloured materials to polychromatic decoration; and with it deserves to be classed two exquisite drawings contributed by Mr. Penrose, to illustrate the polychromatic decoration of St. Paul's Cathedral.

Mr. Newton exhibits a very fine drawing of London from the Victoria Tower, illustrating a proposition for the Embankment of the Thames; and the same subject, though not from the same point of view, is taken by Mr. C. F. Hayward, who also contributes a series of designs and executed works.

Mr. Street is an exhibitor of several drawings; and, we need hardly add, that both original design and excellent draughtsmanship are to be found abundantly displayed in his contribution. It is, however, desirable to direct attention to this series of drawings, because from their quiet style they may some of them escape notice among the more brilliantly-coloured works that hang near them.

Special attention should also be given to the designs, by Armistead, of sculpture to decorate a mansion recently erected by Messrs. Prichard and Seddon. For a happy combination of mediæval art with modern details and forms, and for adaptation to decorative purposes, as well as for spirit and power, these are some of the most remarkable works exhibited, and we hope to find the same pencil and chisel engaged on other works of a similar character.

Some of our best country architects sends drawings of great beauty; thus, Mr. Waterhouse, besides other works, exhibits an exterior and an interior of his Manchester Assize Courts; and Mr. Cuthbert Brodrick his Leeds Town Hall and the Town Hall at Hull; but any one acquainted with the works now in hand or completed within the last few years in the North of England cannot help regretting that a large number of the leading provincial architects are not exhibitors; still it is a somewhat proud reflection after all, that the fine gallery of which we have only mentioned a few of the very prominent ornaments, does not contain anything like all or even a fair proportion of the greatest works executed within the last twenty or thirty years, or even executed since 1851, in Great Britain. Notwithstanding this we have, however, we hope, said enough to justify us in claiming attention to the collection of drawings as one reflecting credit on our architects in general, and exhibiting also great talent in draughtsmanship.

We cannot leave the architectural gallery without remarking that many of the most accomplished exhibitors will have cause as long as they live to recollect the skill, or the want of it, exhibited in the construction of a building about which no one of their profession was consulted; for a large number of the finest drawings are swollen, creased, and mildewed, owing to the dampness of the wall against which they hang; and should there be a wet season, will in all probability be returned to their owners completely spoiled.

THE ECONOMIC CONSTRUCTION OF GIRDERS.

(*Continued from page* 151.)

Since writing the last article on this subject we have calculated the practical weights of several other forms of openwork girders of similar proportions to those already given, and as several of these new forms possess considerable economic merit, and the whole will form a pretty complete investigation of this particular group of girders—having a depth equal to one-eighth of the span, the roadway divided into eight bays, the fixed loading equal to half a ton, and the movable loading equal to one ton per foot run —it is desirable that the calculations of these new forms should also be given in detail, and the results for all the forms collected together in one table.

We group the results under the two distinct cases of the roadway platform being placed—1st, at or above the level of the upper boom of the girder; and, 2nd, at or below the level of the lower boom. We advisedly omit the case of the roadway being placed at the level of the neutral axis, such a position must generally entail the employment of much extra material, and has nothing to recommend it, at least when openwork girders are employed.

Although the table of results shows that the girders taken alone may be made decidedly lighter for the second case than for the first, yet for various economic reasons, the first arrangement, or that in which the roadway rests on the tops of the girders, is to be preferred, when the the choice can be made. Of these reasons for the preference we may mention the following:—First, lightness of the transverse girders; when single principal girders are used in a railway bridge, one being placed immediately beneath each rail, transverse girders may be got rid of altogether, without the use of unduly thick planking; and when the when the girders are double ones, or each capable of supporting one complete line of railway, the distance between them, or the length of bearing for the transverse girders, may be only 11 or 16 feet; whereas, in the case of the platform being at the lower boom level, the lengths of bearing for the transverse girders must be respectively about 14 and 25 feet, according as single or double principal girders are employed. The second reason is that free scope is allowed for the introduction in the best manner of the necessary horizontal and transverse bracings; with the consequent lightness and perfection of action of these elements of the structure. The third reason is, that with the roadway at the top rather than at the bottom level of the girders, the total height of the structure is less by a length equal to the depth of the girder.

There should then, when economy and excellence of construction are considered, be no hesitation in adopting the first arrangement, whenever the circumstances admit of it. But very frequently this cannot be, as the arrangement would not allow of sufficient headway beneath the girders for the requirements of the road or river bridged over.

When constrained to place the roadway platform at the lower level of our girders, it will be a source of great advantage if we can have these so deep that the upper booms may be connected together overhead by a horizontal bracing; for in the absence of such a connection, a considerable addition of material in the upper booms to prevent lateral warpings and consequent failure, would be demanded. But with the girders we are considering, or others of great proportionate depth, it will only be for trifling spans that this knitting together of the two booms cannot be managed. By attaching the transverse girders so that their tops come in contact with the under surfaces of the tie-booms, a clear height above the rails and below the upper horizontal bracing, equal to the depth of girder for calculation, may be readily secured; so that with girders eight depths in span, we may use the connected arrangement, although the span be even somewhat less than 120 feet. And for spans considerably less than this it may still be advisable to adopt this tubular arrangement, by retaining the necessary depth of girder; for instance, for a span of about 90 feet, we could have the depth of girder equal to one-sixth of the span.

When the spans and consequently the depths are great, and the road at the lower-boom level, a light line of horizontal bracing may be run along the neutral plane, or near to it—this will add greatly to the stiffness of the struts of the web, so that the allowance of metal (a) given to them may be considerably reduced. In fact, with such a support against lateral bending, and the support in the plane of the girder afforded by the crossing ties in the first form of girder, the lengths of the struts of the bracing would be virtually reduced to one half.

For either position of the roadway, it will generally be best to adopt one of those forms the results for which are given in the *last* column of Table XXXII. For with such the piers need not be carried up beyond the lowest member of the girder.

It may here be proper to give some further particulars of the principles on which the values of the factor a for the various parts are assigned; particularly as these may not be thought very correct by some readers. And it is for this reason that the calculations are given in such detail, that the results with other values of a (either more correct or in accordance with the practice of other constructors) may be readily computed.

The general dimensions and character of the sections of the booms will be chosen with reference to the greatest stress to be borne, which is here at the midspan; and this must lead to a large excess of metal being given to the less strained bays, so much so that in the girders we are considering the extreme bays may be taken as not reducible below the following percentages of the strongest or central bays when a proper regard is paid to firm and durable construction :—for the sectional area of the extreme bay of the strut-boom we give about 66 per cent. of the section at the midspan, and for that of the extreme bay of the tie-boom, about 35 per cent. of its central section.

Then with regard to the struts of the bracing—the sections of these have in a general sense been taken from actual fabrics. It may be noticed in the first place, that when the vertical component, V, of the stress is the same for a perpendicular as for an oblique brace, the value of a has been chosen the same for each; the reason for this being that the actual stresses ($=V \sec \theta$) in proportion to the lengths are the same. Such a rule would not be correct were the struts all of solid section, or all of exactly similar sections, but when the struts are built up of plates and angle irons, the rule is, within reasonable limits, practically very near to the truth. Again, if we take the case of a strut, say strut A of Table I., which receives support in *one* direction only, from the tie H, crossing and being attached to it at its middle, we find $a =$ ·00060; then turning to the similar strut A of Table XV., which receives no such support, we yet find the value of a still $=$ ·00060, the reason for this is that the latter strut has to carry a stress whose vertical component is equal to $10\frac{1}{2}$ units, whereas the former strut has a value of V equal to only 6 units; the sectional areas will therefore be in these proportions, and it is assumed that the excess of section in the latter will be sufficient to make up for the loss of assistance from a crossing tie.

If the depths of the girders were reduced from one-eighth to one-sixteenth of the span, the lengths of the braces and of the bays would be reduced by one half, and the stresses in the booms would be doubled. Such changes would indicate a reduction in the values of a for all the struts (although the allowance for extra length in the braces might require to be increased), and from the stouter section that could be used for the upper boom its end bays might be reduced in sectional area, to say 60 per cent. of the central ones, and the end-bays of the ties to one-third. We have run out the calculations for such girders—but neither the details nor results are of sufficient interest to call for their being given here. The results are, indeed, only what might have been predicted—viz., the weights of the booms rather less than the double of those for girders of double the depth, and the weights of the webs rather less than those for the deeper girders. Further, the influence of the value of θ, the angle of inclination of the braces, is augmented in affecting the weight of the web in each example, but as the web constitutes only about one-fifth of the whole weight of the girder, instead of one-third as in the deeper forms the importance of an apparently considerable saving on it is greatly reduced when estimated as a percentage over the whole structure; thus, in the examples having a depth of one-eighth of the span, a saving on the web amounting to 15 per cent. would represent a saving of 5 per cent. on the complete girder, but when the depth is only one-sixteenth of the span, to produce this saving on the whole girder would require the saving on the web to amount to 25 per cent.

When the girders are single, *i.e.*, only calculated to carry a moveable loading equal to half a ton per foot run, and at the same time the span is moderate, a marked addition must be made to the values of a for the struts, particularly in those of the web. From this it will be seen that single girders when of moderate span must weigh considerably more than half the corresponding double ones; it is therefore advisable where practicable, as in the case of the roadway being at the upper level, to employ two double girders in preference to four or more single ones. For very long spans, the preference, for various reasons may, on the contrary, be given to single girders.

We may now proceed to describe the various forms of girder the results for which are contained in Table XXXII., and to give the details of the remaining calculations.

The first, second, third, and fourth forms have already been described in the former paper.

The fifth form is a frame with a single series of braces, or what is known as a warren-girder, commencing with a tie-brace, and with $\theta = 26° 34'$ throughout.

The sixth form is also a warren-girder, with the same value of θ, but commencing with a strut. It should be observed that for these two forms, when the roadway is at the lower and at the higher levels respectively, the distribution of the loaded points along the span becomes different from that in the other examples, and the amount of loading due to each of the extreme points is only three-quarters of that due to each of the others; this, as has been shown in a former paper, gives rise in itself to some change in the general results.

The seventh form is identical with the third, except that the tie H of the third is replaced by a strut A introduced in the other diagonal of the end quadrilateral compartment, and the vertical strut A of the third form is converted into the vertical tie H of the seventh.

The remaining forms are modifications of the preceding seven, made in order to suit them better for the particular cases.

The eighth form is the first modified, to carry the road at the upper level, and also to deliver the load at that level to the piers.

The ninth form is the first modified, to carry the load at the lower level, and to deliver it at that level to the piers; this gives the most economical of all the arrangements, although not much more so than the fourteenth form, which further, from having the struts of the web at right angles to the booms, may offer some constructive facilities.

The tenth form is the third modified, for an upper load, and an upper bearing on the piers.

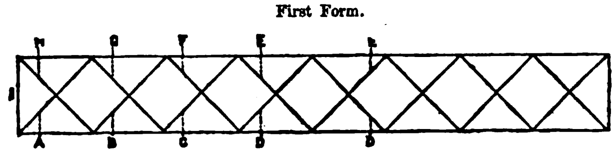
The eleventh form is the fourth modified, to carry the roadway at the lower level, and to have its bearings on the piers at that level.

The twelfth form is the fifth or warren form, hung at the upper angles, and with the end pillars and extreme half bays of the tie-boom omitted.

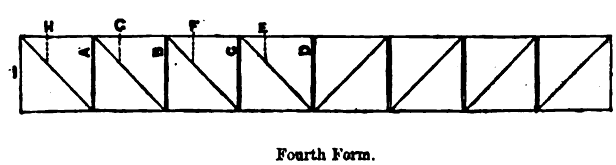
The thirteenth form is the sixth, bearing on the piers at the lower angles, and with the end pillars and extreme half bays of the top boom omitted.

The fourteenth form is the seventh, modified for a load at the lower level, and a bearing on the piers at that level. This form possesses great economic merits, and may be looked upon as competing with the ninth for the first place, for the case of the roadway being placed at the level of the lower boom, and when there is to be but one span, or no connection with other spans over the piers. For the case of the roadway being placed at the level of the upper boom, the first form must still be regarded as holding the first place, whether for bridges with separate or connected spans.

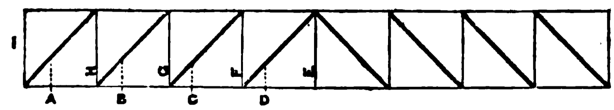
First Form.



Third Form.



Fourth Form.



Calculations of the Weight of Iron in the Bracings and end Pillars, and in the Booms of the several forms of Girder.

The unit of length is taken equal to the depth of the girder, or to one-eighth of the span.

The unit of stress or load is taken equal to one-eighth of the total dead weight, or to one-sixteenth of the whole movable loading that may be brought upon the girder.

The measure of the weight of iron in any part, as given in the tables, is equal to the greatest stress that may act upon it multiplied by its theoretical length in the above units, and by the factor a; and this in the case of a brace will be $= V \sec^2\theta$, where V represents the vertical component of the stress, and θ the angle which the brace forms with a vertical line.

The actual weight of iron in any brace or bay in tons will be obtained by multiplying the representative number in the table by the product in feet-tons of the units of length and stress. For the whole weight of the web or booms of a girder we must further double the results in the tables, since these are given for only half the length of the girder; or as explained before, we must multiply the tabular number by the square of the depth of the girder in feet, to obtain the weight in tons.

The calculations for the first four forms have already been given.

THE FIFTH FORM, *with the loading at the upper level.*

TABLE XVIII. The Web.

Brace.	*a.*	V.	Sec²θ.	Weight.
A	·00060	10·50	1·25	·00787
B	·00067	7·75	1·25	·00649
C	·00077	5·25	1·25	·00505
D	·00090	3·00	1·25	·00338
E	·00045	3·00	1·25	·00169
F	·00045	5·25	1·25	·00295
G	·00045	7·75	1·25	·00436
H	·00045	10·50	1·25	·00591
				·03770
I as a tie	∞	0·00	1·00	·00075
I as a strut	·00060	12	1·00	·00720

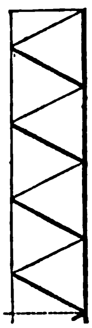


TABLE XIX. The Booms.

(N.B.—Each ordinary bay is one unit long).

Upper Boom.	*a.*	Stress.	Weight.
1st Bay	·00160	5·25	·00840
2	·00070	14·25	·00997
3	·00060	20·25	·01215
4	·00055	23·25	·01279
			·04331
Lower Boom.			
1st Bay (½)	∞	0·00	·00189
2	·000	10·50	·00473
3	·000	18·00	·00810
4	·000	22·50	·01012
5 (½)	·000	24·00	·00540
			·03024

THE FIFTH FORM, *with the loading at the lower level.*

TABLE XX. The Web.

Brace.	*a.*	V.	Sec²θ.	Weight.
A	·00062	9·094	1·25	·00705
B	·00070	6·469	1·25	·00566
C	·00080	4·094	1·25	·00410
D	·00110	1·969	1·25	·00271
E	·00045	4·093	1·25	·00230
F	·00045	6·469	1·25	·00364
G	·00045	9·093	1·25	·00511
H	·00045	11·250	1·25	·00633
				·03690
I as a tie	...	0·750	1·00	·00080
I as a strut	·00060	11·250	1·00	·00675

TABLE XXI. The Booms.

Upper Boom.	*a.*	Stress.	Weight.
1st Bay	·00152	5·625	·00855
2	·00070	14·625	·01024
3	·00060	20·625	·01238
4	·00055	23·625	·01299
			·04416
Lower Boom.			
1st Bay (½)	∞	0·000	·00186
2	·00045	10·125	·00456
3	·00045	17·625	·00793
4	·00045	22·125	·00996
5 (½)	·00045	23·625	·00531
			·02962

The Booms as before = ·07300

THE SIXTH FORM, *with the loading at the upper level.*

TABLE XXII. The Web.

Brace.	*a.*	V.	Sec²θ.	Weight.
A	·00060	11·250	1·25	·00844
B	·00063	9·093	1·25	·00717
C	·00070	6·469	1·25	·00566
D	·00080	4·094	1·25	·00409
E	·00110	1·969	1·25	·00271
F	·00045	4·093	1.25	·00230
G	·00045	6·469	1·25	·00364
H	·00045	9·093	1·25	·00511
				·03912
I as a strut	...	0·750	1·00	·00200
I as a tie	·00045	11·250	1·00	·00506

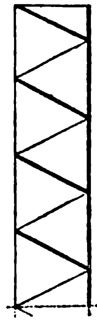


TABLE XXIII. The Booms.

Upper Boom.	*a.*	Stress.	Weight.
1st Bay (½)	∞	0	·00420
2	·00086	10·125	·00871
3	·00065	17·625	·01146
4	·00058	22·125	·01283
5 (½)	·00055	23·625	·00650
			·04370
Lower Boom.			
1st Bay	·00066	5·625	371
2	·00045	14·625	658
3	·00045	20·625	928
4	·00045	23·625	1063
			·03020

THE SIXTH FORM, *with the loading at the lower level.*

TABLE XXIV. The Web.

Brace.	*a.*	V.	Sec²θ.	Weight.
A to H	Same as in Table XVIII.		=	·03770
I as a tie	·00045	12·00	1·0	540
I as a strut	∞	0	1·0	209

TABLE XXV. The Booms.

Upper Boom.	*a.*	Stress.	Weight.
1st Bay (½)	∞	0·0	·00420
2	·00084	10·5	·00882
3	·00065	18·0	·01170
4	·00058	22·5	·01305
5 (½)	·00055	24·0	·00660
			·04437
Lower Boom.			
1st Bay	·00068	5·25	·00357
2	·00045	14·25	·00641
3	·00045	20·25	·00911
4	·00045	23·25	·01046
			·02955

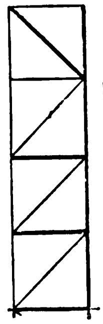
THE SEVENTH FORM, *with the load at the upper level.*

TABLE XXVI. The Web.

Brace.	*a.*	V.	Sec²θ.	Weight.
A	·00060	10·5	2	·01260
B to G as in Table V.			=	·02498
H	∞	0	1	·00060
				·03818
I as a tie	·00045	10·5	1	·00479
I as a strut	·00120	1·5	1	·00180
			The Booms =	·07300

The weight of the booms in this and the next arrangement may be taken the same as for the third form (Table XIV.) The first bay of the upper boom is relieved from all longitudinal stress, and the first bay of the lower boom bears a stress of 10·5; any slight change in the sections of these parts which such differences could warrant, would neutralise one another; and the other bays are all exactly as before.

The Seventh Form, *with the load at the lower level.*

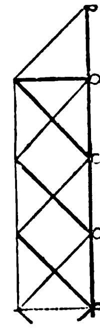


Half of Seventh Form.

TABLE XXVII. The Web.

Brace.	a.	V.	Sec²θ.	Weight.
A	... ·00060 ...	10·50 ...	2 ...	·01260
B to G as in Table VI.		...	=	·02184
H	... ·00045...	3·0	... 1 ...	·00135
				·03579
I as a tie	... ·00045...	12·00	... 1 ...	·00540
I as a strut	... ∞ ...	0	... 1 ...	·00200

THE EIGHTH FORM.



Half of Eighth Form.

TABLE XXVIII. The Web.

Brace.	a.	V.	Sec²θ.	Weight.
A	... ·00067 ...	6·0 ...	1 ...	·00402
B to G as in Table I.	..	...	=	·02176
H	... ·00045 ...	10·5 ...	2 ...	·00945
				·03523

TABLE XXIX. The Booms.

Upper Boom.	a.	Stress.	Weight.
1st Bay	... ·00080	10·5	·00840
2nd to 4th as in Table X.	......	=	·03353
			·04193

Lower Boom ...... Same as in Table X., without 1st Bay... } = ·02700

THE NINTH FORM.

Half of Ninth Form.

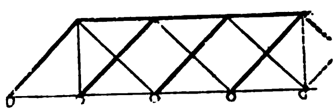


TABLE XXX. The Web.

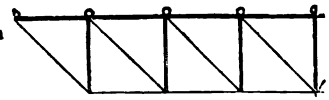
Brace.	a.	V.	Sec²θ.	Weight.
A	...... ·00060	10·5	2	·01260
B to G as in Table II.	......	......	... =	·01971
H	...... ·00045	6·0	1	·00270
				·03501

TABLE XXXI. The Booms.

Upper Boom same as in Table XI., wanting 1st Bay... }	...	=	·03630
Lower Booom.			
1st Bay ... ... =	·00045 × 10·5	=	·00473
2nd to 4th same as in Table XI.	... ...	=	1497
			·02970

THE TENTH FORM.

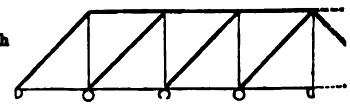
Half of Tenth Form.



The results for this are obtained from the data in Tables V. and XIV.

THE ELEVENTH FORM.

Half of Eleventh Form.



The results for this are obtained from the data in Tables VIII. and XV.

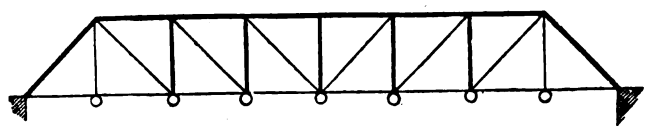
THE TWELFTH FORM.

The results for this are derived from the data in Tables XVIII. and XIX., and Tables XX. and XXI.

THE THIRTEENTH FORM.

The results for this are derived from the data in Tables XXIV. and XXV.

THE FOURTEENTH FORM.



The Web is the same as in Table XXVII. The Upper Boom may be taken from Table XIV., with the 1st Bay omitted. The Lower Boom may also be taken from Table XIV., after making the 1st Bay equal to the second.

TABLE XXXII.—GENERAL SUMMARY OF RESULTS FOR THE GIRDERS.

Description of the Girder.	Results for the Web.			Results for the Booms.			Results for the Girder Complete.		
	Without end pillars, or as described in column 8.	With end pillars as ties, or as described in column 9.	With end pillars as struts, or as described in column 10.	Upper boom.	Lower boom.	Total.	Without end pillars; i.e., attached to the piers by all the extremities of the booms.	With end pillars as ties; or otherwise the girder wholly supported at the extremities of the upper boom.	With end pillars as struts; or otherwise the girder wholly supported at the extremities of the lower boom.
1st Case—Load at Top									
1st Form	·0330	·0357	·0366	·0416	·0310	·0726	·1057	·1084	·1093
2 "	·0322	·0349	·0358	·0460	·0293	·0753	·1076	·1103	·1112
3 "	·0407	·0415	·0479	·0465	·0265	·0730	·1137	·1145	·1209
4 "	·0440	·0487	·0458	·0396	·0337	·0733	·1173	·1220	·1191
5 "	·0377	·0384	·0449	·0433	·0302	·0735	·1112	·1120	·1184
6 "	·0391	·0442	·0411	·0437	·0302	·0739	·1130	·1180	·1150
7 "	·0382	·0429	·0400	......	......	·0730	·1112	·1159	·1130
8 "	......	·0352	......	·0419	·0270	·0689	......	·1042	
10 "	......	·0407	......	·0465	·0229	·0694	......	·1101	
12 "	......	·0377	......	·0433	·0284	·0717	......	·1094	
2nd Case—Load at Bottom									
1st Form	·0310	·0337	·0346	·0447	·0286	·0738	·1042	·1069	·1078
2 "	·0302	·0329	·0338	·0458	·0270	·0727	·1030	·1057	·1066
3 "	·0363	·0372	·0426	·0464	·0266	·0730	·1093	·1102	·1156
4 "	·0476	·0530	·0496	·0396	·0337	·0733	·1210	·1264	·1230
5 "	·0369	·0377	·0436	·0442	·0296	·0738	·1107	·1115	·1174
6 "	·0377	·0431	·0397	·0444	·0295	·0739	·1116	·1170	·1136
7 "	·0358	·0412	·0378	......	......	·0730	·1088	·1142	·1108
9 "	......	......	·0350	·0363	·0297	·0660	......	......	·1010
11 "	......	......	·0476	·0316	·0337	·0653	......	......	·1130*
12 "	......	·0369	......	·0442	·0227	·0719	......	·1088	
13 "	......	......	·0377	·0402	·0295	·0697	......	......	·1074
14 "	......	......	·0358	·0379	·0277	·0656	......	......	·1015

* The result given for this form at end of Table XVII., page 150, was incorrect.

Edinburgh.

R. H. B.

WENLOCK PRIORY, SALOP.

[On a former occasion an account of Buildwas Abbey was given in the pages of this Journal, from the first portion of an excellent volume entitled 'Collectanea Archæologica,' issued by the British Archæological Association, as a medium for giving their lengthened papers, which the limited space of their 'Journal' does not admit of being satisfactorily done. The first volume of the 'Collectanea Archæologica,' now completed by the publication of the second part, contains articles from the pens of many of our best antiquaries on subjects of great historical, architectural, and archæological interest. From these we select the following able paper upon the ancient Clugniac Monastery at Wenlock, by Mr. Edward Roberts, F.S.A., F.I.B.A.]

Notwithstanding the differences which occur in the several histories of this priory, brief as they are, the authors seem yet to agree in accepting as accurate, and as the groundwork of their descriptions, William of Malmesbury's[1] account of it, together with the assumption that it was originally founded by St. Milburga A.D. 680.[2] In a diligent search into the writings on the subject, I have, however, failed to discover that it has been so assumed and stated earlier than the fourteenth century: Bede, a contemporary, does not refer to it; William of Malmesbury, who wrote nearly four hundred and fifty years after the supposed foundation, and must have taken his information from manuscripts now lost to us, or have acquired it by tradition, does not name any year, nor further than that St. Milburg lived and died there; Dugdale says she erected a nunnery there,[3] giving Malmesbury as his authority, who in fact says nothing of the kind:[4] and another account is that she procured the foundation.[5] She appears to have become its abbess,[6] and to have been such at the time of her death, which happened on or about February 20th,[7] (or 23rd,[8] according to some later writers), A.D. 722,[9] and she was buried there.

The place is said to have been anciently called Wimnicas,[10] that being the Saxon name, but it became known only as "Moche Wenlocke"; the Latin names being Wenlochium, Winlocium, or Ventolochium;[11] the British, Llan Meilin, or St. Milburg's Church; and undoubtedly there was in very early times some kind of religous house here, and the probability is that St. Milburga in some way added to its wealth, or assisted in the rebuilding[12] or increasing some portion of the structure; and this together with her royal descent would have induced her election to the office of abbess. It is worth remembering that at the time when she lived there were few places of the kind, and the noble daughters of our land were sent abroad for their education. The references to the position and acts of Milburga would incline me to think that she really added the nun's department to the already existing monastery.

Connected with these subjects is the interesting inquiry into the motives of benefactors; for in the majority, if not in all cases, of retirement to the cloister and grants to the church, the occurrence of a crime, then too frequent, or an event having influence on the passions, was the immediate cause. I think I have sufficient grounds for stating that murder was the occasion of the taking of the first steps towards the advancement of that church and abbey which eventually became the most beautiful, most powerful, and the wealthiest in Shropshire.

Except by comparing writers, it would be difficult to ascertain even approximately the degrees of relationship of the several personages (not historically of much importance) named as being connected with Milburga, and this arises as much from the habitual carelessness of the mediæval scribes, as from ignorance of the exact consanguinity, and the indiscriminate use of similar terms for various degrees. It is however necessary, in order to assign a motive for Milburga's pious acts, that I should endeavour to state some of her family ties, and the deeds antecedent to her retirement from the world. Her parents were Merewald (brother of Wulphere King of Mercia, who commenced his reign about A.D. 657), and Ermenburga[1] (daughter of Ermeurod and niece of Earconbert King of Kent, who began his reign A.D. 640). Her sisters were Mildritha and Milgitha.[2]

Egbert was son of Earconbert, and succeeded him as King of Kent A.D. 664. Within a year[3] after the commencement of his reign he was accessory to the murder of his two infant nephews, Elbert and Egelbright,[4] uncles to Milburga. Egbert is said to have repented of the murder; and as the only modes of exhibiting contrition were by gifts for holy purposes or by entering the church, he acted in accordance with the custom of the age, and granted as compensation a part of the Isle of Thanet at Minster, for the purpose of building a monastery, and Milburga's mother founded a monastery there. Mildred dedicated herself to celibacy, and became abbess of that nunnery[5]—for the name of monastery was applied to houses for both sexes; and although we get no direct statement, nothing is more likely than that the same circumstance, so fruitful to the church, should influence Milburga, and that she should perform some devotional act; whilst her relationship to the royal family of Mercia would lead her to do so at her adopted abode at Wenlock, and also enable her to procure some endowment. The foundation was at that time probably the usual secular college of Saxon times, then converted partly to a nunnery; and to those who have seen the ruins it is needless to say that nothing whatever of the buildings of that date is now in existence. It may be considered as having been of timber, as was almost universal prior to that time, and was by no means unusual both here and on the continent for centuries after, and it is not surprising that, as a consequence, we read of their being frequently destroyed by fire. Monastic buildings, even at that early period of Christianity in this island, were of enormous magnitude, and more particularly in this part of England. Bede refers to one at Banchorium (Bangor), which at the beginning of the seventh century was inhabited by upwards of two thousand monks at the same time,[6] and we shall find that this of Wenlock, though then comparatively insignificant, became the largest in the county of Shropshire.

We are not informed of the time during which Saint Milburga presided over the nunnery, nor the exact time of her death, which was not earlier than A.D. 694.[7] We learn simply that she became beatified, and that on her death she was buried at Wenlock.

It does not seem to have escaped from repeated calamities, mostly arising from warfare, of which, from it great richness of soil and general wealth, as well as from its large population and other circumstances, this part of England was the constant theatre; but the period of four centuries from the time of its earliest foundation to that of its being surrendered to King William the First by the Earls Morcar and Edwin, the grandsons of Leofric Earl of Mercia, in 1071, is one which as regards this priory is a period of almost utter darkness,—a darkness which even the searching eye of the Rev. Mr. Eyton has not penetrated. It is vaguely stated that it was twice destroyed by the Danes; and if so it must have been restored in the interim and have become again a place of defence or worthy of plunder. The entire obliteration of the previous buildings leaves us no means of judging either of the probable dates or extent of the works. It is further stated, with somewhat more precision, that Leofric Earl of Mercia, and Godiva his wife, shortly after 1017, and in the reign of Edward the Confessor, refounded the abbey. There is nothing singular, as has been supposed, in the selection of the spot for the re-establishing of the church and monastery; it was a constant practice to retain sacred sites for like purposes. It was again deserted after this re-founding, and surrendered to the crown 1071, as before stated.

We now come to a period when a little more certainty prevails, and when abbeys sprung up in the land wlth marvellous rapidity and vigour. Whether of Saxon or Norman origin, they equally

[1] De gestis Regum, lib. ii, cap. 13. De gestis Pontificum, fo. 164
[2] Dugdale's Monasticon, v, 72.
[3] Ib.
[4] Malmesbury's words are, "Milburga apud Wenlock requiescit, olim ab accolis nota sed post adventum Normannorum dum nescitur locus Sepulchri," etc. Tanner repeats Dugdale's error.
[5] Brit. Sancta, i, 129.
[6] Tanner's Notitia Monastica, p. 444 (quoting Capgrave).
[7] Brit. Sanct., i, 124.
[8] Acta Sanct., iii, 388, et seq.
[9] Ib.
[10] Monasticon, v. 73. Tanner's Notitia Monastica, p. 444.
[11] Acta Sanct., vol. iii, 388. On the seals it is written Wenlok.
[12] "Her father (Merewald) and her uncle (Wulphere) liberally contributed." Brit. Sanct., i, p. 129. Leland. Collect., vol. iii, p. 170, edit. 1774.

[1] Also called Domneva, or Dompneva. Bollandus falls into an error in saying, "Mater ejus non S. Ermenburga sed Domneva." Acta Sanct., iii, 388.
[2] Brit. Sanct., i. pp. 124, 129. De Gestis Regem, lib. i, cap. 4.
[3] Roger de Wendover. Flor. Hist. p. 150.
[4] Probably prior to 669, When Egbert "gave Reculver to Bass the mass-priest, that he might build a minster there." Bede, Anglo-Sax. Chron. Almost all the mediæval writers mention this murder, with more or less minuteness.
[5] Brit. Sanct. i, 124.
[6] "In quo tantus fertur fuisse numeros monachorum, ut cum in septem portiones esset cum præpositis sibi rectoribus monasterium divisum, nulla harum portio minus trecentos homines haberet." Bede. Eccles. Hist. lib. ii, c. 2.
[7] Bollandus says A.D. 722. Act. Sanct. See ante, p. 145. Leland says A.D. 716. Coll. iii, 169.

partook of the benefits of property, seriously interfered with in our own day by the Statute of Mortmain, which followed the suppressions, and was a necessary step in addition to those acts of spoliation.

With reference to the hitherto reputed Saxon architecture in this building, and to Saxon and Norman architecture generally, it may be proper to explain that after the loss of the arts by the overrunning of the Roman provinces by the Goths, there arose in the course of time an architecture more or less beautiful according to the greater or less rudeness of the country in which it was practised, and which may be considered as one great school prevalent for six or seven centuries—the longest period of existence in any style without material alteration in so many countries subject to different rulers. Originating either in the indiscriminate application of materials taken from Roman temples and houses,[1] or in a rude imitation of them, we obtain various specimens of one universal type. Familiar as the English must have been with pure Roman works, and a high state of civilisation in common with all countries where Romans domiciled, it is remarkable that, so far as we are able to judge from Saxon remains, the worst type appeared here—not very different from the Norman in its elements, but differing most materially in the magnitude and the taste of the works. There was, besides, on the part of the Normans an unaccountable jealousy of or dislike towards the Saxon buildings; and although we can point to a score or two of works either in part or wholly ante-Norman, yet they are very few as compared with the vast number of remains comparatively perfect to this day of what is confessedly only a century or so of later date; and yet, except some of the sacred edifices of the thirteenth and fourteenth centuries, the majority are of Saxon origin. This we have seen was the case with Wenlock Priory.

At the time of the compilation of Domesday-book, the whole of the lands of this church were in the hands of Roger de Montgomery, the first Earl of Arundel and Shrewsbury, to whom they had been granted by the king. From him they passed again almost entire, in the reign of King William II., who consented to the Earl's charter, to the new order of Benedictine monks of Clugny as a dependency to that order, and from that act the fortunes of the house of Wenlock may be said to date. Thus were the revenues and the establishment alienated, as it will appear to our eyes, but attached and secured, as it will have seemed from the Norman's view.

This affiliation continued for three centuries, not however directly to Clugny, for the actual ownership was in the priory of La Carité sur Loire, which was again subject to Clugny. The tribute payable to La Carité was fixed by Earl Roger at 100 shillings per annum; but the occupants and priors were chiefly Normans, so that in fact they possessed the whole of the income. The magnitude of the power of the chief house may be gathered from the fact that at one time the Abbot of Clugny received £2000 a year from the affiliated monasteries in England.[2]

The priory now was fairly started in its career of acquisitions and its magnificence of construction. The few remains of Norman or early transitional works which there are here, are of Earl Roger's commencing, but not finishing, for he died in 1094.[3]

It is stated in Domesday-book, that the Earl had made the Church of Saint Milburg an abbey, by which it must be understood, if it means more than a general term, that it was entitled by its affiliation to be so considered; for it never was really an abbey, being presided over by a prior who was himself subject to the Abbot of Clugny, and after its naturalisation, although it was looked upon as an abbey, it was never legally made one. It is certain, from the entry in Domesday-book, that the Saxon church was actually in existence, though, as before stated, now quite obliterated. William of Malmesbury, writing about A.D. 1125 or 1130, says, "lately, however, a convent of Clugniac monks were established there while a new church was erecting." In the course of the re-erection it could not have happened otherwise than that St. Milburgh's body should be discovered.[4] Whether really so, or only a monkish deception, it was treated thenceforth as a miracle; and has been gravely handed down to us as such, with the additional information that the body was not only found in a perfect state, but emitted the most balsamic of odours, which pervaded the building. The reputation and the

[1] This is visible to this day in existing edifices in Southern and Central Italy.
[2] Eyton, Antiq. of Shrops. iii, 230.
[3] See Planché's Norman Earls of Shrewsbury, p. 74, ante.
[4] In 1101. Wm. of Malmesbury.

profits of the monastery were enhanced by this discovery for several centuries. Her body was re-interred in front of the high altar, on May 26th, 1101.

The priory, as an alien, in common with others of that class, was treated with much severity in after times, and suffered exactions and confiscations repeatedly, until its naturalisation in the 18th of Richard II. During the wars with France its revenues and patronage were assumed by the English kings, and we find its rights exercised by them repeatedly. It nevertheless grew in wealth and importance; its precincts extended over thirty acres; other priories were affiliated to it, and although it did not escape the imposition of taxes (sometimes levied in the name of gifts, although there was nothing voluntary in the transactions, unless it might be in obtaining some *quid pro quo*, in the shape of immunities from feudal services and payments), yet its wealth increased in greater proportion, and enabled it to hold its way above all others. The benefactors were numerous, and some of them were exceedingly liberal. Of these, Isabel de Say, Lady of Clun, was after Earl Roger the greatest; she in her own right as Baroness of Clun, at the end of the twelfth century, endowed the priory with large and valuable patronage.

We have also some evidence of actual erections in progress in one of these donations, namely, a bequest of two merks by Dame Agnes, wife of the second Walter de Clifford, in 1221,[1] towards "the fabric of the Church of Wenloc." The monks began to live better too. In 1252 it is found that the prior owes £6 for the king's wine, which he had purchased—probably the remainder of that which the king had sent there for his own use. We find that King Henry III. repeatedly took up his abode at Wenlock Priory in the course of his journeys, and employed its priors in diplomatic services. These are evidences of the favour in which it was held by royalty; but it, nevertherless, did not free it from pecuniary exactions. Its history is a series of struggles with neighbouring owners for rights and immunities, and of payments, bequests, grants, and charters.

In 1333 its wealth was so increased, that in a contribution on the marriage of Edward III.'s sister, it stood tenth in importance in the kingdom.

In 1337 the first blow was struck at its liberty, and attacks were repeated until they reached their climax two centuries after. In January in that year, Edward III. prohibited this and all alien priories from transmitting tribute to France; and although this was simply intercepting the supplies of the enemy, a course still followed in case of war, the appropriation of the revenues of private estates can hardly be looked upon otherwise than as an arbitrary act of spoliation: the annual hundred shillings payable to La Carité being shortly converted into two hundred for the king's use. In 1361 however, on the conclusion of peace, it was restored to La Carité, to be again escheated on the resumption of the war: this time the commutation being taken at £50 per annum. Nine years later the total value of the temporalities was given at £237 4*s.* 2½*d.* In 1291 it had been £144.

These repeated exactions eventually led to the naturalisation of the priory, which happened on February 20th, 1395, for which six hundred merks were paid to the king, who continued also to receive the one hundred shillings per annum. This arrangement seems to have been made by the prior without reference to his superiors, who were opposed to this deprivation, and did not acknowledge it for upwards of a century, when a Bull of Alexander VI. annulled the nominal state of dependence so long in fact abandoned.

The priory was never exalted into an abbey;[2] but remained after its separation a priory, which really differed but in name.

The surrender occurred January 26th, 1542, when the value had been much reduced, and was returned gross at £481 16*s.* 3*d.*, or about £449 net, and the prior, John Baylie, received a pension of £80; the sub-prior £6 13*s.* 4*d.*; seven priests £6 each; and four others £5 6*s.* 8*d.* each. Thus, in lieu of their large revenues, these thirteen men received £100 amongst them.[3] We have no information of the manner of the reduction of the numbers of monks from about forty to these thirteen; but it may be safely assumed that it spread over some years. These institutions had served their purpose, and we should be ungrateful did we not acknowledge our lasting obligations to them for the preservation of whatever there was of art, science, and literature in the mediæval ages; their destruction was now to be—the instrument was at hand, and this was long before felt to be so.

[1] Eyton iii, 238.
[2] Eyton iii, 248.
[3] Monasticon, v, 80.

Probably as the vacancies occurred they were left unfilled, and there was less violence in the revolution than may now to us seem to have been the case. The state of luxury and laxity into which they had fallen constituted but one of the causes. The times demanded the revolution, and it came, as it sooner or later will come in other countries, when like circumstances shall prevail.

It is necessary only to add, as regards the Clugniac order, that it was a reformed branch of the Benedictines, whose black robes were retained, whose rules were more rigid, and their food and clothing more scant. They were not precluded, at all events, at a later period from the enjoyment of luxurious abodes, as were the Cistercians; and we see in this priory a display of constructive and decorative works of the highest order. The reform was complete in A.D. 912, when the branch was called after Abbot Odo of Cluni,[1] who perfected it; soon after which numbers of priories were attached to it, the parent abbey selecting the priors, and even sending the monks, who were consequently, in the case of our priory, almost all from France. There were stringent and peculiar regulations in regard to silence, which was one of the most distinguishing marks of the order. Most of the branches in England were naturalised early in the reign of Edward III. Wenlock was not so until upwards of sixty years later.

In describing the buildings, it will be convenient for clearness to consider that we are now perambulating the ruins, commencing with the church; continuing with the conventual buildings of the earlier period; and finishing with those of the later date; premising that the buildings and courts alone must have covered upwards of an acre. We will therefore begin at the west end.

Entering the place where formerly was the great west door, we come upon one of the grandest architectural effects in the county. We at once see that the church is cruciform, with aisles to the nave and choir, but only one aisle to the transepts, except as hereafter mentioned. The Lady Chapel has no aisle. The entire length internally is 332 feet,[2] and the breadth, including the aisles, varies from 61 ft. 3 in. in the nave to 62 ft. 4 in. at the east end of the choir. On the left there are the ruined bases of seven large pillars (forming eight bays) between the west wall with its respond and the great tower pier, one only rising some few feet higher than the others. These partake very much of the character of the great abbeys of Yorkshire, particularly of Roche Jervaulx and Guisborough. On the right we have, out of the seven corresponding piers, three in a state of nearly perfect preservation; these carry arches and tiers of other pillars and arches to nearly the full height of the former structure, and we can form a correct notion of the perfection and richness to which the building was brought. This portion, which is of massive Early English architecture, is of the age of King John or the early part of Henry III., and probably in the priorship of Joybertus, who was a Norman abbot, presiding from about 1198 to 1216. The first three bays on the right hand are arcaded in a different manner from the other parts, having inner arches, so as to give space for a room over the aisle and beneath the roof of the triforium.

These shafts[3] are short, and the aisle is vaulted, and constitute the only part of the vaulting remaining, except a small piece in the cloisters. The room above is one of exceeding beauty. The entrance was at the south-east corner, and there was a way out on the opposite side by a few steps into the gallery along the nave walls. The use of this room is doubtful.[4] There are indications of places where presses were fixed, and of the position of stone benches; and I can arrive at no other conclusion than that it was a vestry, of which there were frequently several, this one being accessible from the dormitories, and that this was in use for the early morning services, the processions for which were to enter the south aisle. It may, however, have been the monk's parlour, as there was a distinct stair from the cloister, and stone seats.

The strength of the construction of this part has secured its preservation to our day, while nearly all the other portions have been swept away. On the left hand, that is, the north side of the nave, there is just enough visible of the foundation of a north porch to make us sure that there was such a feature at the fourth bay, beyond which the old aisle wall is in existence for a few feet above the present surface, which it may be proper to remark is not by any means so much raised above the former level as we are in the habit of finding.[1] In several places the turf has been turned back for me, and at a depth of about one foot in almost every part plain tile paving, tolerably perfect, is found; the tiles are very much burnt in the places which I saw, namely, in the nave, the choir, the north transept, and in the greater and small cloister; in the last of which, however, the accumulation is much the greatest, and has evidently been filled in with rubbish from other parts now to some extent lowered. We must not take it for granted that the level of the surface was always as it now is; for, on reference to a view in the 'Monasticon' (v., 73), and Philips's 'Select Views,' as well as Grose's 'Antiquities' (vol. iii.), we find the plates show the ruins buried several feet deeper than they are at present. The nave and aisles were 61 ft. 3 in. wide, but the nave proper was 117 feet long in the clear, 28 feet wide and about 60 feet to the apex of the vaulting which enclosed it. Dugdale, Britton, Philips, and indeed all who have written, have evidently copied from one original, and given wrong dimensions. The error has apparently arisen from the tower space having been added to instead of being deducted from the separate lengths.

Those now given are taken from actual measurements on the spot. The central tower, which is not exactly equal sided, is the next point whence we obtain an entirely fresh view: we will first however remark, that of this tower but a few feet of one pier remain, and three rough mounds to show the position of the others. It was, including its walls, about 48 feet by 46 feet. I have carefully examined the piers and obtained drawings of the plinths and mouldings. I cannot find any evidence of any other towers, so that the usual position of St. Michael's chapel in a western tower of Clugniac monasteries was wanting in this priory. It is just within the range of possibility that the chamber over the aisle was a chapel of St. Michael, but the marks of benches and presses, and the nature of the construction, are against that supposition. The transepts in the clear are together 144 feet from north to south. The north transept has part of two walls remaining and the foundations of other parts. It is worthy of attention from its having two aisles (few abbeys having more than one), one of which at least, that on the west side, was entirely closed in.

The lowest part was a vaulted crypt, now merely bare walls not rising above the surface. The arch would bring the floor several steps above the floor of the transept, from which there was a doorway into the room over the crypt. The window sills belonging to the crypt show that it was dimly lighted. There is a false back to the end of the vault, which would incline one to suppose it might have been intended as a place for the concealment of treasure in time of danger, as well as for the temporary deposit of the dead. In the north west angle of the transept was a doorway to a staircase.

(To be concluded in our next.)

NEW IRON LIGHTHOUSE, AT CAPE CANAVERAL, FLORIDA, U.S. AMERICA.

(Concluded from page 132.)

Cornice of tower.—The arrangement and details of cornice of tower to be as shown on Plate IX.

Brackets.—The brackets, 16 in number, to be of cast-iron. The centre line of each bracket must coincide with the joint of the panel plates of the wall of lantern; and the upper part of the bracket must be secured to them with four wrought-iron bolts 1" diameter; 2 bolts being on each side of the vertical flanges of panel plates. The lower part of bracket must be secured to the tower by a wrought-iron tap-bolt 1" diameter. The upper part of each bracket forming surfaces of contact with the gallery plates must be planed. A cast-iron neck moulding must be inserted between the brackets, and secured to the tower by wrought-iron tap-bolts.

Main gallery plates.—The gallery plates to be of cast-iron. The rebates for the brackets must be planed. Each plate must be secured to the bracket by wrought-iron tap-screws ¾" diameter. The cornice to be of cast-iron, secured together, and to the gallery

[1] Tanner's Notitia. Preface, xiv.

[2] Dugdale and his followers say 401 feet, which, allowing for walls included, is too much by forty feet.

[3] Mr. Blakeway and Mr. Owen, who wrote the account for Britton, erroneously state this to have been filled in subsequently. Britton's Architect, Antiq. iv, 59.

[4] Mr. Mackenzie Walcott calls it a dormitory for the conversi. 'Building News', vi. p. 954.

[1] The view of the west end, drawn in 1771, and given by Grose, shows the ground covering the nave piers as high as the capitals of the inner arcade.

plates, by wrought-iron bolts, with countersunk heads, as shown. There must be 5 half-inch bolts for connecting each segment of cornice to each gallery plate.

Main gallery railing.—The standards of the wrought-iron railing around the main gallery are to pass through and connect the gallery plates and brackets. The cast-iron drop on the bracket is to form the nut for the lower end of the standard. The upper rails pass over, and are secured to the standards by cast-iron balls, having suitable screws cut in them. The lower rails must be secured to the standard with wrought-iron bolts $\frac{3}{4}''$ diameter.

Wall of lantern.—The wall of lantern is cylindrical, and is formed of cast-iron panels, each $\frac{1}{16}$ of a circle. The top, bottom, and side flanges, forming surfaces of contact, must be planed. The lower part of the panels must be secured to section Fig. 7 of the tower with wrought-iron bolts 1″ diameter, arranged as shown. Each joint of the upright flanges to be secured with 6 bolts $\frac{7}{8}''$ diameter, with suitable nuts and washers.

Lantern door.—The door in lantern to be formed of a single sheet of boiler plate $\frac{3}{16}''$ thick, provided with strong wrought-iron hinges, and with strong fastenings to retain it open or closed, and with strong handles and latches for opening it on either side. The jambs, top, and sill to be of cast-iron, with rebates for both inner and outer doors. Four pairs of brass hinges, similar to those on the cylinder doors, must be provided and fitted on the rebates for inside wooden doors. The hinges for the iron doors must be neatly fitted, and the vertical rebates must be planed. The sill plate to be secured to the lantern deck with 3 wrought-iron countersunk screws $\frac{3}{4}''$ diameter. The top of the door-frame will be mitred with the jambs, and secured to the underside of lantern gallery in the same manner as the upper flanges of the panels forming the wall. Each jamb must be secured to the side flange of panel with four $\frac{7}{8}$ inch bolts.

Lantern gallery.—The segments forming the lantern gallery to be of cast-iron, of the form and dimensions shown in Fig. 8. The joints and recesses for the lantern posts or astragals must be planed and well fitted. The holes for the railing standards must be reamed. The surface of contact with the gun-metal mullion sill of lantern must be planed. The segments to be modified for stairway ladder and air registers, as noted on the drawing. Each segment must be secured to the upper flange of lantern wall with two wrought-iron bolts $\frac{7}{8}''$ diameter. The number and size of the bolts for connecting the segments together and securing the lantern posts must be as indicated on the drawings.

Railing around glazing.—The wrought-iron railing around the upper part of the lantern to be as shown in Fig. 2. The rail to be made in 4 parts, with lap-joints, and secured to the standards with brass nuts.

Astragals.—The lantern posts, 16 in number, to be of wrought-iron. Each post must be lined on the outside with gun-metal rebates, and stops for the glass. This lining to be made in three pieces, and secured to the posts with gun-metal screws. Two gun-metal handles must be secured to each post with three gun-metal screws to each. All the rebates for the glass and the sufaces of contact must be planed.

Mullions.—Four sets of horizontal gun-metal mullions connect the posts together at intervals. The rebates for the glass, and all surfaces of contact, must be planed.

Air registers.—One half of the lower set of mullion must be modified so as to contain the air registers. The sliding surfaces must all be planed and well fitted. A stop must be inserted at each end of the slide to regulate the stroke. All the screws for the glass stops must be of gun-metal. Each mullion is united with post by wrought-iron bolts with hexagonal heads and nuts.

Composition of the gun metal or bronze.—All castings hereinbefore specified to be of gun metal, must consist of 9 parts of copper with 1 part of tin, and have a specific gravity of not less than 8·7. The tops of the lantern posts are united by a wrought-iron regular polygon of sixteen sides, which is fastened to them by sixteen wrought-iron tap bolts $\frac{3}{4}''$ diameter. The polygon is made in four parts, with half lap joints, secured together with tap screws with countersunk heads.

Framing of dome.—The ribs and tie-bars forming the frame of dome, to be of wrought-iron, of the form and dimensions as shown in Figs. 9, 10, 11, and 12, Plate XI. The lower ends to be secured to the lantern posts, and the upper ends to the cast-iron crown piece, with wrought-iron tap bolts. The tie-bars to be secured to the ribs with wrought-iron bolts $\frac{1}{2}''$ diameter.

Spider frame.—The spider frame supporting the adjustable bearing for the upper part of lens apparatus to be of wrought-iron. Each tie-rod has a jaw formed on the outer end, and is secured to the rib with one $\frac{1}{2}''$ bolt. The inner ends of all the tie-rods have screw-ends, and are secured to a wrought-iron ring, with nuts inside and out for adjustment. Every alternate tie-rod is further supported by a wrought-iron rod attached near the crown of dome, and provided with a cast-iron turn-buckle. The adjustable bearing for lens apparatus to be of brass, and must be finished bright all over, and well fitted and secured, with gun metal screws, to the wrought-iron ring. The set screws to be of steel.

Sheeting of dome.—The dome must be covered with sheet copper one-sixteenth of an inch in thickness; to have lock joints except below the eaves, where it is only tinned for soldering. The copper is laid on in 16 segments, and each fastened by three brass screws to ribs. The eaves are curved by an arc of 9 inch radius, and the cornice supported by 16 cast-iron brackets, which are set upon and secured by two $\frac{3}{4}$-inch screws each, to the segments on top of posts, their upper ends being secured by a wrought-iron bar, $1\frac{1}{2}$-inch by $\frac{3}{4}$-inch, extending round the lantern, put together in 4 segments, by means of half-lap joints, and two $\frac{1}{2}$-inch screws (heads countersunk) at every joint. This segment is secured to each bracket by one $\frac{1}{2}$-inch screw (head countersunk.) The copper roofing extending down along the bracket is fastened to the glass stops of upper horizontal mullions by the screws which hold said glass stops to said mullions. At each alternate bracket one water spout is placed for conducting the water from the roof.

Ladder hold.—There is a 1-inch copper rod running around the lantern for giving a hold to ladder, and is held to each bracket by means of a stand. This stand (made of gun-metal) has a strap fitted on and secured to it by one $\frac{3}{8}$-inch bolt, and is fastened to bracket by one $\frac{3}{8}$-inch iron screw.

Ventilator.—The globe and other parts of ventilator on the top of dome to be of sheet copper $\frac{1}{16}''$ thick. To the top of the globe is attached a brass nut and a copper pinnacle 4 feet in length, with a platinum point worth 4 dollars. One $1\frac{1}{2}$-inch bolt tappped into this nut, and secured by collar and nut in fixed position to centre piece of ribs, unites pinnacle and globe firmly to the top of the dome.

Zinc lining.—The dome is further provided with a zinc lining, $\frac{1}{32}''$ in thickness, inside of the ribs, put on in sixteen segments, and fastened to each rib by nine iron screws.

Tin cowl.—To prevent all drip or leakage falling upon the apparatus, a tin cone with a tin cowl is placed over it, and fastened by screws to the horizontal tie-rods.

Lantern ladders.—There must be provided two wrought-iron ladders, one for the lower and one for the upper part of lantern. The lower ladder will be secured to the lantern gallery with two wrought-iron bolts $\frac{5}{8}''$ diameter, with countersunk heads. The upper ladder is moveable.

Main doorway.—The space occupied by the door and jambs to be equal to that of an adjoining panel in the same section. Each jamb to be in one piece, of cast-iron, made in dry sand. The rebates for the doors, and the upper, lower, and side flanges must be planed. The jamb must be strongly connected with the adjoining panels, the sill-plate, and the inside cap-plate, by wrought-iron bolts. The sill-plate, is to be of cast-iron, made in dry sand. Surfaces of contact with the door-jambs and adjoining panels must be planed and well fitted. It must be thoroughly connected with the parts of door and tower with wrought-iron bolts. The door-cap and brackets to be of cast-iron, secured to the tower with wrought-iron bolts.

Iron door.—The outer door to be of wrought-iron, made in two parts. The frame to be of bar iron, $1\frac{1}{2}'' \times \frac{3}{4}''$, and sheathed with boiler-plate $\frac{1}{8}$ of an inch thick, secured with rivets $\frac{3}{8}''$ diameter, not exceeding 4″ apart from centre to centre, and driven hot. Each leaf of door must be hung with three pairs of strong hinges (only two pairs are shown on the drawing), made of gun metal, and secured in a thorough manner with tap-screws of the same material. Suitable fastenings for securing the door open and shut must be provided. A lock of approved construction, with suitable knobs, must be provided and fixed.

Balcony.—The brackets sustaining the balcony at the main doorway to be of boiler-plate $\frac{1}{4}''$ thick, stiffened with angle-iron $2'' \times 2'' \times \frac{1}{4}''$, which must be secured with rivets $\frac{1}{2}''$ diameter, not exceeding 3″ apart from centre to centre. Each bracket must be secured to the shell of tower by 18 wrought-iron bolts $\frac{3}{4}''$ diameter. The said bolts may be of the ordinary kind, with nuts, and penetrate the shell, or they may be tap-bolts, at the discretion of the contractor. The greater part of the bolts should be attached at the upper part of the brackets. The floor of balcony will consist of a single plate of boiler iron $\frac{5}{16}$" thick, and must be secured to the T iron and the brackets underneath by rivets ⅝" diameter, with countersunk heads, and placed not exceeding 4" apart from centre to centre. The moulding extending around the balcony to be of cast-iron, and made in three parts, mitred at the angles, and secured in the manner shown. The terminations to be neatly fitted to the tower.

Railing around balcony, &c.—The railing for the balcony, and for the steps leading to it, must be of wrought-iron. The lower ends of the standards must be tool-finished, and provided with nuts and washers. The rail to be made in convenient lengths, with scarf-joints; each joint secured with 2 rivets ⅜" diameter.

Stairway outside of tower.—The outside steps of tower to be of cast-iron; and each step must be secured to the shell of tower with three wrought-iron bolts, one inch in diameter. The said bolts to have hexagonal heads and nuts where they do not come in contact with the panel flanges; but at such places tap-bolts must be used, penetrating the panels 1½". Each step must be attached to the tower, as shown in Figs. 1 and 2, Plate IX. The upper surface of each step must be horizontal; the chipping pieces on the inner end must be neatly fitted to the shape and inclination of tower. The holes for the railing standards must be bored, and the railing standards turned to fit them.

Tower windows.—The inner part of window-frame remains the same for all parts of tower; but the outer part varies in dimension for each section, as shown in Fig. 2. Around the exterior of each window a cable moulding must be cast on the panel. (In section Fig. 7, the cornice brackets cut into the side moulding a little.) The inner part of frame of each window to be of cast-iron, secured to its panel with six wrought-iron tap-bolts ⅞" diameter. The rebates for the sash and the surface of contact with the panel must be turned.

Gun-metal sashes.—The sash to be of gun-metal, finished all over. Its hinge and catch must be neatly fitted. The pin for the hinge to be of gun-metal, with a hexagonal head. The joint formed by the window-frame and panel must be entirely water-tight.

Windows.—In the tower twenty-seven windows are required.

Crane.—The bar-iron frame of the crane at the side of main doorway to be in one piece, and sheathed on both sides with boiler-plate ⅛" thick, secured by rivets ⅜" diameter, in the manner shown; the rivets to be driven hot.

Journals to be case-hardened.—The upper and lower journals to be "finished" and case-hardened. The upper and lower bearings to be of the materials marked. They must be neatly fitted, and must be secured to the tower by wrought-iron bolts 1" diameter, having hexagonal heads and nuts, and provided with suitable washers.

Staying the crane.—For the purpose of guying the crane, two eye-bolts of wrought-iron, 1" diameter, must be inserted in section Fig. 5 of tower, within 8" of the top of the panel. One eye-bolt to be placed at a convenient distance on each side of the crane.

Smoke-pipe.—The smoke-pipe, which is to be of copper, passes through the floors in sections Figs. 4, 5, and 6. The upper part passes out of the tower at Fig. 1, and is terminated with an Emerson ventilator. The elbow at the upper part, when unbolted, may be drawn inwardly, and the pipe then be cleaned; the pipes and ventilator being one-sixteenth of an inch in thickness. The flanges at the elbow to be connected by 6 gun-metal bolts ½" diameter.

For a stove pipe.—In the living-room, section Fig. 5, there must be fitted to the main pipe, at a distance of 4 feet above the floor, a tube 5½" diameter and 6" long, provided with a close-fitting cover. A cover must be fitted to the lower end of the main pipe, with a central opening for a stove pipe 5¼" diameter. The said central opening to have a flange 1½ inch wide, turning downwards, so that it may be hammered to fit closely to the stove pipe.

Cast-iron gutter.—The gutter for collecting the rain-water to be of cast-iron. The terminations of the end segments, and the ends of those segments on the side of tower opposite the main doorway, must be closed. Each segment must be secured to the upper side of a panel of section Fig. 2 with 8 wrought-iron tap-bolts ½" diameter. The joints of the segments must be quite water-tight.

Water-pipes.—The water-pipes leading from the gutter to the tanks to be of galvanized wrought-iron, bore 2", and to be of sufficient length to pass through the floor in section Fig. 4, and enter the tanks 6 inches. There must be four such water-pipes; one at each end of the two rows of tanks.

Water-tanks.—The water-tanks to be made of good plate-iron. A rim of half-round iron to be rivetted around the upper edge of each. One copper over-flow pipe must be provided and fitted, but not permanently secured to each end tank. A brass cock of one inch bore to be secured to the lower part of each tank in the manner shown. All the tanks must be well rivetted and caulked, and made quite water-tight. They must be tested by filling them with water. The tanks in each row are to be connected together by short cast-iron tubes, the centres of which must be 6" below the top of the tanks, fastened with wrought-iron bolts. The joints thus formed to be made water-tight with gum packing.

Miscellaneous Items.

Tower to be painted.—All parts of iron work that have been "finished," or form surfaces of contact, must be well smeared with white lead as a protection against rust; and all the remaining parts of iron work must be painted with two coats of white lead in oil, at the workshop (after inspection), for the same purpose. The iron work inside of the tower, when erected at Cape Canaveral, must again be thoroughly coated with green paint; and the shell of the tower, inside and out, with two additional coats of white lead.

The amount of rivetting the contractor will be required to perform.—The contractor will be required to perform about one-half of the total amount of rivetting hereinbefore specified, and all of the drilling, punching, and fitting. He must also furnish all the rivets required, and the temporary bolts necessary to be used during the erection. The rivetting will be performed at such places as will not prevent shipment; or at such places as may be designated by the agent of the department.

Drawings only show finishing sizes.—The contractor will please observe that on all the drawings the dimensions shown or marked are finishing sizes, that is, the exact measurements when the work shall have been completed; consequently, for whatever parts are to be planed, turned, &c., such extra allowance of material must be made as he may deem necessary, and no reductions from the dimensions shown will be allowed.

Iron work to be erected at workshop.—All of the metal work must be fitted together and erected at the workshop, and inspected and approved by the agent of the Light-house Board, before it will be received. All castings which are honey-combed, or otherwise imperfect, will be rejected.

Marking.—All parts of the ironwork must be chisel-marked according to an uniform system, and a set of drawings also marked to correspond.

Boxing.—The crane and bearings, the window-frames and sashes, all the parts of lantern above the upper gallery, all the bolts and nuts, the railing standards, and generally such small parts as are liable to be lost, mislaid, or injured, must all be substantially boxed and strapped with iron. Boxes to be marked, and a list of contents of each box furnished the Lighthouse Board.

Contractor responsible for the safety of the structure.—The contractor will be held responsible for the safety of the structure while in his care, and he must take such precautions, as to suitable foundations, &c., as will prevent injury to the work.

Wooden doors.—The contractor for the metal work must furnish all the wooden doors required, which must be of the best sash stuff, primed, and painted with two coats of white lead. He must provide and fit all the necessary hinges, locks, and fastenings; all of which must be of gun metal, and of suitable strength.

Wooden sheathing for floors.—The floors in sections Figs. 4, 5, and 6, must be sheathed with well-seasoned heart-pine flooring boards, 1 inch in thickness, laid on with the joints radiating from the axis of tower, tongued and grooved, and dressed on the upper side. These floors must be furnished and fitted by the contractor for the metal work; and they must be secured to the plating by gimlet pointed screws, 1" long, and not exceeding 15" apart. The holes for them must be drilled in the plate iron, and countersunk on the under side.

Brick work.—The brick work for the tower will be executed by the Lighthouse department at Cape Canaveral. The wall in section Fig. 3 will be one-and-a-half brick in thickness, or about 12½ inches; and in sections Figs. 4, 5, and 6, it will be the length of one brick in thickness, or about 8½ inches. In section

Fig. 7, and in the lantern, it will be the width of a brick in thickness, or about 4½ inches.

Bricks and mortar.—All to be of good, sound, hard bricks, laid in mortar composed of two parts of clean sharp sand to one part of hydraulic cement. The sand must not be impregnated with salt. The brick work on the interior of tower must be painted with three coats of white lead. The floor in section Fig. 3 will be paved with bricks laid on their edges.

ESSAY ON ARCHITECTURE BY MR. PALGRAVE.

THE catalogue of the Fine Art department of the International Exhibition of 1862 contains several essays the merits of which are in risk of being overlooked. The author—Mr. Palgrave—has in another publication printed for the Commissioners of the Exhibition, "the Handbook of the Fine Arts," ventured upon a series of bold criticisms of the works of living artists, which have evoked severe and wrathful denunciations by his antagonists, whose cause some of the newspapers have espoused with no little zeal. Upon the questions, whether Mr. Palgrave has done wisely in provoking a storm of indignation which he might have certainly anticipated, or whether his estimate of individual artists be justly severe or indiscriminately acrimonious, we abstain from expressing any opinion. But of one thing connected with his papers we are quite sure, —that those which are contained in the Fine Art Catalogue deserve careful perusal from all who take interest in the modern progress of art. Of the essays on painting, sculpture, and engraving, as those subjects are not strictly within the scope of this Journal, we offer no opinion beyond this—that they are manifestly the results of much careful observation and intelligent appreciation of the purposes to which each art should be limited. The essay on architecture is more immediately within our province, and we have no hesitation in expressing an almost unqualified admiration of it. Among the multitude of dissertations on the comparative merits of different styles of architecture, we know of none more perspicuous than Mr. Palgrave's concise essay, from which the following extract is taken. The extract is confined to the portion of his paper which relates to Gothic and modern architecture, and is here given not merely for its own merits, but also for the purpose of inviting the attention of our readers to the rest of the essay.

"Now came that mighty change for which the work of Rome had been the preparation. She had taught the world how nations might be ruled by the spirit of Law: the tribes of the North now showed how they might be animated by the spirit of Liberty. The long struggle to unite these frequently antagonist forces is the history of modern Europe. We have here to note the manner in which Architecture was affected by it. The characteristic of this art is, that none other comes so directly home to a man; and every phase of the human mind, as it developed itself through ten centuries, is written on the buildings of the middle ages. It is in this capacity (it has been well observed) that 'Architecture is to be regarded by us with the most serious thought. We may live without her, and worship without her, but we cannot remember without her. How cold is all history, how lifeless all imagery compared to that which the living nation writes, and the uncorrupted marble bears! how many pages of doubtful record might we not often spare, for a few stones left one upon another! The ambition of the old Babel builders was well directed for this world; there are but two strong conquerors of the forgetfulness of man, Poetry and Architecture, and the latter in some sort includes the former, and is mightier in its reality.' —How, then, did the nature of the great Teutonic invading races express itself in the art we are here concerned with?

A few words will sum up this: they created the only genuine style of modern Europe. Hitherto, it should be noted, we have found but one such—the Greek. The Roman, Romanesque, and Byzantine styles are transitional from this; the principal elements in all, blending with the vigour and freedom of the north, took life again in the Gothic. Under this name, in accordance with the suggestion of Mr. Fergusson's admirable history, the whole architecture framed in Western Europe by the immigrant conquerors between 800 and 1500 will be here included, although from about 1150 onwards that Pointed form, to which the name has been restricted, began almost everywhere to supersede the Round-arched. As, however, the Pointed architecture, though the most important and original development made in any style, is essentially only a development of the circular Gothic, it seems most correct to class them under the one name which points to the Teutonic origin of both; although the long centuries of ruin and renovation have rendered it impossible to ascertain what portion the race of Theodoric itself held in revitalising the decayed civilisation of Spain and Italy.

The first clear existing specimens, in fact, of the Gothic, appear due to the successors of the Goths in the valley of the Po. In the earliest Lombard buildings we find the plan and the details based on the Romanesque: but from the beginning, vaults are an essential feature. As that rich supply of single shaft columns which Roman buildings gave had been chiefly exhausted during the Romanesque period, and as the weight of vault required additional supports, columns were coupled together or united with piers of masonry: and presently, by a change recommended alike by its effect and its constructive advantage, these shafts, in place of breaking off at the first story—as in the Basilica—were prolonged to the base of the roof-line. This point once reached, ribs were carried from them over the intersections of the vault; and the Gothic system of internal construction was complete in its main features. Externally, the weight of the roof was relieved by an invention for which the Roman plan of massive walls (as exemplified in the Pantheon) was a clumsy substitute: the invention of the Buttress. This in the *round* Gothic, is always kept flat, and thus in some degree repeats the form of the merely ornamental Roman pilaster. Where the inner arches (as in Italy) were ordinarily of wide span, domes were often employed as a form of vault: and this style was widely diffused thence through Central and South-western France and the Rhine valley. In the doors, the plain lintel entrance which had almost exclusively prevailed from the Greek to the Romanesque styles, was abandoned, and they were treated as many-pillared recesses, on which the best efforts of the sculptor were more and more concentrated. As the Gothic thus advanced, through a thousand attempts, to harmony and vital union of features, a new and most attractive feature was, for the first time in architecture, added to the design. Hitherto, speaking in a broad sense, mass in *length*, not mass in *height*, had characterised the art from the Rhine to the Euphrates. But Towers were now incorporated in all the larger public buildings: and soon, under the general impulse to build higher, the lofty angular roof already placed (in part for protection against northern winters) over the tower or the church, shot itself upwards into the flame-like aspiration of the spire. How much do we owe to an invention apparently so simple! Let the reader think what he would lose, not only of charm in effect and of picturesqueness in outline, but even of high and peaceful thought, were these features wanting from the view, when at the close of the day's journey our road turns, and before us, over the level line of blue waters, a hundred towers burn in the last light of sunset, and we feel it is Venice:—or where over the massy orbs of forest, and the quiet roofs gathered round it as if for familiar protection, some solitary spire goes darkly up, painted in purple haze upon the amethyst and sapphire sky, and announces the unknown village which is to be our resting place.—And when the hours of happy research return, the Gothic charm which so allured us in the general aspect of twilight does not fail on nearer examination. What looked so fair in outline, will be found complete and lavish of loveliness in detail. For the wild northern intensity which acquiesced at first in the Romanesque plan, has thrown all its life into the ornament, and covered doorways and capitals with the beasts and birds of chase, huntsmen and warriors, labourers and knights, or inwreathed them with stranger fancies—the dragons and wolves of the old mythology, the Runic knots of Fate, and the Serpent by which the world is to be devoured.

Whilst the round Gothic worked onward thus in the great southern river valley of Charlemagne's empire, to the perfection conspicuously exhibited in Verona, the style, carried northwards, took other forms in the great cities that edge the Rhine. Here, between 1000 and 1200, the magnificent groups of domes and minaret-like towers were built which still adorn Cologne: churches which in grand arrangement and balance of the parts, and in the admirable contrast kept between light and shade by the plain and the recessed portions, show that this form of architecture, if fully developed, would display qualities inferior to none ever practised. Other modifications of the same manner appear in Switzerland, Spain, and France; each varied with a life and freedom of which the very idea appears to have vanished from the modern world: the latest phase being that worked out by the Normans in their duchy, and which followed their conquests to Sicily and England.

Then followed the last great change in living architecture; prepared, indeed, in all essential points by the work of the preceding centuries, and in many details known long before; yet, by its own intrinsic beauty, seeming like a new creation. It is certain that no style has ever excelled the pointed Gothic in picturesque and lavish beauty of plan and of ornament in the poetry of its lines, in the romance with which our own associations invest it. Yet the Gothic builders themselves—Suger of S. Denis, William of Canterbury, or Marc d'Argent of S. Ouen—would have been unconscious of that halo which Time, the beautifier, has cast over their master-pieces. Every essential feature of the pointed style, except the tracery of the windows, the glass that filled them, and the arched flying buttresses that sustained them, had been before practised; the same exquisite architecture which so moves us in the cathedral was familiar to them in the street; the only wonder of those inventive centuries, could they have foreseen it, would have been that their descendants should submit to the long unloveliness of Wimpole Street, or admire the confectionary-pettiness of the Rue Rivoli. It must not, however, be imagined that the pointed Gothic, on the whole,—though with large allowance for the sublimity of Egypt, the variety of India, the grace of Athens, and the vitality of its own immediate predecessor,—the most consummate architecture which the world has seen, rose from the ground 'like an exhalation.' Both in construction and in decoration it obeyed the spirit of the time. In the ornament we may trace the gradual softening and purification of the rugged northern mind which, gradually turning from those subjects of violence or fantasy already noticed—war and wild creatures, and visions of spectral superstition, now sought its pleasure in the sculpture of sweet human forms, or enwreathed arch and capital, base and niche, with the herb of the field, or the leafage of the forest; festooning the level length of cornice with the hawthorn or the lily, and budding forth from the spire in crowns of floral loveliness. Whilst these are the essential characteristics of the detail, the construction is based on the passion for loftier and slenderer forms than the circular style appeared able to provide. And as the previous styles from their mode of covering spaces might be classed under the Lintel and the Arch, so the pointed Gothic might be named the architecture of the Gable, whether angular or curved. The latter form, commonly called the pointed arch, is obviously capable of greater height than the semi circle; it had been long known in many countries, France included, as an occasional expedient; it now quickly became the law for all larger apertures. Two external causes aided the rapid growth of the style; the first, that the eleventh and twelfth centuries were the great age of mediæval building and monastic institution: the other, the discovery of that stained glass which clothed the churches of the time with a glory surpassing any internal decoration hitherto practised. To contain this, the windows were enlarged; to frame it, the bars of wreathed masonry, known as tracery, were invented. Soon the ambition of skilful masons, revelling in the radiance of emblazoned saints and gem-like arabesques, raised the ribbed roof to a dizzy height, and placed it on piers divided by walls of coloured crystal. The real wall was planted without the building in forests of detached buttresses,—the sculptor peopled with Scripture Histories every vacant space and 'coign of vantage',—and the Cathedral of the middle ages was created; an embodiment in stone and glass and woodwork of all that was most lovely and most daring in the minds of men; a concentration of all they admired here or hoped for hereafter.

To the builders of Central Northern France the clearest evidence proves that this invention is due; nor, except in France and in England, whither it was carried so soon that the style there went through a living and original development, was it truly understood during the Middle Ages. Space, however, fails to trace a course, which after two centuries, through many causes, though none inevitably inherent in the pointed style itself, led to a gradual decline, even in France and England; whilst in Spain, Italy, and Germany, the style was never really understood, or exhibited in its force and purity. In Venice, indeed, Gothic forms, uniting with the Romanesque of Constantinople, produced a manner of extraordinary grace and individuality, and one so directly adapted to modern city requirements, that only the modern indifference to architecture can have prevented its introduction. But we must pass to its later phases. That mighty change in the human mind, which gave birth to the Reformation and to the revival of ancient literature, fell precisely at the time when the perfection of the Italian art in painting and sculpture, with other causes, rendered Italy omnipotent over European taste. And there a pedantry, which to us seems incredible in its puerile absurdity, led men to the conviction that the art of the Romans —a race at no time capable of any spontaneous or real Fine Art—was the one rule and law for the Christendom of 1500 years later. Incredible to us, we have said . . . in all matters but in Architecture. For in Architecture that imitation of Roman work, best known through the name of Palladio, reigns in every capital and city of Europe. No one would deny that great genius and inordinate expense have given us a few buildings in which the Italian style has been led to graceful or noble results when in the exceptionally-gifted hands of San Michaeli or Scamozzi, Wren or Chambers, of the architects of the original Louvre or the original Whitehall. But no one can possibly assert, that the style which has filled London with the dead monotony of Gower or Harley Streets, or the pale commonplace of Belgravia, Tyburnia, and Kensington—which has pierced Paris and Madrid with the feeble frivolities of the Rue Rivoli and the Strada de Toledo—which has in ten thousand towns substituted baldness and bareness and blackness for the colour and charm and life of Gothic, the square hole for the traceried window or clustered doorway, the square outline for the pinnacled shrine,—unable to employ the commonest material, and costly, beyond the reach of all but the very rich, when employing the finer——In a practical country, and an age which has renewed the popular love for art, it is needful to waste words on the conclusion?

To state the plain facts should be sufficient: we have seen that the Roman style is a heterogeneous and mechanical formation, put together from foreign styles by a tasteless race, by whom they were misunderstood, and arrested by political causes before it had reached that stage of unity which alone gives a soul to art. This style, restored in part from ruins, in part from the treatises of Roman theorizers, was applied in later times, when society was altered, to the palaces and churches of Italy and France, during a century of the deepest social degradation,—to minister to the luxury of Francis or Borgia, or supply temples for the infidel superstitions of Leo and Julius. It was never treated as suitable for ordinary life: it cannot be rendered suitable for it. Unable to condescend to a cottage, it triumphs as the decoration of the stage. Palladian, Renaissance, Italian, Louis Quatorze, Louis Quinze—whatever name it bears, it is still but the copy of a copied architecture—a galvanized pedantry.

Architecture such as this can have no hold on men's hearts; vulgar pride or learned connoisseurship are the only tastes it appeals to. And from its fatal domination has arisen an evil worse than the frozen formaltiy it fosters; wherever this Palladianism has spread, with it spreads like a canker that dead indifference to the art, which will never be cured whilst men live in houses and meet in buildings that can give them no real pleasure, But when once a practical, intelligible, and beautiful style arises, the natural delight in architecture our race has always taken in healthy days of taste, will arise with it, and the cold arrogant spectres of the bastard Roman pass beyond the reach of contempt itself. Nor should it be fancied, that to return to former excellence involves that copied art which will never be other than lifeless. Gothic, fair as it was, never reached its full development; we have but to take up the thread which the dilettante dropped, and carry out, with far greater means, the style invented for us by our neighbours and our countrymen.

The examples here quoted have been mostly selected from churches—buildings which both invited the greatest skill and have survived most frequently to modern days. But the peculiar glory of Gothic in all its phases is, that it is equally adapted to every architectural requirement of human life. No other style is at once so high, and so humble; so rigid in obedience to its purpose, or so free in arrangement and detail. What was done of old in the minster, was done in the street; the style of the Country was the style of the Town. This was not an architecture, as those of Egypt and of Greece, reserved in its purity for religion; not as that of Rome, incapable of descending without loss of essential character to private dwellings; but like the 'common sun, the air, the skies,' suitable at once to the church and the palace, the factory and the town hall, cottage and castle; taking each material and carrying to the utmost its capabilities, from the marble in its snowy slab or purple-veined tablet, to the earth of the field, or the rubble of the quarry; at home no less in shops and alleys, than where the manor-house lights up the landscape with its gray or russet gables, or the valleyside chapel stands, like a chased tabernacle of precious workmanship, amongst rude rocks and the frowning mountain walls of nature. And it should specially be noted, that Gothic alone has been able to beautify the dwellings of the poor. These are no idle phrases; they are strictly exemplified during all the centuries of the round and pointed Gothic; nor, so far as we know, has any other style been equal to the same universality of service. It is not on remote or elaborate or antiquarian reasons that its excellence rests: Gothic is simply the one style which, by the circumstances of its development, has united in itself all the best constructive and the best ornamental forms of the world's inventions in Architecture. From the lowliest offices of use to the loftiest majesty of loveliness, this noble art has shown herself equal to the occasion; unrestricted by varieties of climate, nay, finding in them only additional opportunities for beauty and for convenience; at once the most economical in means, the most varied in adaptabilities, the most intelligible and exquisite in results. It is no fine figure to say, that by ten thousand proofs Gothic has stamped itself on the fair face of Europe as the Architecture of Heaven, and the Architecture of Home. Man's requirements in the province of building do not substantially vary; they are amongst the things 'that have been, and will be again.' In this matter, then, on which side is Common Sense? Why seek impossible new forms, or repeat styles which are bastard, or lifeless, or unpractical,—whilst men of like passions and blood with ourselves have solved the problem once, perfectly, and for ever."

THE STATICS OF BRIDGES.

*The Suspension Chain.**

To construct the Catenary Curve when the Horizontal Tension is known becomes a simple matter; since the direction of the Tangent at any given elevation can be readily found (as shown in the last paper), and this enables the equidistant ordinates to be successively determined.

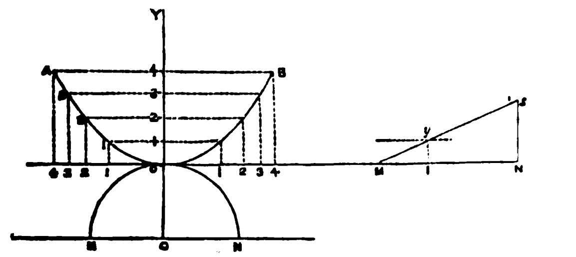
Fig. 37 shows the process of describing the Catenary after this method. The Horizontal Tension T is given, and also w, the sectional weight of the chain, so that $\frac{T}{w} = a$, (or horizontal tension in terms of weight of chain), is known. The Directrix MN is first laid down, and the Directing Circle MON described

* Continued from page 71.

with radius $= a$. The axis 0Y is subdivided at the points 1, 2, 3, 4, &c. (the intervals being equal or increasing, as may be found convenient). The lengths of the successive tangents to the circle drawn from these points will, as already explained (*ante* p. 71), be equal to the successive lengths of the arcs 01 $(= s_1)$, 02 $(= s_2)$, 03 $(= s_3)$, 0A $(= s_4)$, &c. To find the horizontal distance 01, a right-angled triangle is drawn on the base $MN = 2\,a$, and with the vertical side $Ns = s_1$ $(= {}_1T)$, then $1y$ being equal to the first subdivision of the axis 0Y, M1 is equal to the first horizontal subdivision 0 1.

To find the next distance, 1 2 horizontal, follow the same construction, only making $Ns = s_1 + s_2$. To find 2 3, make $Ns = s_2 + s_3$. To find 3 4, make $Ns = s_3 + s_4$. Care must be

FIG. 37.



taken, when the subdivisions on the vertical axis are not all made at equal intervals, to make $1y$ in the triangle equal to the vertical interval (0 1, 1 2, &c.) corresponding in each instance to the point to be determined. The horizontal distances 0 1, 1 2, &c. having been successively found, and plotted off on the base line on either side of the axis 0Y, the points 1, 2, 3, &c. in the curve are obtained by the intersection of the ordinates in the usual way. If the triangle becomes too large, proportionate lengths may of course be substituted for $2a$ and s.

The radius of curvature of the Common Catenary at the vertex 0 is $= a$, which accords with equation (D), *ante* p. 70. The radius of curvature at any point having the vertical ordinate y is $= \frac{(a + y)^2}{a}$. And since, from equation (8), *ante* p. 71, $t = w \times (y + a)$, it follows that the radius of curvature (with a given horizontal tension) varies as the square of the tension in the direction of the tangent, the tension being taken in terms of the sectional weight of the chain.

For Catenaries generally, the following equations exhibit the relation that holds between Curvature, Tension, and Sectional Weight. T is the horizontal tension (as before), t the tension in the direction of the tangent, and a the angle of inclination with the horizon:—

$$\text{Radius of Curvature} = \frac{\text{Sec}^3 a \times T}{\text{Sectional weight}} = \frac{\text{Sec}\, a \times t}{\text{Sectional weight}} = \frac{t^2}{T \times (\text{Sectional weight})}$$

When the chain carries a load, the rate of loading measured in the direction of the tangent (*i. e.*, per foot run of chain) has to be added to the sectional weight of the chain itself.

It has appeared necessary to say thus much about Catenaries, or the curves in which chains hang as determined by their sectional weight, as the subject forms part of the theory of suspension bridges. But the determination of the curve due to the suspended load is far more generally required in practice than that to which the unloaded chains would adjust themselves; and in this inquiry it is of course most convenient to take the horizontal rate of loading (per foot run of platform) rather than the rate of loading per foot run of chain (*ante* p. 70, col. 1).

From equation (C) (*ante* p. 70),

$$\frac{d^2y}{dx^2} = \frac{\text{horizontal rate of loading}}{\text{horizontal tension}}$$

It therefore follows, that when the rate of loading is uniform throughout, $\frac{d^2y}{dx^2}$ is constant, showing that the curve of the chains is in such case a parabola. Calling P the parameter, $\frac{d^2y}{dx^2} = \frac{2}{P}$ from which it is readily found that

$$P = 2 \times \frac{\text{horizontal tension}}{\text{horizontal rate of loading}} \quad \dots \quad \dots \quad (1)$$

Since the ordinary and the greatest loads on suspension bridges are generally uniformly distributed, the parabola is the curve of most common application, and its extreme simplicity renders the study of the question comparatively easy.

The following equation gives the parameter (P) in terms of the span (S) and rise (H):—

$$P = \frac{S^2}{4H} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

From equations (1) and (2) is deduced the following equation for determining the Horizontal Tension (T), when the Span and Rise are given:—

$$\frac{S^2}{8H} = \frac{T}{\text{horizontal rate of loading}} \quad \dots \quad (3)$$

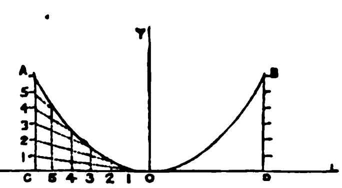
When the parameter p is ascertained, the ordinates are readily calculated from the usual equation of the parabola, viz.—

$$y = \frac{x^2}{P} \quad \dots \quad \dots \quad \dots \quad (4)$$

The radius of curvature at the vertex or lowest point $= \frac{P}{2}$

The parabola may be described without calculating the ordinates, by the construction shown in Fig. 38. 0Y is the axis of the curve, and CD the span. The rise CA, DB, is either given, or (if the parameter only is given) found from equation (2). Divide the half-span 0C and the rise CA into the same number of equal parts. Number the points of subdivision 1, 2, 3, &c.,

FIG. 38.



from the vertex (which is zero) on 0C, and 1, 2, 3, &c., from C (which is zero) on CA. From these last points draw lines converging to the point 0, and upon the points in 0C set up ordinates. The intersection of each converging line with an ordinate of the same number is a point in the parabola.

If the rise CA is not equal to DB, the vertex will not come in the middle, but its distance from the half-span may be determined by the formula given *ante* page 70, col. 1.

In calculating the actual tension of the chains it is of course essential to take in their own weight, which as already observed (*ante* p. 70) may usually be dealt with as if it formed a part of the uniformly distributed load on the platform. When the extent of the span is so considerable that the chains become very massive, more especially if they are of increased section towards the towers, it may be perhaps found advisable to take the respective weights of chain for each horizontal subdivision of the platform, so as to find the exact distribution of the total weight of chain and load. The true Curve of Moments could then be constructed, so as to enable the actual line of the suspension chains to be drawn or calculated with any degree of nicety. But in ordinary cases the departure of the line of the chains from the parabola is too minute to be of any account. Take as an instance a bridge of a hundred feet span and ten feet rise of chain. The distributed load on the platform tends to bring the line of chain to a parabola, of which the equation is $y = \frac{x^2}{250.}$ For the same rise and span the equation of the Common Catenary is

$$y = \frac{a}{2}\left(E^{\frac{x}{a}} + E^{-\frac{x}{a}} - 2\right)$$

a being (approximately) $= 126{\cdot}61$.

If we call the departure (as measured plumb) of this catenary from the parabola z, we shall find that z becomes greatest at a distance of 35 feet from the half-span, or 15 feet from either tower. At these points $z = 0{\cdot}032$ feet, or the catenary droops below the parabola by a little less than one-thirtieth of a foot, or a little more than 0·38 inch.

This drooping of the catenary indicates a difference at either point in the moment due to the weight of the chain, compared with what it would be if the weight were equally distributed, of about 0·0063 : 1, or $\frac{1}{160}$th part.

The effect of the chains being drawn up at these points, so as to coincide with the parabola, would be to throw upon the platform the task of converting the unequally distributed weight of the chains into an equally distributed load; or of rendering an equivalent service by modifying the bearing of the suspended load upon the rods, so as to throw more load upon the middle of the chains, and less upon the sides.

If we suppose that the roadway by its stiffness thus rectifies the tendency of the chains to lapse into a slightly fuller curve than the parabola, and calculate the consequent strain on the platform, we shall find it to be extremely small. $\frac{1}{375}$th part of the entire weight of the chains placed at each of the points of greatest difference (or 15 feet from either tower), would, if the platform were not suspended, produce an equivalent strain.

The lengths of the parabola and catenary supposed would only differ by $\frac{1}{40}$th part of an inch, or by about $\frac{1}{50000}$th part of the entire length of either; a difference which a variation of temperature of 3° Fahr. would neutralise.

When it is further taken into account that the roadway of any suspension bridge must possess at least a moderate degree of stiffness, in order to withstand the force of wind, as well as to correct to a greater or less extent the effects of partial loading, good reason will be seen for regarding the parabola as the real practical curve for suspension chains.

(*To be continued.*)

THE ARCHITECTURAL EXHIBITION

(*Concluded from page* 151.)

The "Malvern Wells Railway Station"—in reality a very pretty and clever work—is scarcely pictured to advantage in (101), though its chief merits are to be realised in its subordinate details, and covered shelter, in which various effects of colour are successfully grouped, these being the more distinguishable owing to the method of lighting from above which has been adopted. (101A) shows the drawing which obtained the Students' Prize at the Institute of British Architects, and is by Mr. R. H. Carpenter, a son, we believe, of the late eminent architect of that name. Like the majority of its class, it is in the prevailing type of Italian Gothic, treated however as one bold mass, with seemingly well-studied details. In the "Design for County and Borough Halls, Guildford" (110), by Messrs. Hooker and Wheeler, we are at a loss to discover its claims to be "selected by the committee of taste, and recommended to the shareholders for adoption," the whole conception being of the most meagre kind, weak in appearance, and stinted in every way. A "Sketch for arrangement of Schools" (112), may be explained as in plan consisting of the three chief divisions of the rooms radiating each from a common centre, an arrangement open however to some objections. (113A) "Oaklands" is a mansion in Northumberland, erected by Messrs. Walton and Robson, who also contribute in (216—221) a series of really excellent designs, chiefly for schools and parsonages. It is perhaps unnecessary to remark that these are all based on mediæval principles, and they have the merit of expressing their several purposes by the special characteristics which each part is made to assume, and this without any undue expenditure of funds, if we may judge from the delineations before us. We commend to especial attention the "Belmont Parsonage" (217). A "House" near Durham, by the same architects, shown in (254), is deserving of a like mention.

As in former years, Mr. J. P. Jones is a liberal exhibitor. The large frame (114) sent by him, illustrating "Buildings to be erected,—now erecting,—and, not to be carried out at present," offers, on the whole, an excellent and somewhat formidable looking array. Mr. Jones possesses a ready skill in making the best use of the means at his command, whether we regard the adaptation to a given site, or the practical working out of his ideas. This is fully borne out by an examination of the various drawings just referred to, and which number about a dozen. With some of them we had previously become familiar in another guise.

In (115) Mr. J. Drayton Wyatt exhibits five perspective views, the most noticeable being No. 1, the Interior of King's College Chapel, London, as now in progress from the designs of Mr. Scott, at whose hands the old oblong Classic room of Sir Robert Smirke is undergoing a complete transformation. The new scheme is founded on the ancient basilican arrangements, the length being divided into nave and aisles by slender iron columns, coupled, and of twisted form. The east end is a semicircular apse, on the domed ceiling of which is indicated painted decoration. The roof over the nave is open, of rather low pitch, the principals consisting of semicircular arches springing from corbel shafts, and having the panel-spaces formed between the intersections of the trusses and purlins filled with inlay-patterns, to be constructed out of various coloured woods. Mr. Drayton Wyatt also exhibits (224) a view of the "New Library" now being erected at Harrow, in remembrance of Dr. Vaughan, till recently the head master of the school.

Beulah House, near Durham (120), by Mr. Gibson Kyle, is one of the very few modern Italian mansions of which it may be said that the requirements of the style are preserved without any apparent sacrifice of more essential features. It is altogether a most satisfactory production. Very little ornamentation is introduced, the chief effect in this respect being gained by rusticated quoins judiciously managed. Mr. Appleton's two designs for the Devon and Cornwall Bank, Totnes (122, 128), are, by a strange oversight of the hanging committee, separated. This is the more absurd, since they are both based on precisely the same plan: not that we have any especial idea of the merits of either, though to one of them (128) the first premium was awarded. One of the best studies in accordance with Mediæval precedents is shown in (131), the south porch now erecting at St. John's Church, Yeovil, from the designs of Mr. R. H. Shout. In this the curious localisms observable in old West of England architecture are well identified, more particularly the mode of treating the square label and the low curved gable over it. The whole of the drawing is very careful.

An important and promising drawing (133), is described as a Competition Design for Improvements at Bath, and is by Mr. W. J. Green. The scheme embraces a new street, provision markets, abattoirs, &c.; the view before us representing the interior of the central market. In the construction of this building metalwork forms, as may be expected, the prominent feature. The roof, too, is of iron construction, and of low pitch. The general idea is a happy one, and has been well worked out. Mr. Knightley's five sketches (134) are unfortunately hung so high up as to preclude their being examined in detail. This is the more to be regretted as they appear to be quite deserving of a place "on the line." They comprise different views of the stables and riding school at Chantilly. Mr. C. N. Beazley's design for a church at Pentonville (136), shows that its author has yet much to learn in mastering Gothic principles. We have already adverted to the clever Gothic sketches by this gentleman (81), as exemplifying the kind of study likely to be most serviceable in acquiring this knowledge. Of Mr. J. Johnson's design for Stockport Observatory (138), we would just remark that among other absurdities it shows a main pier so cut through and weakened that it would unquestionably be dangerous. No. 142, "Design for a Cemetery Chapel," by Mr. Wimble, has some very good features, but is withal too smart for its object. In (144) Mr. W. Homann exhibits a beautiful arrangement of colour in decorating a "Renaissance Ceiling." Several other works by this artist demand a like praise; such as (119, 127, 291); also the beautiful design for wall decoration, shown in (306).

We have already referred to the competition for the Hull Town Hall as well illustrated in the present Exhibition; (156) is Mr. Goldie's design for the same, which bears the stamp of that boldness and originality which most of his works evince, though all may be traced to that peculiar type of Northern Italian examples, which now run so high in public favour. Another good design of a similar kind, that for the "Corn Exchange and Public Offices, Newbury," by Mr. C. J. Phipps, would have been still better had the details been less coarse; but in (172) Mr. Salvin treats us to a bit of genuine Old English Gothic revived, of domestic character, such as that clever architect has so closely and profitably studied. It represents the "Master's Court" at Trinity College, Cambridge; the drawing before us (which by the way hardly seems to do justice to its merits) being by Mr. J. S. Statter. Mr. Milcham has two perspective views (175, 176) of the design which obtained the Soane medallion from the Institute of British Architects, but which we cannot bring ourselves entirely to approve. There is an affected severity of handling which seems quite out of place, although in a "Museum for sculpture and painting" it is doubtless correct that the contents of the building, rather than the edifice itself, should be the attractive feature. We observe a little faulty perspective in some portions of the drawing too, for which we were hardly prepared. The "Croydon Cemetery Chapels," by Mr. Robins, have, if we rightly remember, been exhibited before as drawings; however, in the shape of photographs, of which several are grouped in (186), they may again be noticed as rather above the average. A pair of Iron Gates (192), designed by Mr. Fowler, jun., for Don Escandon, Mexico, and which have been manufactured by Messrs. D. and E. Bailey, of Holborn, cannot be classed under any particular style of art, but partake chiefly of the Renaissance element. They are well arranged as regards the disposition of the ornaments, which, in the upper part especially, are freely and tastefully managed.

Some charming gems of colour arrangement are noticeable in the sketches, by Mr. J. P. Seddon, of some ancient continental stained glass; the subjects being the Crucifixion, from the Church of St. Remi, at Rheims, and (199) a study of three figures from the west front of Rheims Cathedral. On looking at these specimens, and comparing them with modern work in general, one cannot but be struck with the disparity of the latter; we have yet much to learn from the old masters as to the due relationship which should prevail between forms, as expressed by individual outlines, and such as depend chiefly on a certain arrangement of colours, more or less vivid, yet in faithful subserviency to the general tone of the whole. Several well-designed "Villas, Lodges, &c.," are shown photographed (in 194) by Mr. J. Giles. Those of Italian character are, however, to our mind, preferable to the Gothic. We particularly admire the gate entrance and lodge, and not the less so on account of its common-sense simplicity. The materials are white and red brick, with Bath stone dressings, and Italian tiles on the roof.

Mr. G. E. Street is a contributor of but one drawing (195), which is the exterior of a very unpretending church about to be erected at Brightwalton, Berkshire. A well-proportioned tower rises at the west end of the south aisle, and is finished by a plain shingle broach spire. There is apparently a stone roof to the porch. The "New Presbyterian Church," now being erected in Islington, by Mr. T. C. Clarke, and of which an interior and exterior are given (201, 206), is decidedly a very commonplace affair; though there is an evident attempt at originality, which unfortunately here takes a wrong direction. The advisability, too, of trusting a heavy roof so feebly constructed and supported as that of the nave, appears questionable. In a pretty little drawing (203), Messrs. Hooker and Wheeler exhibit a "Competition Design for Schools at West Bromwich." These are of red brick, rather plain in detail, but well grouped; a very good feature being made of an octagon tower, or staircase. "Union Chapel, Highbury," as recently altered (209), is transformed from a well-proportioned and consistent Classic building into one of a decidedly nondescript kind. It has undergone repeated changes during the last twenty years, and it is to be regretted that in these alterations so much has been conceded to providing accommodation, at the sacrifice of comfort and good taste in other respects. "Shuckburgh Church, Warwickshire" (211), appears to be the remodelling of an old edifice, and this in the most florid Perpendicular style. If there be a fault, it is that of over richness, and a degree of elaboration in the roof, which the building itself scarcely seems to call for; while it is possibly questionable how far such a thoroughly eastern-county type of re-construction throughout should have been transferred into a district where hammer-beam roofs and other features are almost, if not altogether, unknown.

Miss E. Travers again sends a welcome drawing, boldly manipulated indeed for a female hand, and withal more truthfully than many would-be architects care to produce. It shews (213) the curious Norman chancel arch in Yaverland Church, Isle of Wight. In (215) Mr. T. M. Rickman exhibits some spacious schools he is now erecting in Kentish Town. They are plain in character, but redeemably satisfactory in general arrangement and treatment: the walling is chiefly of red brick. Several important competition drawings, by Messrs. Green and De Ville, illustrate their design for the proposed Palais de Justice, Brussels, and are shown in (205, 210, and 225) These are quite specimens of their class, and models of study as regards the plans, which have evidently been prepared at the cost of no little time and labour, so that it is gratifying to find that they were rewarded by a third premium. Messrs. Green and De Ville are among the most liberal contributors to the Exhibition in the shape of competition drawings; and Mr. Green individually contributes his design (a very clever one) for "Improvements at Bath," (228, 237, 240), comprising new street, provision markets, abattoirs, &c., which obtained the second premium. Mr. T. Vaughan maintains his position as a pains-taking and industrious student. His "Sketches from the Continent" (229—236), are as carefully detailed as those of former years, but are more indicative as yet of patient labour than rapidly expressive skill. One of the most attractive competition designs exhibited is that by Mr. W. Wilkinson, of which the front elevation and an interior view are given in (238, 239). Boldly conceived, and well carried out, on the light iron and glass principle of semicircular roofing, it bore away the second premium. In some respects it widely differs from the selected design, as now being executed, and drawings of which we look in vain for on this or any other Exhibition wall.

"Coloured decoration," as shown by Mr. Lightly in a series of Italian mosaics (241), is of a very useful kind, the patterns being well chosen, and by no means intricate. Mr. W. White sends several drawings, of which "Stanhope Rectory, Norfolk" (245), appears to be the least whimsical, all being more or less open to this charge. In Messrs Hooker and Wheeler's restoration of a mansion in Kent (253), there are some very good points, as well as in the Manor-house at Brympton, D'Evercy, Somerset (259), exhibited by Mr. R. H. Shout. Some "Warehouses" (262, 263), by Mr. T. C. Clerke, will add to the already attractive masses of new buildings of that class eastward of St. Paul's. Two or three large and well-drawn pictures are devoted to a "Design for a College," by Mr. Ernest George. Of these, the Interior of Hall (268), and a portion of the Elevation, showing the principal group between the quadrangle (271), strike us as the most original and effective, though the whole betokens considerable aptitude in design, and a due acquaintance with Gothic details. Mr. Joseph Clarke's only contribution is the Interior of a Church at Point-de-Galle, Ceylon (277), in which the necessities arising from the climate of the place appear to have been successfully met. A large cartoon of stained glass (278), by Heaton and Butler, which is placed over the door, is a very clever composition. The subject is "the Entombment."

On the screens in the room are several drawings which our space will not permit us to particularise as their merits deserve; we must therefore be content with noticing a few: (293) shows to a large scale some of the beautiful details which Mr. Wilkinson has embodied in the large building he has erected in Bishopsgate-street; (298) is an attractive sheet of selections from the Architectural Publication Society's 'Dictionary of Architecture,' which we are glad to find is progressing rapidly as well as satisfactorily. A recent visit to Worcester has served to confirm the rumour that the exquisite Guesten Hall in that city was doomed to be swept away. The walls are by this time probably levelled to the ground. And this in spite of the most urgent protestations, and without any sufficiently justifiable cause. Thanks to Mr. Dollman, its details have been fully as well as carefully analysed, and published in his 'Examples of Antient Domestick Architecture.' Mr. H. Curzon, also, in (300) of the present Exhibition, gives the roof with equal accuracy and to a large scale. Another very excellent drawing of the same class, is (302) by Mr. T. J. Willson, in which the "Stalls of Lincoln Minster," as measured and drawn by him, are illustrated even to the minutest detail, and accompanied, moreover, by a small plan showing the original arrangements, which in some respects differ from the existing ones. Nearly the whole of the second screen is devoted to a "Selection from the sketches of the Class of Design of the Architectural Association" during the past session. These sketches embrace designs for roofs, staircases, stables, coach-houses, windows, lodges, pavements, sculpture, metal work, &c., and are of various degrees of merit, but we are disposed to single out, as among the best, Mr. E. J. Tarver's "Ornamental Hinge" (315), in which is introduced the subject of the "Temptation of Eve;"—"National Schools," by the same gentleman, albeit they are rather fanciful;—"A Hinge" by Mr. M. H. Thomson;—and the several designs for "Entrance lodges and gates."

The Pugin Collection of Drawings and Sketches.

The distinctive feature of the present Exhibition—one indeed amply sufficient in importance to constitute an exhibition by itself—is the vast collection of sketches, drawings, and water-colour effects, from the hand of the late Welby Pugin, and now the property of his only son, Mr. E. W. Pugin, to whom the public at large—but the architectural profession especially—are indebted for the privilege of thus beholding the results in part of that amazing energy and aptitude in handiwork which could thus condense far more than the usual labour of a lifetime into that of a very, very few years. Pugin died when he had scarcely passed his fortieth year, but he left behind him memorials of indomitable perseverance, in tracing out and pursuing a then almost untrodden path, one beset with difficulties, which to an ordinary explorer would seem insuperable, but which that master-mind was enabled successfully to combat. While therefore we are called upon to make allowances for those peculiarities which marked the individuality of the man, and which undoubtedly occasionally led him beyond due bounds, it is impossible to contemplate, even for a moment, the chain of circumstances which guided his actions from time to time, without the irresistible conviction that those actions were based on the purest love of his art, at whose shrine he was prepared to sacrifice worldly distinction, wealth, comfort, and, as the event proved, even life itself. Nor must it be forgotten, in scanning the host of drawings of all kinds, of which those before us are after all but a mere sample, that nearly every line and touch was suggested by his own mind, and produced by his hand alone. Pugin was emphatically his own draughtsman: he scorned to live on the brains of others, and allowed no one to interpret his own ideas; he was his own designer, delineator, and colourist; the sole author of all that by pen, pencil, or brush was endorsed by his well-known initials, to which was not uncommonly appended his significant motto and constant watchword, "*En Avant.*"

The illustrations which, under the term of the "Pugin Collection," are now hung on the walls at Conduit-street, completely fill those of the west gallery, besides several large screens in the centre of the room itself. To these must again be added the portfolios of working drawings, which, though less pictorially attractive than the subjects which are framed, will be examined by the professional eye with certainly not less interest. The east side of the room is occupied by a series of "Designs of Works" executed by Mr. E. W. Pugin, who is praiseworthily travelling in the same path which his father rendered so famous.

It would be quite superfluous to attempt anything like a critical description of this unrivalled collection, while anything short of this would merge into a kind of catalogue merely. Leaving, therefore, the general mass, we must be content to state that the sketches from Chartres, Evreux, and Caen, on the north wall; those from Avignon, Milan, England, &c., on the south; and the 370 foreign sketches on screens Nos. 2, 3, 4, 5, 6, will be found eminently valuable, both as models of expression, and *repertoires* of design, while the more elaborated drawings of Bilton Grange, near Rugby—perhaps the most successful of Pugin's domestic structures—and those for his own house at St. Augustin's, Ramsgate, will be regarded with equal curiosity and delight. Nor must the marvellous achievement which suggested and perfected the hundred and seventeen "Designs and Plans for the restoration of Baliol College, Oxford," be passed over without comment, and a word of passing regret that their accomplished author was not permitted to realise his well-digested scheme. In the "Scarisbrick Hall" he was more fortunate, and has displayed a portion of the results of his labour in the eleven drawings which grace the north wall. Then, also, the screen No. 1 contains a vast store of thought, as indicated in the 160 original designs which are there arranged; and some of the ideas for the completion of the Roman Catholic Cathedral, Southwark, more especially a rough but highly effective elevation of the west end, showing the tower and spire as proposed to be completed, testify to that versatility of genius and power of delineation in which Pugin then had as few rivals as he has now genuine successors.

Some interesting leaves from his diary, at a comparatively early age, which are displayed on one of the walls, show the impulsive nature of his mind, and the picture of the distinguished architect intended to be realised by those who were not personally acquainted with him, is rendered still more complete, by the family mementoes with which the spectator is made familiar; also by the portrait (life-like no doubt) of Pugin's father, the author of the well-known "Specimens" and "Examples" of Gothic architecture; and by the highly-finished portrait of himself, by Herbert, R.A., which has been engraved; also by the examination of the original manuscripts and illustrations of several of his published works, and which, though kept under lock and key, are left in charge of the curator expressly for the purpose of examination.

We may remind our readers that the Exhibition will close on the 30th of this month.

INSTITUTION OF CIVIL ENGINEERS.

April 29, *and May* 6.—The first paper read was "*On the Sea Dykes of Slesvig and Holstein, and Reclamation of Land from the Sea.* By John Paton, M. Inst. C.E.

After referring to the vast extent of land inclosed by these dykes, as being probably greater than in any other part of the world, the author pointed out the changes to which the west coast of Denmark had been subjected, and the influence which such variations had had on the dyke works. In illustrating this part of the subject, the line of demarcation between the elevation and depression of the Scandinavian Peninsula was alluded to, and it was shown that south of this line there had been no general depression of the land for many centuries, an old Viking harbour on the Island of Romoe being instanced as having undergone no change, although local variations had taken place. An account was then given of the principal storm floods which had occurred on the Danish coasts during a period of two thousand years. The traditional state of the coast before the Christian era was then described, and its condition in A.D. 1240 and in 1860 was shown by diagrams, from which it appeared that the old boundary of the main land was outside the present islands, the collective area of which originally amounted to 1500 square miles. The author believed that these variations were owing to a general subsidence of the land (and not as understood by the term encroachment of the sea), and facts were adduced of the existence of vast submarine forests, and even submarine tumuli, in which stone and flint weapons had been found, assigned to an age nearly four thousand years ago. These forests, and also submarine peat bogs, in which were distinguished the fen plants of fresh water, together with trunks of trees, were met with almost everywhere on the coast, under the present surface of the sea, sometimes being covered with a depth of 12 feet of water. It was considered, for various reasons, that the sudden and general depression of the land probably occurred about two thousand years ago; while, at the same time, it was pointed out that local subsidence and other variations had taken place. A great part of the marsh land rested on peat moss, and on water containing peat, which continued to sink until far below the level of the sea. The Wilster and the Kremper marshes in Holstein, covering an area of about twenty square miles, were illustrations of these changes. It was stated that when a boring was made for the purpose of testing the nature of the ground, the rod suddenly dropped sixteen feet, and a stream of gas rushed upwards, and burned for several days. When a high rise of tide occurred in the North Sea, salt-water springs had burst forth from the marshes; and, had the pressure continued, the utter destruction of these marshes would no doubt have been the result. Immense exertions had been made to remedy the evils arising from these peculiarities. The phenomena noticed in these marshes, together with the salt-water eruptions and curious storm floods, were considered as highly important in the design and construction of engineering works, and as affording the means of satisfactorily accounting for some of the most tremendous disasters on record, hitherto attributed to the bursting through of the protecting lands. It was believed that this view was confirmed by that remarkable case the formation of the Zuyder Zee, originally a fertile land of nearly two millions of acres, although a marsh resting on peat bogs. The author considered that the destruction of the isthmus between Steveren and Medemblik was the effect, and not the cause, of that great eruption, and that the district was destroyed by the pressure and eruption of water from below, consequent on the sudden and great elevation of the water in the North Sea; and instances were adduced showing a communication between the wells of that district and the North Sea. Other local peculiarities were pointed out; and the Island of Amrum was stated to have risen twenty feet since the time of the earliest recorded flood. Similar occurrences had taken place in other countries, but there were no positive traces of such upheaving on other parts of the west coast, or on the islands. Heligoland had lost seven parishes in less than two hundred years.

Although in many places the sea had washed away the shores and cliffs, yet this was comparatively of limited extent, and a greater area of marsh land had been restored since the embankments were made; the inner marshes being always lower than the outer, while the forelands continually increased. The Lyster Deep, drainage of the country to the westward, and deep fiords on the eastern side of the Duchies were then noticed, as well as the formation of the Aggar Channel, which occurred during the greatest storm flood on record, that of 1825. This storm flood arose from the south-west, and some curious phenomena were observed during its continuance, the water rising to an extraordinary height and with singular rapidity, while it fell as suddenly. The author considered that this flood, as well as others, could not have arisen simply from the effects of violent gales in the North Sea, and he attributed them to volcanic movements of the bottom of the sea; alluding to the phenomena observable during the earthquake in Jutland in 1841. In further corroboration it was remarked that from the twelfth to the nineteenth century two hundred and fifty-two earthquakes had occurred in the Scandinavian Peninsula and Iceland; the movements in the former being usually from S.W. to N.E., or almost invariably the direction in which the most disastrous storm floods affected the Danish coasts. It had been stated by Mr. Mallet that during the great earthquake at Lisbon the sea was much agitated along the coasts of Holland and Friesland, and vessels were dashed against each other; shocks of earthquakes and tremblings being felt at several places in Holstein, the water in the wells rising so high as nearly to inundate the land in some places, while the River Eider was particularly agitated. The effect of these storms upon the islands, and the protection afforded by the 'dunes' were then commented on. The disappearance of the dunes between the Island of Amrum and the Eiderstedt was attributed to the washing away of the land on the eastern side; while at the same time it was pointed out that, at particular places where the sandy dunes were levelled by occasional floods, they were singularly productive of grasses, a rental of £3 per acre having been realised, and under certain conditions good crops of grain had also been obtained.

The construction of the dykes was then described in detail; historical records being given of the earliest forms, including the 'halligs,' remnants of large tracts of land, which were shown to be of great antiquity. It was considered that the preservation of the halligs and of the islands was of vital importance to the whole of the marshes, the full force of the sea being broken on them before reaching the main land. It was noticed as a curious fact, that while the forelands were forming rapidly, the halligs were as rapidly decreasing; and that, consequently, the beneficial influence they exercised would probably cease with time. The Island of Pellworm was specially instanced, as possessing a vast influence on the maintenance of the marsh district; although owing to its isolated and exposed situation, the peculiar nature of the soil, and the gradual depression of the land, it was somewhat questionable if the strong and perfect stone dykes, or indeed any other works, except the inclosure of the intervening space between the main land, would absolutely free the island from danger. The dykes were classified as summer dykes, inside, and outside or sea dykes. The former were the most ancient, having been constructed by the early settlers on the 'warfths' as a protection against occasional tempests. Details of the various forms of dykes were then given. Generally, in Slesvig, a slope of 3 to 1 was used on the seaward side to a height of 10 to 12 feet above the ordinary level of the water. There was then a cess or bench of 10, 12, or 15 to 1, according to circumstances, the section being entirely dependent on the position, the extent of the foreland, its height above the ordinary flood level, and its exposure to the direct action of the waves and wind. The variations in the rise of the water on different parts of the coast had a considerable influence on the height of the dykes; and it was shown that a high level of the crown was not always desirable, the banks on the Island of Pellworm being instanced as illustrations. The application of the curved stone facing for defending the dykes appeared only to be justified under peculiar circumstances, and by the want of straw and the scarcity of labour in the time of danger: as it was thought to prevent the natural rising of the ground, and to cause a depression at the foot of the facing, besides being very expensive. The materials for and the mode of formation of the dykes, and the various plans of protection adopted, were then treated of. Above the ordinary flood level, grass plots, covered or uncovered with straw matting, were shown to be of much importance; while in exposed places, where every ordinary tide reached the dykes, the sea slopes were sometimes covered with straw matting stitched down in a peculiar manner, or they were pitched with stone, or protected with fascine or hurdle works. These and other methods had all been adopted with uniform advantage under the circumstances in which they had been employed, particularly that of protecting the slopes with twisted straw-bands. It was stated that there was no feature in connection with the dykes of greater importance than the projecting works or groynes, and diagrams were exhibited illustrative of the extent to which they were now being carried out, some being constructed of great length, nearly 8000 feet, with the object of connecting one of the small islands with the main land. Numerous examples were given of their advantage in exposed localities, as at Schlenkulen, in Holstein, where there was a depth of water of from 90 to 100 feet. The author thought the skilful manner in which the Dyke Inspectors, both in Slesvig and in Holstein, had overcome the difficulties, entitled them to the highest commendation. He then alluded to the precautionary means adopted in time of danger, pointing out that by the laws regulating the dyke lands, the inhabitants of the 'koogs' contributed to the maintenance of the dykes, according to the position of their land, its exposure to danger, and the intrinsic value of the soil.

In conclusion the author reviewed the general advantages of these works in England, Holland, and Denmark, and the results which had been accomplished, as well as those which still remained to be achieved. He considered the true test of successful engineering enterprises to be not so much the perfection of the gigantic works which had been raised up as monuments of skill, but rather the benefits they conferred upon the world. Judged by this standard it was contended that no other engineering works were of more paramount importance than reclamations from the sea. It was observed that the country, which was originally a trackless waste, now consisted of some of the richest land in Europe, furnishing, together with the kingdom of Denmark, corn to England to an extent only surpassed by two other great states of the world, besides vast numbers of cattle, sheep, and horses. These results were then compared with what had been accomplished in the Lincolnshire Fens and in Holland, and it was remarked that the three marsh countries were capable of affording a larger supply of grain than was now imported from America, Russia, and Prussia combined. Indeed, independently of other great inclosure works, it was estimated that the annual revenue of those countries was at least eight millions sterling, a sum equivalent to more than the net passenger receipts of all the railways in the United Kingdom. There were still upwards of 600,000 acres of land in England and Ireland worth from £20 to £60 per acre, which might yet be reclaimed, and if similar districts in other countries were added to this calculation the magnitude of the results could scarcely be overrated. It was remarkable that, notwithstanding the many advantages attending reclamation works, which could now be effected at a less expenditure than formerly by the judicious application of steam power, such enterprises were still regarded with suspicion and distrust, although they afforded the means of the soundest and most profitable application of capital.

The second paper read was "*On Reclaiming Land from Seas and Estuaries.*" By James Oldham, M. Inst. C.E.

It was remarked that, considering the character of the river Humber and its tributaries, and the nature of the soil and the geological formation of the district, it was not surprising that the foreshores, except where efficiently protected by artificial works, should be easily washed away, and the water become loaded with a vast mass of earthy matter, to be again deposited in less disturbed situations. In addition to these natural deposits the surface of the low lands was frequently raised, and rendered available for cultivation by a system of 'warping,' the common process of which was described, such as had been practised on the Trent, the Ouse, and the Don.

The degradation of the land on the whole of the sea-coast of Holderness from Bridlington to the Spurn was then pointed out. It was found by observations extending over a considerable period, that on 40 miles of coast the loss amounted on an average to 2¼ yards per annum; but the progress was far from uniform, in some places no change being perceptible, and in others as much as 10 or 15 yards disappearing in twelve months. As bearing on this branch of the subject, an extract was given from a paper which was read at the meeting of the British Association in 1853, "On the Character and Measurements of Degradation of the Yorkshire Coast," by Dr. J. P. Bell.

The phenomena of tidal deposits and accretions in the formation of new land having been explained, it was shown that the greater part of Sunk Island, and of the immediate locality, had accumulated during the last seventy or eighty years. This island was situated at from 7 to 11 miles from the Spurn, on the north bank of the estuary of the Humber, having a line of coast of about 6¼ miles. It contained 7000 acres of inclosed land under cultivation, the property of the Crown; and adjacent to it, and forming an addition to the mainland of Yorkshire, there were about 3000 acres of rich alluvial soil. The accretions in the Humber and on Sunk Island were found to rise until the surface of the land was coincident with the average level of all tides. When this point was attained, marine plants appeared; and as soon as the surface of salt-water accretions was covered with vegetable life they were considered suitable to be embanked. Various opinions were entertained as to the source of the material forming these accretions. The author believed that it proceeded from the sea face of the coast of Holderness, as it could only come in with the tide, and be deposited at the time of high water. In support of this view a quotation was made from "The Geology of the Yorkshire Coast," by Professor Phillips; and a paper "On the Chemical Constitution of the Humber Deposits," by Mr. J. D. Sollitt, read before the British Association in 1853, was also referred to.

In practical operations on the Humber, endeavours were in the first instance made to secure a thoroughly uniform surface to the land to be inclosed. Thus, a year or two before embanking the ground was drained by 'gripping,' so as to let off the whole of the standing pools, and allow the depressions to silt up. The permanent drainage of the land was provided for by a sluice, the size and the level of the cill of which were determined by the rise and fall of the tide, and by the extent of land to be drained. With regard to the sectional form and area of the bank itself, where the outer face was exposed to a heavily rolling sea, the slope should be gradual: and if the soil to be used in its construction was light, then the bank must have a wide base, and there should be a puddle wall in the centre, to prevent leakage. If a slip took place in a tidal embankment, fascines or faggots should not be employed, as they were liable to act as conductors for the water.

In illustration of these remarks, the works of the last embankment for inclosing 700 acres of new accretion at Sunk Island were described. They were commenced in April 1850, and were completed in the December following, the tide having been excluded by the first of July; and they were executed under the direction of the author as engineer, Mr. G. C. Pauling being the contractor. The total length of embankment was 6067 yards. That portion which had to encounter the storms of the Humber was 3943 yards in length, its greatest height being 8 feet 10 inches, width at the base 61 feet, and at the top 4 feet. The outer face had a slope of 5 to 1, and the inner of 1¼ to 1. The remaining portion of the embankment was 2124 yards in length, had an average height of 6 feet 3 inches, though in one part it was 7 feet 6 inches high, was 32 feet wide at the base, and 3 feet at the top. The outer face had a slope of 3 to 1, and the inner of 1 to 1. In making the embankments, the material removed in forming the drains round the inside of the inclosure was employed; where this was not sufficient, the contractor was permitted to excavate from the foreshore, provided the cutting did not exceed 4 feet 6 inches in depth, and did not approach within 6 feet of the bottom of the outer slope. Channels were cut to allow the water which accumulated in these pits to run off after every tide; and within four years these pits were silted up by tidal deposit alone. The banks were raised at once to the height of ordinary spring tides, the natural creeks being left open. These were then filled up simultaneously, and the whole of the banks brought to a uniform level to the full height required. The first bank cost ten shillings and sixpence, and the second four shillings and sixpence per lineal yard; or at the rate of fivepence farthing and fourpence farthing per cubic yard on the average respectively. The banks were perfectly watertight from the first, and the greatest settlement in any part was not more than 15 inches.

Details were then given of the self-acting draining sluice, or clough, which was provided with tidal doors, and had been erected at a cost of £380. It appeared that the foundation consisted of timber piles, and that the superstructure was composed of brickwork with stone copings. The hollow quoins, the framing of the gates, and the top cills were of English oak; the bottom cills being of elm timber. A door, capable of being raised or lowered by machinery, was provided to admit of the outfall, which was liable to be silted up in dry seasons, being occasionally scoured; and this door could be used, in very dry seasons, for admitting a quantity of tidal water to fill the fence ditches.

Soon after the exclusion of the tidal water the marine grasses decayed, and fresh water grasses gradually appeared. In about three years a tolerably good surface of pasture was naturally formed, and on Sunk Island there arose a spontaneous growth of white clover. Some remarks were then made on the value of this land for tillage, and it was stated that the tenants on Sunk Island admitted that they frequently obtained six imperial quarters of grain per acre. Flax was also produced in large quantities and of fine quality; and root crops, as potatoes, turnips, mangold wurtzel, &c.

The third paper read was "*On Reclaiming Land from Seas and Estuaries.*" By J. H. MULLER (of the Hague).

The author stated, that he understood works of this class to comprise an area either of salt marsh, samphire ground, slake, mud, or sand, lying more or less above the level of low water, and being reclaimed from the sea by means of embankments, and drained by natural means through the sea banks. Reclaiming land was frequently looked upon as a hazardous speculation, owing to the probable contingencies where water had to be dealt with, and to the benefits being generally prospective. It was often condemned on account of the state of the ground, which was pronounced to be unsuitable for the purpose. But the question should not be determined in that way; for the value of the ground before being reclaimed was no measure of the merit of the proposal, which could only be decided by comparing the cost of the necessary works with the improved value that would be given to the land when that operation had been accomplished.

After contending that the effect of reclaiming or draining land was to remove the cause of malaria or ague, and not as had been erroneously asserted to produce it, the author proceeded to point out, that in designing such works the object should be to inclose the largest area with the least length of bank, and the smallest average cross section. These points were regulated by the direction of the sea bank, to which attention was next called. It was sometimes recommended that the sea bank should be as nearly as possible parallel with the current, and at an angle to the prevailing winds. But experience seemed to show that where creeks did not interfere a different system was preferable; and that one side should be boldly exposed to the full force of the gales, and that the current should be allowed to act upon it almost at right angles, if at the same time that one side would shelter or protect the two other sides. By this arrangement a less extent of bank required supervision during gales, and it also presented advantages during construction. The line of the embankment should, if practicable, cross creeks at right angles, and at the same level; and in all cases care must be taken to secure the bottoms of the creeks by aprons to prevent them from becoming deeper.

The extent of land to be reclaimed at any one time was then considered, and it was argued that large areas were the least expensive in the end; for if a small area was selected at first, some portion of the original sea banks would be useless when an increase became desirable. If the banks could not be constructed entirely on the salt marsh, it was preferable to go to half-tide level. The difficulty in the construction did not increase with the size of the area reclaimed, but depended upon the openings left in the banks. As instances,—in reclaiming a piece of land of 1000 acres by a bank three quarters of a mile in length, the seat of which was 6 feet below the level of high water, only one opening 7 chains in width was left. In another case, in reclaiming 1700 acres by a bank four miles in length, the seat of which was 8 feet below high water, three openings of 5, 7, and 12 chains in width were left. In neither case was the speed of the outgoing current materially increased during the progress of the works, nor indeed until the cross section of the openings was diminished. In completing the latter work the aprons were raised 18 inches, or 2 feet at a time, by wood-work, stone, and clay. It was expected that the current would increase in the third opening, when the two others were raised; but this did not occur, as the water within the inclosure did not reach so high a level as that without; in fact it never attained to high-water mark. When the aprons were above the level of the reclaimed land, the current on leaving became violent. This could not, however, be avoided in finally closing a bank.

Between the old sea-bank and the edge of low-water, the soil might be divided into four distinct classes:—the salt marsh, of clay, about the level of summer spring tides; then samphire ground, slake or mud, or rich alluvial matter, to half tide; next, hard sea sand; and lastly, near low-water mark, quicksand. Banks entirely on the salt marsh were the easiest and the strongest that could be made. Those on samphire ground and mud were the most difficult; slips were of constant occurrence, the use of waggons and horses was impossible, and a large proportion of the material was washed away as it was deposited, before the bank was consolidated and raised above high-water mark. In fact, for waste, settling, and contingencies, from 60 to 100 per cent. of the original quantity must be calculated upon as necessary. If a storm arose during the progress of the works the slopes could not be protected; and indeed a bank constructed on such a bottom was always unsafe. When the line of the embankment was laid at the half-tide level, or about the limit of vegetation, and on hard sand, it was possible to make the whole of the reclaimed land fit for cultivation, and this plan need not cost more, and was safer, than by adopting the higher but softer bottom. Banks on a lower level were not advisable.

Having stated the conditions to be observed in the direction and situation of the banks, the next question requiring attention was the cross section. This naturally divided itself into two parts:—the main body to resist the dead weight of the water when at rest, and the mode of protecting the slope to enable it to resist the action of the water when in motion. With regard to the first point, the best cross section was that where the centre of gravity came nearest to the bottom and to the toe of the bank. For this reason steep slopes, with a cess or bench about the level of high-water, were preferable to flat slopes without a cess or bench. Sand standing at its natural slope was sufficient to resist still water.

Breaches in banks were attributable either to a small percolation of water underneath the seat, or to the defence or protection of the slope being insufficient. Frequently it was not possible to obtain clay in sufficient quantities to form a puddle wall in the centre of the bank; and if the force of the wave was strong enough to break through stone and wood, clay would not be able to resist it. Sometimes, at extraordinary high tides, a breach would occur above the cess, but this rarely happened, and the time during which danger could arise was so short, that the evil might be remedied before the next returning high tide. When the water rose above the top of the bank, the back unprotected slope was liable to be damaged, and thus to lead to a breach. This might be averted by driving stakes into the top of the bank, and placing planks, supported by clay or other materials behind them.

With respect to the protection of the slope, there was a difficulty in ascertaining correctly the force of sea-water when violently agitated. Mr. Storm Buysing had stated, in his work on hydraulic engineering, that the shock of the water and floating objects against slopes increased in the same ratio as the sine of the angle formed by the slope with the horizon. De la Coudraye and Brémontier contended, in their theory of the motion of waves, that the water only moved vertically up and down, without any horizontal displacement. It was well known that the sea had the power to destroy banks and to displace stones of considerable weight; and the engineer must be guided by experience in dealing with these matters rather than by speculative opinions.

The materials employed for the defence of slopes were of three different kinds, clay and grass flags, wood and stone. When banks were constructed on salt marshes, the body consisted of clay taken from the adjoining excavations In this case it was advisable, after trimming the slopes, to sow coarse and meadow grass and clover seeds, and to protect the whole with a crammat. The crammat, which cost threepence or fourpence per square yard, was composed of a layer of clean barley straw about two inches thick, evenly laid, and fastened to the clay by straw bands or strands, sixty to ninety stitches being made per superficial yard. In two or three years the bank was so consolidated that the mat did not require renewal. When these banks were on a lower level than the salt marsh, a protection of clay and grass was insufficient. In such cases a layer of clay, protected by stone at a slope of 4 or 6 to 1, was employed in England, but without a cess or bench. This afforded the requisite strength, but it was expensive, and as usually constructed it needed much repair. The author thought that, when the bank was constructed on samphire ground (as within a comparatively short period a new salt marsh or foreshore would be formed) it would be sufficient to protect the slope of the bank with wood, and that the slopes above the cess need not be protected, nor be flatter than 3 to 1.

A description was then given of the protection by fascine work. This consisted of layers of faggots 5 or 6 inches in thickness, placed in a direction up and down the slope of the bank, the thick ends overlapping the thin ends of the lower rows. These were fastened down by stakes, which were left 8 inches above the faggots, and were connected together by means of willow binders, or 'wattles,' something like hurdle work. When the proper sort of wood was obtained, this protection would endure from five to seven years, and was quite able to resist the action of the tide. The strength of this kind of protection might be increased by increasing the number of the stakes and binders, or by filling in with stone, firmly wedged between the rows of stakes. The stone defence, as commonly constructed by the Dutch on islands exposed to the ocean, was formed thus: when the slope was trimmed, a layer of clay 12 inches to 18 inches in thickness was spread over it, covered sometimes with a crammat. Over this, bricks in one or two courses were laid, and then from 6 inches to 12 inches of brickbats, on which stones from 12 inches to 18 inches in depth were set. This work, though very durable, was costly, and hence should only be adopted where security rendered it necessary; as, for instance, for banks near to low-water mark. Details were then given of four different cross sections, and it was observed that, with a stone defence, the slopes were recommended to be flatter and the banks to be higher than where wood protection was employed; for it was expected that the former would be built in more exposed situations. In some cases it had been found advantageous to introduce rows of oak stakes at intervals above the surface of the stone, to break the force of the waves.

In the construction of sea walls or banks, the most difficult operation was that connected with the crossing of creeks before alluded to, especially when the bottom was 10 feet, 20 feet, or more under low-water mark. In England the usual plan was to fill in large quantities of material from the sides; but this was a costly method. In Holland, on the contrary, the custom was to raise the bottom uniformly to the level of low-water by means of cradles. The cradle was formed of brushwood, bound together by ropes and osiers, and was usually from 2 feet to 3 feet thick. It should be made on a flat sand, or silty ground, about 3 feet below high-water, of the full length of the opening, and of proportionate width; being perfectly flexible, it adapted itself to the inequalities of the ground. It was stated that particular attention must be paid to the stakes or fastenings by which it was held down, as the safety of the cradle depended entirely upon them. After being so secured it was weighted with clay, brickbats, and stones. The mode of constructing a cradle, of floating it to its place, and of sinking it in the centre line of the intended embankment, were then minutely described. The sides of the opening were next protected with similar cradles, the lower end of each resting on that first laid. Subsequently other cradles were sunk over these, until the work reached low-water mark, when the width of the embankment was gradually increased by throwing in sods on the flood side, protected by fascine work weighted with stone. The same process was then pursued on the ebb side. When the surface of the creek was level with, or above low-water, cradles were not required. In such cases the ground was covered with a thin layer of clay, protected by an apron of fascine work.

In conclusion, the mode of constructing the banks themselves, by side cuttings at least 20 feet from the foot of the slopes, was described; and it was urged that each part undertaken should be raised to its full height in one tide, the exposed side being covered with a thin layer of clay. In the next tide this should be provisionally protected by a crammat, and before the ensuing spring tide the work should be finally protected with stone or wood.

May 13 *and* 20.—The first paper read was "*The Malta and Alexandria Submarine Telegraph Cable.*" By H. C. Forde, M. Inst. C.E.

It appeared that in May 1859, Her Majesty's Government determined that a telegraph cable should be laid between Falmouth and Gibraltar, and the late Mr. Lionel Gisborne and the author were appointed joint engineers. Subsequently, and after some progress had been made with the construction of the core and the outer covering, it was proposed to use the cable to join Rangoon and Singapore. This idea was however abandoned, and in January 1861 it was decided that it should be laid be ween Malta and Alexandria, an operation which was carried out in the summer of that year, the communication having been successfully completed on the 28th October 1861.

The recommendations of the late Mr. R. Stephenson and Sir Charles Bright, as to the form and size of the cable to be used between Falmouth and Gibraltar, were then referred to; and it was stated that iron covered cables, of three sizes, were designed for the varying depths up to 600 fathoms, and for the greater depths across the Bay of Biscay, a cable covered with twelve steel wires, each enveloped in a hempen strand, laid in a spiral form. The latter was abandoned when the destination of the cable was changed; but the other forms of outer covering were retained, as considerable progress had been made with their manufacture. If it had been known at first that the cable would be laid in comparatively shallow water, a different design would have been adopted. The outer wires were much larger than those of the Atlantic, the Red Sea, and the other Mediterranean cables containing a single conductor; and the conductor was nearly four times the size of the Atlantic cable, and twice that of the Red Sea cable.

The contract for the manufacture of the core was intrusted to the Gutta Percha Company; the contracts for the outer covering, and for laying and maintaining the cable for thirty days after completion, were let to Messrs. Glass, Elliott and Co. The conditions of the contracts were then given in detail, the main features being that the core and the cable were to be kept continually under water during the manufacture and the laying, and that the electrical tests were to extend from the commencement of the manufacture until thirty days after submersion of the whole line. The different processes involved were next described, and it was stated, that under a pressure of from 600 lbs. to 800 lbs., the electrical condition of the core improved about 10 per cent. The relative resistance per knot, both as to conduction and insulation, of the Atlantic, the Red Sea, and the Malta-Alexandria cables, was represented by the numbers 1, 4 and 37. It was requisite that great care should be observed in making the joints of the core, of which there were four thousand two hundred in the Malta-Alexandria line, as the slightest imperfection in any one would be attended with danger.

A difficulty having arisen in keeping the cable permanently under water, one portion became exposed to the air, and was allowed to dry. When tested, a loss of insulation with increased resistance in the conductor was observed. An investigation by Dr. W. A. Miller, F.R.S., showed that this deterioration was due to heating, from the effects of oxidation. It was consequently resolved, that the original idea of fitting the two ships with water-tight tanks should be carried out. The way in which this was accomplished, and the manner of coiling the cable on board, were then alluded to. The eye of each coil was fitted with an open framework of timber, by which arrangement a fault was cut out of the centre of a large coil, without its being necessary to uncoil the whole cable, as would have been the case with a solid eye.

Previous to commencing the operation of laying, the route was most carefully surveyed by ships of the Royal Navy, when it was ascertained that the Admiralty charts were in parts incorrect in latitude, and were deceptive as to the soundings, the general depth and the conformation of the sea bottom being very different to what they were represented to be on the official charts.

Each ship was fitted in the following manner: A large V sheave, furnished with a small friction band, was suspended above the centre of the hold, and over this the cable was led. The paying-out apparatus, placed on one side of the stern, consisted of three V sheaves in one vertical plane, and parallel to the centre line of the vessel, each sheave being provided with a friction-strap. The cable was passed over these sheaves under three weighted jockey pullies to the brake drum, round which it took three or four turns; then over a fixed sheave, and under a movable weighted pulley into the sea over a fixed stern-wheel at the level of the last sheave. The dynamometer employed was similar to that used on the occasion of the successful laying of the Atlantic cable.

The first portion of this line was laid between Malta and Tripoli, the greatest depth being 420 fathoms. The cable was paid out at an average rate of 4·94 knots per hour. The maximum strain to which the heavy shore-end was subjected was 20 cwt., but with the main cable this did not exceed 12 cwt. The estimated slack paid out in the deep water was not quite 5 per cent. No difficulties of any kind occurred until attempts were made to splice the main cable to the Tripoli shore-end, which had been laid by another ship. Nine unsuccessful attempts were made, owing to bubbles forming under the fresh gutta-percha, but by cutting off a length of 25 fathoms of the shore-end a perfect junction was effected. The remaining cable on board this ship was laid in the direction of Benghazi, the maximum depth attained being 150 fathoms, the average speed of paying out 5·3 knots per hour, and the greatest strain 9 cwt. The cable next laid was part of the third section, commencing at Alexandria, and extending nearly 300 miles to the westward, towards Benghazi. The roughness and irregularity of the bottom rendered this operation very critical; but by carefully selecting and laying out the route to be pursued, after accurate soundings had been made, and by only paying out in daylight, it was successfully completed. Six days were occupied in laying 128·8 knots of heavy cable and 153·32 knots of main cable, or a total length of 282·12 knots. Thirty-two buoys were laid down to mark the route, and upwards of sixty different courses were run. The maximum depth of water was 102 fathoms, the mimimum, for a short length, was 13 fathoms, and the average 35 fathoms. Subsequently, the second part of the third section between Alexandria and Benghazi, and the second part of the second section between Benghazi and Tripoli were laid, and the communication was established. No accurate estimate could be made of the actual slack paid out, but as a general rule in depths under 100 fathoms, from 2 to 2½ per cent. was the utmost that could be got out of the ship when the cable was running quite free. The angle at which the cable was paid out ranged from 40° to 45°. The maximum speed was 7·15 knots, the minimum 4·5 knots, and the mean 5·25 knots per hour.

Respecting the tests during and after the laying, it was observed that as the cable was paid out, its electrical condition invariably improved; the highest resistance being found in the deepest and coldest water, and the lowest in the shallowest and warmest water. Experiments as to the rate of working showed, that the speed attained agreed very nearly with that which had been anticipated, namely, five words per minute through a length of 1100 knots, except through the short sections, where the limit of the speed depended simply upon the skill of the clerk.

The communication was accompanied by a map, showing the general course of the cable, by a longitudinal section of the sea bottom, and by diagrams of the electrical tests. Specimens of different cables were also exhibited.

The second paper read was "*On the Electrical Tests employed during the construction of the Malta and Alexandria Telegraph, and on Insulating and Protecting Submarine Cables.*" By C. W. SIEMENS, M. Inst. C.E.

Having been employed by Her Majesty's Government as the Electrician to superintend the manufacture and shipment of the Malta and Alexandria Telegraph Cable, the author was in a position to speak as to its actual state of insulation, at different stages of its progress, and as to its general superiority compared with former lines. The methods of testing differed essentially from those previously resorted to. This was the first line that had been tested systematically throughout; and the importance of a uniform and well-devised system of electrical tests being carried on during the manufacture, shipment, laying, and subsequent working of submarine cables, had been fully proved.

The covered strand of conducting wire, in lengths of one nautical mile, was placed for twenty-four hours in tanks filled with water maintained at 75° Fahrenheit. It was afterwards removed into a pressure tank, containing water at the same temperature, and when uniformly heated, it was tested for conductivity and insulation, and the result, expressed in units of resistance, noted. A pressure of 600 lb. per square inch was then applied, and the electrical tests were repeated. Before any coil was approved, it was required that the copper resistance should not exceed 3·5 (Siemens) units, or possess 80 per cent. of the conductivity of chemically pure copper; that the gutta-percha resistance per knot at 75° should amount, at least, to 90 million units, corresponding to about 80 per cent. of the highest insulation that could be obtained with the best gutta-percha of commerce; and further, that the insulation should improve when the pressure was applied, which was invariably the case when the covering was sound. The coils were then transferred to Messrs. Glass, Elliot, and Co.'s works at Greenwich, where they were submerged in tanks until required for the sheathing machine. The sheathed cable was coiled into large tanks, and was always intended to be covered with water, but owing to a defect in the construction of the tanks, this regulation could only be partially carried into effect. It was also intended, in the first instance, that the ships should be provided with water-tight tanks to receive the cable during the outward voyage; but owing to the passive resistance with which every deviation from previous routine was usually met, this plan was not carried out, until the heating of the cable on board the S. S. Queen Victoria had proved, at great cost, that tanks were essentially necessary. There were other important advantages obtained through the adoption of the water tanks by which the causes of failure in paying out were avoided, and the operation was rendered comparatively safe and easy.

In conducting the electrical tests of the Malta and Alexandria cable in the course of its manufacture, the chief object was to obtain throughout strictly comparative results. For this purpose it was necessary to adopt a standard measure of resistance, by which to express both the conductivity of the copper conductor and of the insulating covering. This standard measure had been supplied by Dr. Werner Siemens. The unit of resistance was that of a column of pure mercury, contained in a glass tube, one metre in length between the contact cups, and of one square millimetre sectional area, taken at the temperature of melting ice. As the testing apparatus had been already described in the blue book 'On the Construction of Submarine Cables,' it was not necessary to repeat it. In the Appendix to this paper, tables were given of the results of observations on two sections of the cable, at various stages of their progress, between Malta and Tripoli, and between Tripoli and Benghazi; and diagrams were exhibited representing graphically these results. On comparing the insulation of the cables after being laid down, with the insulation observed shortly before on board, there was a decided improvement after submersion. This was partly due to the pressure upon the cables, the insulation improving 2 per cent. on an average for every 100 lb. of pressure upon the square inch, and partly to the lower temperature at the bottom of the sea.

For working the line, Messrs. Siemens, Halske and Co. had supplied ink-recording instruments, fitted with peculiar arrangements for discharging the residuary charge of the cable, and capable of being worked by exceedingly feeble battery power. Although the line was divided into three electrical circuits, messages were transmitted mechanically and instantaneously, at the intermediate station, by a system of double relay, or translation. By this plan messages could be sent instantaneously from London to Omsk, in Siberia, and there would be no electrical difficulty in establishing the same direct intercommunication between London and Calcutta.

Respecting the construction of a cable of a more permanent character than any hitherto made, to which the author had given much consideration for many years, it was observed that with regard to the insulating covering, nature seemed to have provided only two suitable substances, india-rubber and gutta-percha, combining permanent pliability at all ordinary temperatures with high insulating property. India-rubber had a higher insulating power, a lower specific induction, and was capable of resisting higher temperatures than gutta-percha; but the latter could be put upon the wire in a plastic state by a dye process, and gave greater security against faults than the lapped india-rubber covering. It was also less liable to receive accidental injuries, to become sticky or semifluid when exposed to the atmosphere, and resisted the action of water more perfectly.

The absorption of water by gutta-percha, india-rubber, and compounds of india-rubber, such as vulcanised india-rubber, Wray's mixture, and a compound with mica, under various pressures and temperatures, and from water containing different degrees of salt in solution, had been fully investigated. These experiments served to show that an increase of pressure up to 50 lb. per square inch did not increase the rate of absorption, which was found to be more rapid from pure water than from sea water, and from sea water than from brine. Raw an unvulcanised india-rubber absorbed water in greater quantities than the other materials; while, next to gutta-percha, vulcanised india-rubber showed, both in fresh and salt water, the greatest insensibility to absorption.

The results of experiments on the insulating and inductive capacities of wires coated with india-rubber in combination with gutta-percha, compared with those of special gutta-percha and pure india-rubber at different temperatures, were then given. The lengths experimented upon varied from 600 to 2500 yards. The specific resistance of special gutta-percha decreased from 9·11 at 50° Fahrenheit to 1·50 at 80° Fahrenheit, or to about one-sixth of its original value; while the combination of india-rubber and gutta-percha had, under the same circumstances, only gone down to about one-third of its insulation at 50° Fahrenheit. The inductive capacity of the combined india-rubber and gutta-percha wire, and of pure india-rubber covered wire, was 0·7 to 1. Notwithstanding the comparatively high insulating property of india-rubber, its low inductive capacity, and its power to resist heat, its gradual dissolution in sea water was a circumstance which alone rendered it inadmissable for submarine wires, unless it was securely inclosed in another waterproof medium, and gutta-percha appeared in every respect well suited for such outer covering. It was desirable that the india-rubber should be brought upon the wire without the application of heat, or solvents, both of which often entailed a gradual decomposition of that material, particularly when exposed to atmospheric influence in contact with copper. Dr. W. A. Miller had stated, that the liquefaction was the result of a process of oxidation, from which it might be inferred that the effect could not take place where oxygen was excluded. It, moreover, was important to produce a perfectly cylindrical covering, and taking advantage of a peculiar property of india-rubber cohering perfectly where two fresh cut surfaces were brought together under considerable pressure, the author had constructed a covering machine which fulfilled the several purposes. Such combined india-rubber and gutta-percha covered wires had been tried under various circumstances, exposed to the atmosphere, to water, or the moisture of the ground, for nearly two years without betraying any signs of gradual deterioration of the india-rubber, or the appearance of faults. A circumstance greatly in favour of the bi-covered wire, was that the gutta-percha shrank upon the india-rubber covered wire, and when any mechanical injury to the covering occurred, the yielding india-rubber was forced into the gap, by the elastic pressure exercised by the gutta-percha, and prevented the appearance of a fault.

The outer covering of cables, as hitherto constructed, was certainly the least perfect part. An iron sheathing was very necessary to protect the insulated core in shallow waters, but for cables in more than 30 or 40 fathoms of water, the iron sheathing was an element rather of weakness than of strength. It rendered the cable ponderous, its shipment expensive, the paying out risky, and repairs impossible, owing to the difficulty of raising a heavy cable from a great depth under any circumstances, and the absolute impossibility of doing so after corrosion of the iron wire had made some progress.

When the Falmouth and Gibraltar cable was first contemplated, the author, in conjunction with Mr. Forde, proposed to cover each iron wire with gutta-percha, with a view to prevent oxidation; but the system was not acted upon, except by way of experiment. Mere protection of the wire was however not sufficient, in the author's opinion. It was capable of mathematical demonstration, that in paying out a wire-sheathed cable with a considerable strain upon the breakwheel, it would untwist while in suspension in the water, to a considerable extent, causing elongation of the core to the amount of, say one per cent., or even more. On reaching the bottom, the strain and consequent twist would be released. Copper wire could not be elongated more than 2 per cent. without receiving a permanent set; and it was also a well ascertained fact, that when telegraph core had been stretched at any time beyond the limits of elasticity of the copper, the latter being henceforth too long for the more elastic covering, would tend to assume a serpentine form, and to push its way through the insulating material by slow degrees, particularly in places where short bends or kinks occurred.

Based upon these views the author designed a sheathing of the following description:—The insulated conductor, or core, was passed in the sheathing works through a series of three machines in close succession. In passing through the hollow spindle of the first machine, a close spiral covering of hemp, previously saturated in Stockholm tar, was applied in such a way, that each string was and remained under a given strain. The second machine was in similar construction to the first, but supplied a second covering of hemp wound in the opposite direction to the first. The rope thus formed passed next through a stationary clip, with longitudinal grooves to prevent it from turning round in the operation immediately following, which consisted in the application, under the influence of great pressure, of from three to six strips of copper, or other metal which might best resist the action of sea water. These strips were accurately guided into the revolving covering tool, so as to overlap each other equally for nearly half their breadth, the pressure applied being sufficient to crush, or socket the one metal down where it was covered by the other. This cable had no tendency to untwist; its extension with half the breaking strain upon it did not exceed one-half per cent., and being very strong, and of only double the weight of water, it would support about 8 miles of its own weight in the sea.

Considering that good ship's sheathing lasted about 10 years when the ship was at rest, and that the cable had two layers of metal, with hardened tar between, it appeared not unreasonable to suppose, that this sheathing would last at the tranquil bottom of the ocean from 20 to 30 years at least. Several short lengths of this cable were now being tried under various circumstances, and the results so far were promising of success upon a larger scale.

After the meeting, Mr. F. C. Webb (Assoc. Inst. C.E.) explained a modification of the ordinary sextant, by which larger angles could be measured than with the instruments now in use. Two sextants (by Messrs. Fletcher, of Leadenhall-street) were exhibited, one on the common arrangement and the other on the modified principle.

It was stated, that when the arm of the common sextant was at zero, the lines of incidence and of reflection of an object seen in the horizon glass formed a certain angle with one another, both at the object and horizon glass; and that this angle, termed the constant angle, deducted from 180°, gave the extreme theoretical angle which could be measured. Practically this measurement was still further reduced, by the limits within which it was possible to reflect an object from a plane surface with accuracy, and which, if assumed as 170° instead of 180°, would give the angle from which the constant angle must be deducted to obtain the extreme angle capable of being measured. The smaller the constant therefore, the nearer would this angle approach 170°, with a given amount of accuracy. It was observed that this constant angle was dependent on the relative position of the object glass, the eye piece, and the horizon glass; and was in fact the angle formed by a line drawn from the eye piece to the centre of the horizon glass, with a line drawn from the centre of the horizon glass to the centre of the object glass.

The reduction of this constant angle to a minimum was effected in the modification alluded to, by placing the eye piece very near to the object glass, and the horizon glass as far as possible both from the object glass and the eye piece. The extreme angle capable of being measured was thus considerably increased, and with conditions more favourable to accuracy; for whilst the angles of incidence and reflection in the object glass were not smaller than in an ordinary sextant, those in the horizon glass were constantly larger. With a given angle to be measured the conditions were more favourable to accuracy, since the lines of incidence and reflection formed larger angles with the reflecting surfaces, both in the object and the horizon glasses.

In marine and land surveying, and in taking altitudes of celestial objects with an artificial horizon (where the angle to be measured was double the altitude), this increase in the capabilities of the instrument was, it was believed, a manifest advantage.

The following candidates were ballotted for and duly elected:—J. G. Fraser, H. Hayter, R. Johnson, A. M. Rendel, J. D'A. Samuda, I. E. Tanner, C. F. White, as Members; and Major A. C. Cooke, R.E., Capt. W. H. Mackesy, C. E. W. Ogilvie, W. Sugg, D. Thwaites, J. R. Warham, and J. Weild, Associates.

THE ALBERT MEMORIAL.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—I have seen in your Journal several valuable suggestions as to the proper nature of the monument to be erected to the late Prince Consort. The injudicious proposal of the obelisk having been overthrown through the objections raised by many respecting that most inappropriate description of monument, the question is now again before the world. Regretting that the character of the movement has been weakened through the failure referred to, all persons must see that this consequence of an attempt to force a question against the sense of the public has its satisfactory aspect in offering a warning to those who might attempt "jobs" of the like nature in future. What object could an obelisk answer? The mere monument of brute power confided to one hand, and by that hand directed to achieve a single object, which was only great because it was difficult and astonishingly costly; such a memorial has few charms for the modern mind, which fails to see so much in those vulgar elements of greatness—size, force, and cost, as an Egyptian of Rameses' time naturally did. Prince Albert was a patron of art; let him be commemorated by a statue. To the question,—A statue for the Prince? most men answer,—undoubtedly a statue for the Prince. There is no other method of commemoration which presents so many and such lasting claims for employment as that of sculpture. Carved in marble, or cast in bronze, a monument insures almost an immortality for the personage the nation delights to honour to that extent. Much has been said, and can be said, in favour of the public gratitude taking the form of some kind of benevolent institution; but if we are to have a national monument of gratitude, given by the nation in its corporate and collective capacity, it must be such a one as all the world may see and remember; a high-placed statue, in marble or bronze, paid for out of the national treasury, by vote of the national representatives, and wrought by an English sculptor, to the memory of the friend of England.

A statue placed before all men's eyes fixes the memory and encourages the hopes of others; the wing of an hospital, save to the immediate numbers receiving direct benefit from its use, soon loses the name of its founder. The edifice must be enormous indeed which wholly embalms a man's memory,—such a man as the Prince was; and people are convinced that no public building will wholly satisfy the newly awakened feeling of the world, which rushes with the more fulness in the channel of gratitude, from the conciousness that it has been a little negligent and dull of hearing when the voice was alive that spoke so kindly and well. Hospitals and great institutions are monuments rather than memorials, as has been well said, and familiar use makes them to be forgotten except by those benefited. How many amongst us know the name of the founder of St. Thomas's or St. Bartholomew's? Guy's has preserved the name of its founder, because of its romantic tale, and in no small degree from its own oddity of title; but even Guy's does not do what it was meant to do. It forms almost a solitary example of a turning from an original purpose to one not less, but even more, benevolent. The house for "incurables" of Dr. Guy has become one of the most magnificent, if not the most magnificent and fully blessing centre of medical help in Europe. The chances that any change of destination, such as the course of time must be expected to bring upon a similar institution erected to the memory of Prince Albert, should take a similar right direction, are too small—as innumerable examples sadly prove, wherein the fatherless and sick have been plundered—for us to desire that his memory should be committed solely to the charge of any such fortuity.

I have said that no public building will wholly satisfy the feeling of the people of England in this matter, and believe they will look to the national representatives to vote a sum for the erection of a statue on a grand scale, to commemorate him who served them so well. Let this be the national expression of Parliament; and as the three or four thousands of pounds such a purpose will demand are not of much moment, the general public form of gratitude may take any larger scope the flood of subscriptions may allow. It might well be the plan proposed by Mr. Cole, of completing an idea said to be much entertained by the Prince,—that of founding an Industrial University, the special object of which should be to grant degrees and honours in those particular sciences and arts which directly influence works of industry.

The schools of the Department of Science and Art, by granting certificates of competency to those trained therein, already exemplify a portion of this scheme; hence, I say, the proposition is to complete a noble project already commenced and in action, much attended to by the Prince, and in the working of which his loss will be sensibly felt for some time to come. With the details of the plan as proposed by Mr. Cole in his letter to Lord Granville I do not entirely agree; believing that the idea of granting degrees for the fine arts of painting, sculpture, architecture, and music, must be watched with great heedfulness, lest the whole plan be brought into contempt thereby. The "when combined with industrial application," the limit proposed for the practice of this portion of the scheme, is so vague that many will join me in fearing its futility. Consider how it could be defined. Grant a certificate for figure-drawing as the accomplishment most needful for an artist, and is it to be expected any body of examiners would give the same to a Turner? Unquestionably not; and so men of that sort would fly from the body, and their example would license a thousand empirics, and weaken the value of the scheme. The world has always a suspicion of such things. You can grant a degree in dentistry, because you can examine the claimant, and test him practically; but can you examine a painter upon the soul of his art? can you define its limits? or are you at once to say that painting *per se* is not an industrial occupation? The idea of the proposed University is a noble one, and was present in men's minds long before Prince Albert or Mr. Cole came into the world. Yet it may be well carried out to the Prince's honour if confined strictly in application to art manufactures, where definable and definite technical skill is required for the mere life of the thing to be produced; but in Art, which flies for its means of expression to form, to expression, to chiaroscuro, to ineffable colour or composition, one and all by turns, no test can be applied. The more successful the scheme might be in that part of its application, the more mischief it would do.

Either this or any other great scheme for education or for testing education would serve the purpose in view as well as or better than an hospital or an asylum. If an asylum was to be adopted a heedful thought might be given to that end for which Turner devoted so much of his savings. A little sign of gratitude for his great gift might be found under the greater payment to his royal contemporary, and the nation might so relieve itself of the shame of having taken the unhappy letter rather than the spirit of a great man's words. The Prince served the cause of the arts to the best of his ability, and some portions of the teeming gratitude of the country might fitly find expression, if an asylum be founded, in the realisation of an even grander scheme than "Turner's Gift" comprised.

We may take it for granted that the national gratitude will find expression in some kind of public monument, and it may be expedient to consider what kind is fittest to the occasion. We cannot boast of rocks like those Sesostris carved his own figure upon, and which the Chaldean king used again. "The Pyramids have forgotten the names of their founders;" and if we, following the ancient example of Britain, were to pile a mound of earth as large as Cissbury Hill, people might a few ages hence dispute about its meaning. The obelisk which lies in the mud of the Nile has been proposed for removal, as it inevitably is on any public occasion, but the public fails to see its appropriateness to commemorate an Anglo-German prince; and however beautiful the obeliscal form is, we believe our architects have not devoted sufficient attention to the study of the obelisk to enable them to produce, in a satisfactory manner, anything but a copy of the forms already known; and this, I believe, no one will desire, if the monument is to be characteristic and national. Neither can the obelisk be said to be popular amongst us. Even less popular are the monumental columns which have been employed, for such opposed reasons, in commemoration of Nelson and H.R.H. the Duke of York. A third will not be tolerated. Then comes the Greek or Roman temple form of manifestation, of which one or two examples have been but negatively fortunate. The Gothic Memorial Cross might be worth considering; and if Her Majesty determine upon a special and personal expression of her own feelings, the site at Charing Cross has a name and everlasting sympathies connected with the most apt and beautiful series of works dedicated by household love; and Victoria of England might repeat upon the same site, for Albert of Saxony, what Edward of England did for Eleanor of Castile. This form of monument seems almost sacred to religous or marital memories. The Scott monument at Edinburgh forms the only example, in our memories, of a diverse employment.

Putting aside works of utility, such as bridges, of which we can have enough as required, there seems no doubt but that a statue constitutes by far the best form of monument open to us. Few will hesitate to vote for an equestrian statue, for not only is that the noblest form, but, oddly enough, we have had fewer downright failures in equestrian statues than in statues on foot. The most luckless of these, Wyatt's "Duke," owes much of its grief to the position fate and some "board" have bestowed upon it. London offers many sites for the national statue. A most appropriate one is already filled, by the desire of the Queen that the space above the arcade in the Royal Horticultural Gardens, which was to have held her own statue, should hold that of the Prince himself. Moreover, fine as this site is, it were not public enough, if unappropriated. To a certain extent the placing this memorial at South Kensington supplies a want many must have recognised, *i.e.*, that something of the sort should appear in that suburb with which His Royal Highness was so much identified. Otherwise, the Kensington Road, immediately above the Gardens, would offer a noble site, visible in three directions as far as the eye can reach, close upon the site of the International Exhibition, and more open than any space could be found in front of the latter. By widening the road on either side, which readily could be done, any interruption of traffic by the erection of the statue on this site would be avoided. This would also be more public than the site suggested in Hyde Park where the great transept of the Exhibition Building stood, and near enough to commemorate that also. No sculptor would like to see his work—a work upon which so much time will needfully be spent—placed anywhere within hearing of the monstrous "Duke:" otherwise Hyde Park Corner is a grand site for a grand work. It is quite certain that statues are never more to be buried in gardens, so we may dismiss the idea of any "square" giving a habitation to the one contemplated. There is a noble space right in front of Buckingham Palace, at the head of the Mall, which, although dominated by the ridge of Piccadilly, is yet open enough, and has the sanction of the continental custom of placing royal statues in front of royal palaces. If this site be thought more royal than national, it is at any rate preferable to the summit of the Marble Arch, unless, indeed, the memorial takes the form of a chariot and horses, or a great group of many figures,—which, as portraiture seems essential under the circumstances, appears out of keeping with the occasion. The summits of triumphal arches are only fitting to the display of such groups from their very forms; and any attempt to repeat the monstrous folly at Hyde Park Corner will only constitute a second instance of barbarous ignorance and stupidity. Regent Circus seems unfit, and Waterloo Place has hardly room for a large work without interfering with the works already there, or which on a smaller scale might find standing room between the Guards' Monument and the York Column.

Anyone who has seen the effect of placing an equestrian statue within a quadrangle, of which Mr. Foley's Lord Hardinge, when exhibited at Burlington House, afforded a noble example, will agree that such is a favourable locality. I may name, amongst other sites, the very appropriate one of the front of the new buildings now in course of erection at South Kensington for the use of the Department of Science and Art. There was presented to Parliament along with the report on the South Kensington Museum, made the year before last, a perspective view and ground plan of certain works proposed by Captain Fowke for the use of this department. These embraced a crescent-shaped court-yard, bounded by a screen of columns on the north side, and thence opening into a quadrangle. It is understood that some such work as this is decided upon: at any rate, the departmental buildings now in course of erection are part of this plan. However the façade may be carried out, there must *be* a façade, and in front thereof ample room for the equestrian statue of the Prince, backed by buildings he himself contemplated, in a locality he may be said to have erected, amongst living interests and actions to whose furtherance he dedicated much of his life. Almost every other part of London has some associations not peculiar to the Prince's life and labours. Palace Yard, rather unfortunate in its present predicament, inclosing Baron Marochetti's bad statue, has legal or historical memories not to be disturbed. The Horse Guards is military; Charing Cross might do well,—and there is a vacant pedestal at the corner of Trafalgar Square; but then no one would like to see Prince Albert pendant to George IV.—that would be too hard upon his late majesty. I therefore offer three suggestions—the front of Buckingham Palace; Charing Cross; and the front of the new Museum at South Kensington—and advocate the last.

With respect to the nature of the statue, let us enter an earnest protest against anything in a Roman toga. Probably sculptors exist who would dare to put a man wearing such a garment upon a horse. Let us also exclude—feeling the world has got beyond the boyishness which loves these things only—the chlamys and the peplum, together with the military cloak, the cocked hat, the sword, and even the eternal scroll itself. Put the Prince on horseback, in the dress he wore amongst us, honestly and not conventionally treated. To do this the sculptor has a difficulty to overcome, and in overcoming it he will show his knowledge of his art. It may be done and has been done, and ought to be done again. To shirk the question of armour by indenting it upon a man's skin, according to the fashion of poor Richard Cœur de Lion, shows the weakness of an artist. To meet it boldly, like Verocchio did with the magnificent Bartolomeo Colleonni, shows the art and wins the victory. To shirk the question of modern costume, and show the muscles through a garment such as no human being ever showed or could show, may be a sad temptation to the sculptor bred upon the antique, and whose knowledge of art is limited to its classical developments; but the world says that the time has come when no further toleration shall be given to such trifling. The monument should be bronze, because that bears London air incomparably better than marble, and cannot be fractured.—I am, &c.

London, May 20th. 1862. F.G.S.

REVIEWS.

A Manual of Civil Engineering. By W. J. Macquorn Rankine, C.E., LL.D., F.R.S., &c.—London: Griffin, Bohn, & Co. 1862. [Second notice.]

We have already (*ante* p. 90) briefly noticed this work, and mentioned the general scope of each of the three parts into which it is divided, reserving for the present occasion the discussion of its details.

The First Part, treating of Field Work, is full and explicit. Instructions are given as to surveying with the chain and offsets, plotting surveys and measuring areas. The formulæ used in trigonometrical surveys are next set forth, including as much spherical trigonometry as is needed for great surveys, with some serviceable approximations for practice. The theodolite with its use and all the adjustments, the sextant, and other instruments, are clearly explained; as also all the details of triangulation, including the method followed in surveying mines.

A chapter is given to the spirit level, with its adjustments; the ordinary method of levelling; levelling by the theodolite, by the plane table, by the water level; and computing heights by the barometer, or by observing the boiling point. Besides the common directions, corrections for the curvature of the earth and atmospheric refraction are introduced, with instructions as to the distances at which such corrections become necessary or appreciable. Prof. Rankine's method of keeping the field-book is very precise, and in accordance with what is, we believe, usually taught in works on the subject; intermediate sights being entered twice, first as foresights, and then as backsights. Experience does not however lead us to recognise any practical advantage in this double entry, which, when the intermediate sights are numerous, gives a much greater mass of figures to cast up on completing the page. A good deal of ciphering is saved by entering nothing in the backsight column but actual backsights, except in the case of the last sight at the foot of a page being an intermediate sight, when it must of course be repeated as a backsight at the top of the following page. The foresights on "pivots" (as well as the last foresight in the page whether on a pivot or not), should be distinguished by inclosing them in cartouches. By adding these foresights only, and adding the figures in the backsight column, and subtracting one sum from the other, the reduction of the levels may be completely and easily checked.

In treating of Setting Out, our author gives, in addition to the more ordinary directions, instructions how to deal with the difficult cases that frequently arise. It is right to state that the elegant and ready method of setting out curves by the angle at the circumference, now so generally practised, seems to have been first published by Prof. Rankine, in 1843. Chapters on Marine Surveying, and on Copying and Reducing Plans, conclude the First Part of the volume.

The Second Part of the work is devoted to Materials and Structures, and in it the strength of materials and the principles and details of construction are explained very fully, and in a lucid and satisfactory manner. Resolution of forces, the theory of couples, the finding of centres of gravity in various cases, friction, and angles of repose, are in the first place discussed. Triangular and other framework, suspension chains, and arches of various forms, are next examined. After giving the general formulæ for the Parabola and for the Common Catenary, a comparison is made between the two curves by substituting an infinite converging series for the definite equation of the catenary. The following are the results:—

"The ordinate is supposed to be measured from a point at the distance m below the vertex.

Ordinate of the

$$\text{Catenary; } y=m\left(1+\frac{x^2}{2m^2}+\frac{x^4}{24m^4}+\frac{x^6}{720m^6}+\text{\&c.}\right)$$

$$\text{Parabola; } y=m\left(1+\frac{x^2}{2m^2}\right)$$

Slope of the

$$\text{Catenary; } \frac{dy}{dx}=\frac{x}{m}\left(1+\frac{x^2}{6m^2}+\frac{x^4}{120m^4},+\text{\&c.}\right)$$

$$\text{Parabola; } \frac{dy}{dx}=\frac{x}{m}$$

Area of the

$$\text{Catenary; } \int y\,dx=mx\left(1+\frac{x^2}{6m^2}+\frac{x^4}{120m^4}+\text{\&c.}\right)$$

$$\text{Parabola; } \int y\,dx=mx\left(1+\frac{x^2}{6m^2}\right)$$

Length of the

$$\text{Catenary; } s=x\left(1+\frac{x^2}{6m^2}+\frac{x^4}{120m^4}+\text{\&c.}\right)$$

$$\text{Parabola; } s=x\left(1+\frac{x^2}{6m^2}-\frac{x^4}{40m^4}+\text{\&c.}\right)$$

It is to be borne in mind that the quantity denoted by m in these formulæ is *double* of that denoted by m in Article 125.

The following table exemplifies their results for the case $x=m\div 3$:

	Ordinate $=m\times$		Slope.		Area $=mx\times$		Length $=x\times$
Catenary	1·0561	...	0·3395	...	1·0186	...	1·0186
Parabola	1·0556	...	0·3333	...	1·0185	...	1·0182
Difference ...	0·0005	...	0·0062	...	0·0001	...	0·0004

In the foregoing extract, m represents the modulus of the catenary or half the parameter of the parabola, representing in each curve the proportion between the horizontal tension and the horizontal rate of loading at the lowest point. The curves compared have therefore at the vertex the same ratio of tension to loading, and consequently the same curvature; and from this point of departure they begin to diverge very slowly, as is seen above. It may be interesting to compare these results with those where the span and rise is fixed, and the parabola and catenary determined accordingly. In such a case the curvatures at the vertex differ, and the two curves have three points in common. In another part of our present number an instance is given where the common rise is one-tenth of the common span, and the amount of the maximum difference is ascertained. This will be found very much smaller than that which separates the two curves, starting (as in the preceding extract) with a common curvature.*

The "Catenary of Uniform Strength" is also very close to the parabola, though not so close as the common catenary, which occupies an intermediate position between the two former curves.

The very useful principle of the Transformation of the figures of equilibrium of Frames or Chains by means of Parallel Projection is explained and applied. The transformation of the Catenary by proportionate reduction of ordinates, so as to obtain a curve for an arch, is an elegant instance, and also that of the distorted elliptic rib.

* In the investigation referred to the letter a is used, as is m, by Prof. Rankine to denote the modulus of the catenary.

The hydrostatic arch is analytically examined, and the following mechanical method of describing it is also given:—

"A mechanical mode of drawing a hydrostatic arch is based on the fact, that its figure is identical with one of the "elastic curves" or forms assumed by an uniformly stiff spring when bent.

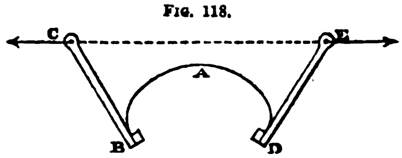
The accuracy of figure and uniformity of stiffness of a spring are to be ascertained by the two following tests:—

First, the spring when unstrained should be exactly straight.

Secondly, when bent into a hoop by pinching the two ends together, it should form an exact circle.

A spring A (Fig. 118), fulfilling these conditions, is to have its ends fixed to two bars at B and D, and the other ends of those bars, C and E, are to be pulled directly asunder. Then the straight line CE, in

Fig. 118.



which the forces so pulling the bars are exerted, will represent the upper surface of the loading material, and the spring A will assume the figure of the corresponding hydrostatic arch. Any proportion of rise to span can be obtained by varying the tension on the ends of the bars, and the proportion which their lengths bear to the length of the spring."

The mathematical principles of arches generally are fully discussed, not omitting the usual laborious tentative methods for determining the Points and Angles of Rupture.

On the Strength of Materials, the Transverse and Shearing Strains, Section, and Deflection of Beams, the process of designing them, and kindred topics, our author treats fully, and with his usual clearness and method.

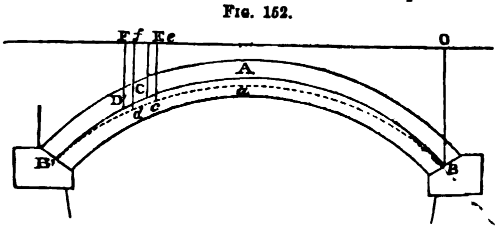
The complex question of the Arched Rib (or Arch Girder) is fairly encountered, and treated in a manner that shows a full appreciation of the nature of this delicate problem. The cognate problems of the Suspended Girder and the Tension Rib having been discussed at some length in this Journal, and the results of a rigorous analysis (though not all the steps) presented to our readers, we quote with interest the process which Prof. Rankine has followed in his independent investigation.

"180. *Strength and Stiffness of an Arched Rib under vertical loads.*

Fig. 152 represents an arched rib, springing from a pair of abutments, and supposed to be under a vertical load. Let B A C D B′ be a curve traversing the centres of gravity of all the cross-sections of the rib; this may be called the neutral curve; and it represents the figure of a "linear arch," or indefinitely thin rib, whose conditions of equilibrium are the same with those of the actual arch.

When a vertical load is distributed over the arch, agreeably to the conditions of equilibrium of the neutral curve, each particle of the arch

Fig. 152.



is compressed, in a direction parallel to a tangent at the nearest point of the neutral curve; and but for the circumstance to be stated presently, that compression would be uniform throughout each cross-section of the rib, so that the neutral curve would be the "line of resistance."

But the compression depresses the whole arch, so that the neutral curve assumes some new figure, such as B a c d B′, in which its curvature at each point differs from the original curvature; and hence, even under a load distributed as for an equilibrated or linear arch, there is a bending action combined with the direct compression. When the distribution of the load differs from that suited to the neutral curve as a linear arch, the bending action varies in its amount and distribution.

In either case the arch acts in the double capacity of a rib under direct compression, and a beam under a transverse load; and its strain and stress at each point are the resultants of the strains and stresses arising from the directly compressive action of the load, and from its bending action.

Problem First. General Case.—In solving problems which relate to this subject, it is in general most convenient to measure co-ordinates from a point such as O, in the same vertical line with one end B, of the neutral curve.

C being any point in the curve, let

x = O E be its horizontal distance from O;

y = E C its vertical depth below O;

Let l = B B′ be the span of the neutral curve, and k its rise.

Let w be the whole intensity of the vertical load, whether constant or variable, in lbs. per inch of horizontal distance, so that

$$\int_0^l w dx \text{ is the whole load on the arch.}$$

The load $w\,d\,x$ on each small portion of the arch may be conceived to consist of two parts,

$w_1\,d\,x$, producing direct compression alone, being distributed according to the laws of the equilibrium of a linear arch,—that is,

in such a manner that $w_1 = \mathrm{H}\dfrac{d^2y}{dx^2}$ (H being the still undetermined horizontal thrust of the arch), and

$$(w - w_1)dx = \left(w - \mathrm{H}\frac{d^2y}{dx^2}\right)dx \quad \ldots \quad \ldots \quad (1)$$

producing bending.

Having formed the preceding expression, by putting for w and $\dfrac{d^2y}{dx^2}$ their proper values, proceed as follows:—The vertical component of the shearing force at any point such as C is

$$\mathrm{F} = \mathrm{F}_0 - \int_0^x w dx + \mathrm{H}\left(\frac{dy}{dx} - \frac{dy_0}{dx_0}\right) \quad \ldots \quad \ldots \quad (2)$$

F_0 being the still undetermined vertical component of the shearing force at B, and $\dfrac{dy_0}{dx_0}$ the slope of the neutral curve at that point.

The bending moment at C is

$$\left.\begin{array}{c}\mathrm{M} = \mathrm{M}_0 + \int_0^x \mathrm{F} dx = \mathrm{M}_0 + \mathrm{F}_0 x - \int_0^x\int_0^x w dx^2 - \\ \mathrm{H}\left(y_0 - y + x\dfrac{dy_0}{dx_0}\right)\end{array}\right\} \quad \ldots \quad (3)$$

M_0 being the still undetermined bending moment at B.

The alteration of curvature produced in the neutral curve at C by the bending action is $-\mathrm{M} \div \mathrm{E\,I}$; the negative sign being prefixed to denote that downward curvature is to be considered as positive; and the alteration of slope is expressed as follows:—

$$i = \frac{dv}{dx} = i_0 - \int_0^x \frac{\mathrm{M}}{\mathrm{EI}} \sqrt{1 + \frac{dy^2}{dx^2}} \cdot dx \quad \ldots \quad (4)$$

i_0 being the still undetermined alteration of the slope at B.

The vertical deflection at C is expressed thus,—

$$v = \int_0^x i\,d\,x \quad \ldots \quad \ldots \quad \ldots \quad (5.)$$

The bending action of the load is thus expressed by the four equations, 2, 3, 4, 5, containing four indeterminate constants, H, F_0, M_0, i_0. If, in each of those equations, x be made $= l$, expressions are obtained applicable to the further end of the span, B′. These expressions may be denoted by F_1, M_1, i_1, v_1.

Let $d\,s = \mathrm{C\,D} = \sqrt{d\,x^2 + d\,y^2}$ denote the length of an indefinitely short arc of the neutral curve. That arc is not altered in length by the bending action of the load; but it is altered by the direct compression in the proportion given by the following equation:—

$$\frac{dt}{ds} = -\frac{\mathrm{H}\dfrac{ds}{dx}}{\mathrm{EA}} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

in which A denotes the sectional area of the rib at C, and the negative sign indicates compression.

To find the combined effect of the bending action and the compressive action on the figure of the neutral curve, proceed as follows:—

Let u denote the positive horizontal displacement of a point in it, such as C. For example, C D being the original position of an indefinitely short arc, and c d its altered position, let

$$\mathrm{O\,E} = x; \qquad \mathrm{O\,F} = x + d\,x;$$
$$\mathrm{E\,C} = y; \qquad \mathrm{F\,D} = y + d\,y;$$
$$\mathrm{C\,D} = d\,s;$$
$$\mathrm{O}\,e = x + u; \qquad \mathrm{O}\,f = x + u + d\,x + d\,u;$$
$$e\,c = y + v; \qquad f\,d = y + v + d\,y + d\,v;$$
$$c\,d = d\,s + d\,t.$$

Then from the two equations,

$$d\,s^2 = d\,x^2 + d\,y^2;$$
$$(d\,s + d\,t)^2 = (d\,x + d\,u)^2 + (d\,y + d\,v)^2;$$

The following is deduced:—

$$2\,ds\,.\,dt + dt^2 = 2\,dx\,.\,du + du^2 + 2\,dy \cdot dv + dv^2;$$

and from this the terms dt^2, du^2, dv^2, may be rejected, as inappreciably small compared with the other terms, reducing it to the following:—

$$ds \cdot dt = dx \cdot du + dy \cdot dv;$$

whence is obtained the following expression for the horizontal displacement of D relatively to C:—

$$du = \frac{ds}{dx}\,dt - \frac{dy}{dx}\,dv \;\ldots\quad\ldots\quad\ldots\quad (7)$$

For dt put its value according to equation 6, and make $\frac{ds^2}{dx^2} = 1 + \frac{dy^2}{dx^2}$ and $dv = i dx$; then

$$du = -\frac{\mathrm{H}}{\mathrm{EA}} \cdot \left(1 + \frac{dy^2}{dx^2}\right)^{\frac{3}{2}} dx - i\frac{dy}{dx}\,dx \quad\ldots\quad (7\mathrm{A})$$

which, being integrated, gives for the horizontal displacement of C relatively to B and in a direction away from it,

$$u = -\int_0^x \left\{ \frac{\mathrm{H}}{\mathrm{EA}} \left(1 + \frac{dy^2}{dx^2}\right)^{\frac{3}{2}} + i\,\frac{dy}{dx} \right\} dx \quad\ldots\quad (8)$$

an expression containing the same four indeterminate constants that have already been mentioned; and if x be made $= l$, there is obtained the alteration of the span B B′, which may be denoted by u_1.

If the abutments are absolutely immovable, $u_1 = 0$. If they yield, u_1 may be found by experiment. Hence, as a first equation of condition for finding the indeterminate constants, we have

$$u_1 = 0, \text{ or a given quantity} \quad\ldots\quad\ldots\quad (9)$$

A second equation of condition expresses the immobility in a vertical direction of B′, the further end of the rib, and is as follows:—

$$v_1 = 0 \quad\ldots\quad\ldots\quad\ldots\quad (10)$$

The ends of the arched rib are either fixed or not fixed in direction. In the former case, $i_0 = 0$; and in the latter, $\mathrm{M}_0 = 0$; so that in either case, the number of indeterminate constants is reduced to three. One more equation of condition is therefore required; and it is one or other of the following:—

If the ends are fixed in direction, $i_1 = 0 \quad\ldots\quad (11)$

If they are not fixed in direction, $\mathrm{M}_1 = 0 \quad\ldots\quad (11\,\mathrm{A})$

The values of the three constants being found by elimination from the three equations of condition, are to be introduced into the expressions for the moment of flexure (3) and the deflection (5), which will now become formulæ for calculation.

If thrust be treated as positive, and tension as negative, the greatest intensity of stress at any given cross-section is to be computed by the formula,

$$p_1 = \frac{\mathrm{H}\frac{ds}{dx}}{\mathrm{A}} \pm \frac{\mathrm{M}m'h}{\mathrm{I}} \quad\ldots\quad\ldots\quad\ldots\quad (12)$$

the positive or negative sign being used according as the moment M acts towards or from the edge of the rib under consideration, whose distance from the neutral curve is $m'\,h$.

From the expression 12 may be deduced the position of the point where the stress is greatest for a given arrangement of load, the arrangement of load which makes that stress an absolute maximum, and the corresponding value of the stress.

The vertical deviation of the line of resistance from the neutral curve at any point is given by the expression

$$\mathrm{M} \div \mathrm{H}; \quad\ldots\quad\ldots\quad\ldots\quad (13)$$

and its perpendicular or normal deviation by the expression

$$\mathrm{M} \div \mathrm{H}\frac{ds}{dx} \quad\ldots\quad\ldots\quad\ldots\quad (14)$$

and these deviations take place in the direction towards which M acts.

When the deflection is found by direct experiment, the following formula may be used to compute the greatest stress from it:—

$$p_1 = \frac{\mathrm{H}\,\frac{ds}{dx}}{\mathrm{A}} \pm \frac{4\mathrm{E}m'hv}{n''l^2} \quad\ldots\quad\ldots\quad\ldots\quad (15)$$

The preceding is a general method, applicable to all cases in which the load is vertical."

In the preceding extract we are glad to recognise the same principles that guided our own investigation—the only principles on which an accurate solution of either problem is possible.

If space permit we may be tempted to return to this volume, which contains a large mass of information well arranged, and bears the marks of digested study and original thought.

CHEMISTRY AS REPRESENTED IN THE INTERNATIONAL EXHIBITION, 1862.

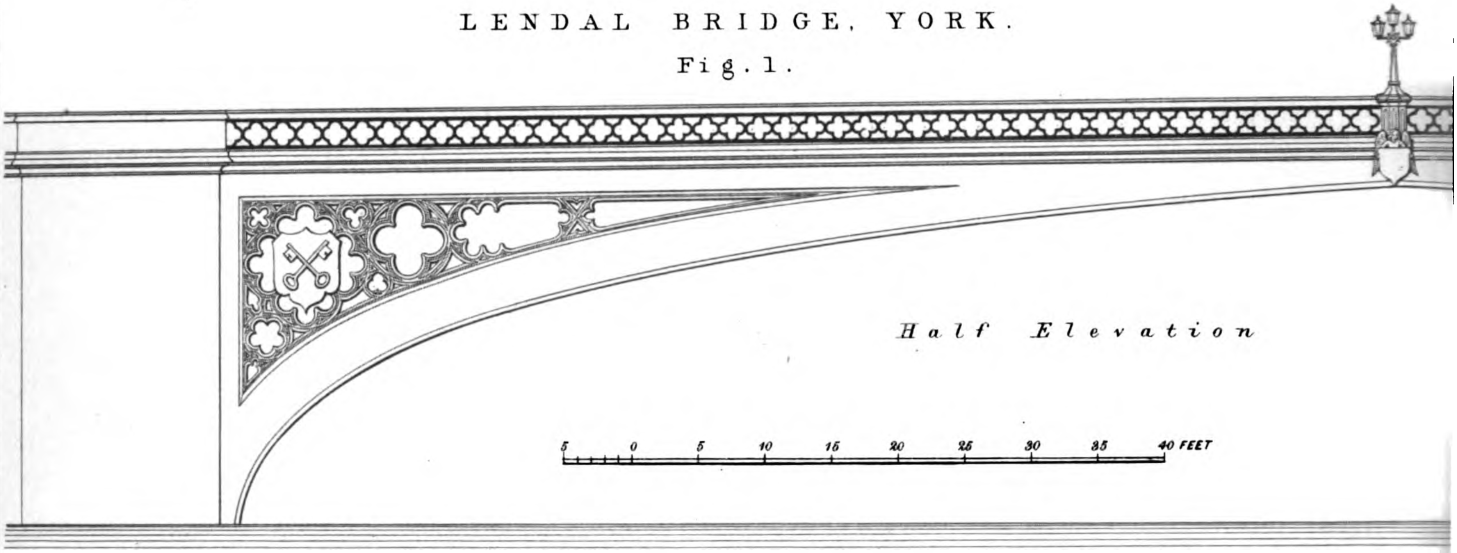
The great importance of this branch of science, viewed as an auxiliary to every other, beside its immense value when taken in the abstract, cannot but claim for it the notice of every journalist. We need not retrace our progress to a very far distant date in order to arrive at the period when our continental neighbours, more especially the French, produced unquestionably the finest chemical, as well as the purest pharmaceutical preparations of the day. Hot and strong has been the contest for the palm during each succeeding year since the Exhibition of 1851, and in fairness it must be admitted on all sides that we cannot yield our laurels to any other country, and may indeed say, without overtaxing our national modesty, that we carry the palm ourselves.

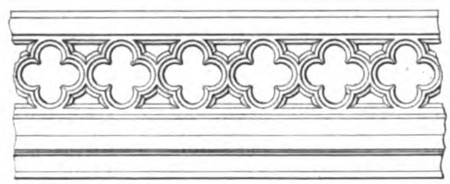
No legislative fiat can so thoroughly remove a nuisance arising from the exhalation of noxious vapours as the discovery of the fact, that such exhalations consist of products that may be collected to the advantage and profit of the parties in whose premises they are eliminated; and again, no sooner does a legislative interference compel our manufacturers to collect any deleterious product that has usually found its way into our streamlets and brooks, than the question is seriously discussed, how shall an utilization of these mischievous products lessen the expense to the manufacturers of the removal of the incubus; and often has chemistry found a use at a tempting price for such a debris, which debris has at last grown to be a commercial necessity, and taken its place in the important category of demand and supply. Indeed, the marvels that chemistry has wrought in the utilization of these objectionable and poisonous substances proves at every step of their development that nothing useless exists in creation, and that it largely rests with man to subdue and appropriate all elements to his service and the universal good of mankind. Architecture is, and will yet be more, largely indebted to the science of chemistry for the removal from the atmosphere of towns those destructive elements that are so fatal to architectural beauty. Certainly it might with an apparent show of justice be said that chemistry began the mischief, but we think the more correct judgment on the matter would be that the imperfect knowledge of that science, and the halting in the pathway of utilizing chemistry has caused this perversion of the facts of the case. The trophy in Class 2 is at once a support to our argument, the ammonia alum forming the principle mass in this trophy has for its alkaline constituent the ammoniacal products of the gas-works; and is it not a matter for deep regret that for so long a period this valuable alkali was set free to combine in noxious forms with other substances in our atmosphere, whilst we were collecting camels' dung in foreign climes for the manufacture of our chloride of ammonium and other forms of this highly volatile and useful substance. Not only is the science of chemistry proving itself in a high degree beneficial in removing causes of destruction to our buildings, but every age finds it rendering essential service in the improvement of the materials of building construction. Our wood is now preserved most effectually,—our iron has reached an almost incredible degree of perfection in its manufacture, in its tensile strength, and indeed in all its other characteristics. Our cements are obtainable of extraordinary fineness and durability. Our lime is more carefully chosen in its material, and more skilfully prepared. Our bricks, whether containing more or less silica or alumina, are compounded, manufactured and burned so as to insure a much greater crushing resistance, compactness, and durability, than ever they before attained. And stone, that paradox, being at one and the same time the emblem of strength and durability, whilst before our eyes it displays the greatest amount of perishability,—may now be impregnated with a material nothing more or less than glass, (technically termed silicate of alumina); which, from sound reasoning, may have been, the means adopted of hardening many of those almost imperishable records of the ancients; and nothing is more likely than that the discovery of this extraordinary substance, and its peculiar manipulative advantages, will lead to the successful adoption of an external decoration in stereochromy, so long deemed a desideratum.

Having thus introduced the branch of science so completely represented in Class 2, we hastily note a few of the objects and productions most worthy of attention, though it cannot be expected but that we must from our limited space omit mention of many objects exceedingly worthy of a most careful investiga-

LENDAL BRIDGE, YORK.

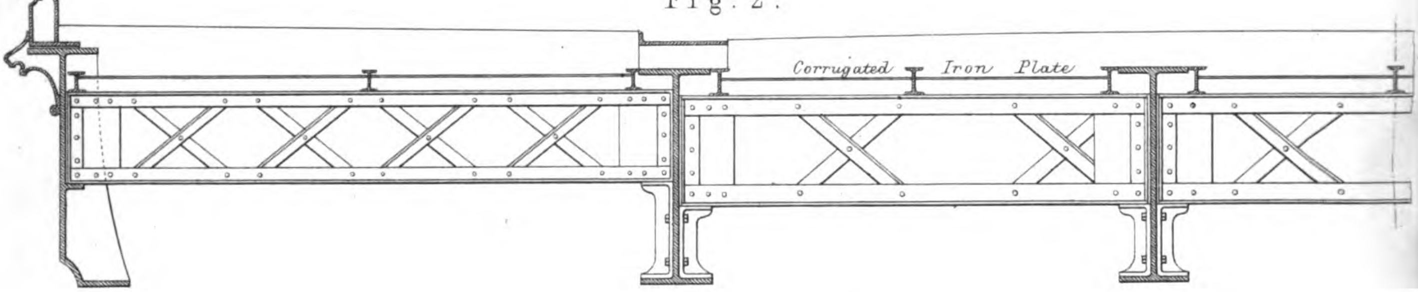
Fig. 1.





Part of open Parapet Enlarged

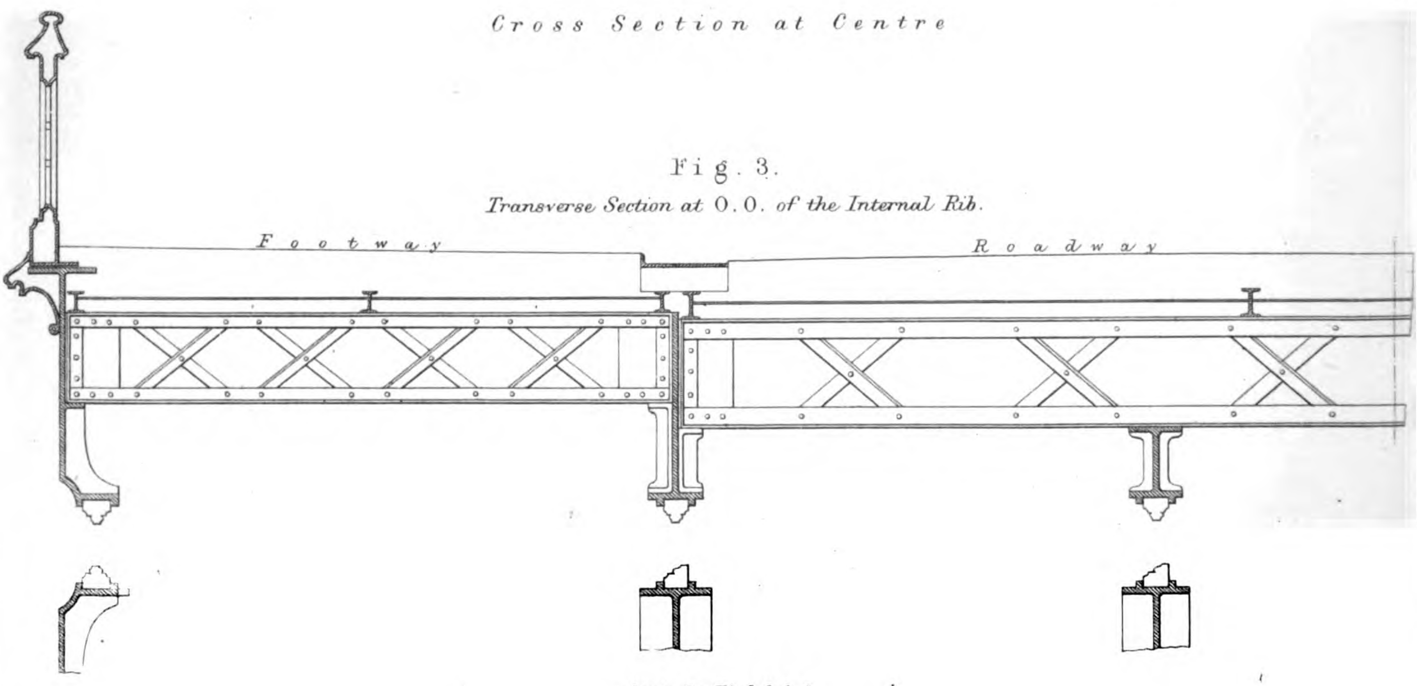
Fig. 2.



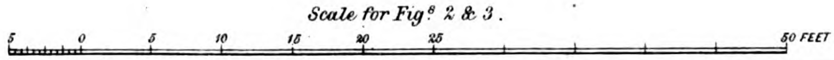
Cross Section at Centre

Fig. 3.

Transverse Section at O. O. of the Internal Rib.



Scale for Figs 2 & 3.



June 1862

J.R.Jobbins

LENDAL BRIDGE, YORK.

Half Elevation of Internal Rib and Details.

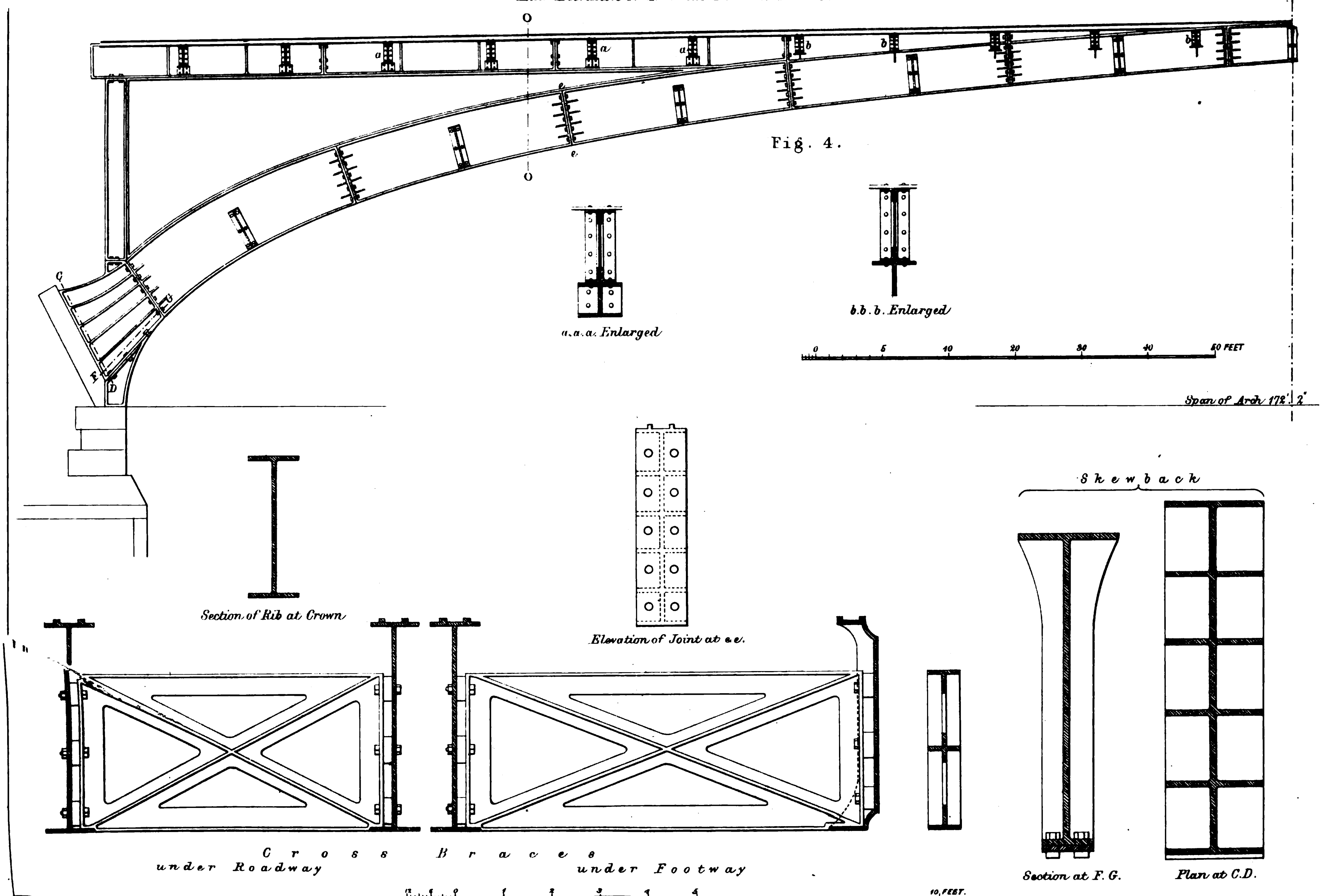


Fig. 4.

J. R. Jobbins

tion. We have introduced the trophy, but much finer specimens are to be seen in the class, of the most of its constituents; we mention, therefore, only the latest arrival, that of the new substance Thallium, belonging, we suppose, to the class forming a link between the metallic and mineral kingdoms. This substance has been discovered by the aid of the spectrum analysis of Mr. Crookes. The soda alkalies are superbly represented in all the beauty of their crystalline forms by our manufacturers, and certainly are unmatched for their great purity and lowness of price. The sulphates of copper and iron are also exceedingly fine; and our valuable and beautiful product, ferro and ferrid cyanide of potassium, which give birth to so many useful, beautiful, and even deadly poisonous productions, are to be seen in all their magnificence as the production of the Hurlet and Campin Alum Company; and the bi-chomate of potash, parent of all our chromes, and sister of our brilliant magenta, is shown in very fine crystals.

All the before-mentioned strike the visitor at once from their size; but of course the acetate of rosaline, the queen of the coal tar products, is one of the most novel, as well as one of the most charming, productions in the class: in fact, we have in it a chamelion crystal, which in solution forms the magenta colour. If we dip a feather therein we have all the gorgeous effect seen in the plumage of birds of tropical climes. The crowns exhibited by Messrs. Simpson, Maule and Co. we are informed, were crystalised in a bath of material no less than £1500 in value. We must not forget however that Mr. Perkins was the first to discover the application of aniline to the process of dyeing. Under that able chemist, Dr. Hoffmann, he learned the properties of the aniline, and from him also the fact of its being obtainable from coal tar. A valuable mass of aniline, as also its product, are to be seen in Mr. Perkins' case in the Exhibition, whose mauve and purple have suggested the substitution of other re-agents for bi-chromate of potash; bi-chloride of mercury, producing magenta; bi-bromide of tin, fuschiacine; nitric acid, ozaleine; arsenic acid, purple and reds; bi-oxide of lead, roseine; manganese salts, pinks and reds. Such results, then, has chemistry produced from oil of tar, and we must not forget that analine is but one of eleven bases obtained from that noxious substance.

Aluminium is exhibited in bulk by Bell Brothers, of Newcastle, who also exhibit fine specimens of sodium, the novelty of which consists in its introduction into the market at an extraordinarily low price, placing it in the category of available metals. We have also a new production (of which we have before spoken), by Bartlett Brothers, of Camden-town, consisting of specimens of silicate of alumina, produced from the union of silica and alumina in an alkaline menstruum. Here we have solved the grand question, with regard to the silicates, how shall they be rendered insoluble and yet applied in a liquid state. This discovery reveals the fact that such combination of silica with alumina remains in a liquid form for a certain and controllable length of time, and then the re-agent alumina, combines with the silica, forming a glassy product insoluble in hot or cold water, or even in dilute acids. These results are all exhibited, with the application of the solution to stone for the purposes of its preservation, as also to powdered waste stone, showing its power of combining those materials without heat; these manufacturers also exhibit fine specimens of the silicates and aluminates of soda and potash.

Oxalic acid from sawdust is exhibited by Robert Dale and Co. Rumney has liberally prepared specimens of the new dyes, and their application to fabrics since 1851. All the dyes—indigo, lichen, madder, garancine, meurexide, are well represented by both scientific men and manufacturers. The fine and rare chemicals are of course most interesting to the professional man, but there is much to admire in the collection of iodides and iodine products, lithia and nickel salts. Messrs. Hopkin and Williams have some exceedingly fine preparations in both chemical and pharmaceutical products. Starch is exhibited of exceedingly fine quality, by the large firms so well known as producers of this article. The Pharmaceutical Society have a splendid collection of drugs (in a case displaying most excellent taste); Haubury, Dickinson, Watts, Usher, Holland, and Brastick are not behindhand in the same products. Artists' colourmen of long standing and renown have shown a spirit of emulation worthy of the object to which they have devoted their energies, and their complete success is apparent in the contents of their several cases, and the unique arrangement of their dazzling products. M'Farlane and Co. exhibit a fine mass of crystals of codeine, said to be worth £200. Mr. F. O. Ward shows in his case exponents of his proposed mode of extracting potash from the mineral felspar, which contains a large percentage of pure alkali. This product will never revolutionise the alkali manufacture so long as the present sources hold good, but when they fail it is by no means a bad idea that the rocks and hills shall supply the desiderata. A mode of separating woollen from vegetable fibre is also illustrated by the same exhibitor; wool succumbing to heat sooner than cotton; the one is destroyed by superheated steam, whilst the other is manufactured into paper. The preparations from opium are exceedingly fine, with other preparations and products, revealing an amount of progress of an almost incalculable extent in the interval between 1851 and the present time.

Nor should we leave this class, with its important exponents of this invaluable science, without a word on the energy and care displayed by the superintendent, Mr. Charles Quin, and his assistant, Mr. Thomas, who, under great disadvantges attendant on the annexe in a structural point of view, and its having been a gangway for heavy goods until the latest moment, have reduced what at at one time appeared to be a perfectly unmanageable mass, to a court of order, displaying no small amount of taste in its arragement.

LENDAL BRIDGE, YORK.

(*With Engravings.*)

In this Journal for June last descriptions and drawings were given of the bridge then being erected at York. The disaster which attended the placing of the large road-girders, and which caused the whole of the ironwork of the bridge to fall into the river, will be in the recollection of our readers. The cause of that accident is even now a disputed point; the engineer was not in any way responsible in the matter, as it devolved upon the contractors to place the girders in position.

The complete wreck caused by this disaster, leaving only the abutments uninjured, afforded an opportunity for the reconsideration of the general design of the bridge; and it was eventually determined, by the Corporation of York, to adopt a more ornamental design.

Under these circumstances, Mr. Page, C.E., was asked to furnish drawings, and the result is the erection of the bridge now in progress; illustrations of which accompany this notice.

The design consists of a Tudor arch of cast-iron, 175 feet span, 25 feet rise, shown in Plates 13 and 14, where Fig. 1 represents a half elevation of the bridge: Fig. 2 a transverse section at the centre: Fig. 3 a transverse section of bridge at 0, 0, on internal rib: and Fig. 4 a half longitudinal section of bridge, showing one of the internal ribs, with details. The spandrils are filled with open Gothic tracery, the principal openings being charged with shields bearing the arms of the see of York. The interior spandrils are filled with an iron-plate pierced to correspond in pattern with the external Gothic spandrils. The parapet consists of quatrefoil openings. The springing-line of the new bridge is at the ordinary summer level of the river. The six longitudinal ribs are entirely of cast-iron, and are 3 feet deep at the crown, increasing towards the abutments. These ribs are stiffened by cross-beams varying in depth from 2 ft. 10 in. at the crown to 3 ft. 9 in. as they approach the abutments. A bed has been cut in the brickwork for the reception of the skew-backs against which the ribs abut; the skew-backs resting upon granite slabs 18 inches thick.

A covering of corrugated plates rests upon the bottom flange of iron-joints, placed longitudinally upon the transverse girders; the corrugated plates for the carriage-way are $\frac{3}{8}$-inch thick, and for the footway $\frac{1}{4}$-inch thick.

The carriage-way is formed of a layer of concrete 3 inches thick, consisting of cork and bitumen, placed immediately upon the corrugated plates; upon this is a layer of concrete, formed of Portland cement and gravel; and upon the latter is placed the granite paving. The footpaths consist of a layer of concrete 6 inches thick, covered with 3 inch York paving.

The uninjured abutments are retained, with the addition of concrete backing to provide for the thrust brought upon them by the substitution of an arch for a girder.

The estimated quantities for the new bridge are—

	Tons.	Cwt.	Qr.
Cast-iron	239	0	0
Wrought-iron	69	1	1
	308	1	1
Roadway	224	15	0
	532	16	1

The contract for the provision and erection of the cast-iron is £3426. The bridge is being erected under the superintendence of Mr. Page, C.E. Messrs. Hawks, Crawshaw, and Sons, of Gateshead, are the contractors.

THE MIDDLE LEVEL SLUICE.

TWENTY years have elapsed since the low-lying flats of the Middle Level have been exposed to so formidable an invasion of their old enemy as was heralded by the blowing up of the great sluice on the 4th of last month. Won by the slow and persistent efforts of many generations from the ancient dominion of the waters, the meres and fens, which were once the debateable district of the tides of the German Ocean and the rivers carrying the water-shed of six counties, have gradually been converted into some of the finest arable and grazing lands of England.*

The partial and isolated works of the churchmen holding the higher lands had prior to the Reformation reclaimed considerable districts. But it was reserved to the skill and enterprise of a Dutch engineer (Sir Cornelius Vermuyden) to devise and carry out, under the auspices of the Earls of Bedford, a comprehensive scheme for draining the entire level. This work, successively encouraged by James I. and Charles I., and interrupted by local prejudice and discontent (fomented at the outbreak of the Great Civil War), was completed under the Commonwealth. The main feature of the plan was the cutting a straight drain (the Old Bedford River) from Earith to Denver, carrying the waters of both Ouzes, the Cam, and three other rivers, towards Lynn Harbour, and discharging them at Denver through a self-acting sluice constructed to exclude the flood tide. Much however yet remained to be done before the whole of the district could be effectually reclaimed and secured from the occasional floods of the inland waters, for which the outfall provided was inadequate, and which had to be in great measure kept under by pumping by windmill.

Subsequently it was found that Lynn Harbour was being silted up, which was attributed to the stoppage of the tidal water by Denver sluice; and in the midst of contentions on this subject Denver sluice blew up in 1713, and was not again constructed until 1748-50.

The conflict of local interests appears to have afterwards so interfered with the proper conduct and maintenance of the drainage, that when the late Mr. Rennie was called in, about fifty years ago, some districts of the Fens were fast relapsing into their old condition. Mr. Rennie's plan was a grand and simple one. He devised a system of intercepting catch-water drains to carry off the upland waters, and straight cuts for the outfall of those of the bottom level. But only one part of the scheme was then adopted, viz., the construction (commenced in 1817) of the Eau Brink Cut, by which the outfall of the Ouze near Lynn was shortened by two miles, and an extra fall of not less than five and a half feet during the ebb consequently obtained at St. German's. Thus the discharge of the inland waters of the Middle and South levels was for the first time effected with anything like adequacy. Nothing further was done for twenty years, when the disastrous floods of 1841 again compelled immediate action. Mr. Walker was consulted, and a portion of his scheme carried out. This consisted in the construction of the Middle Level Drain (or Walker's Cut), by which the waters flowing successively through the channel of the Old Nene above Ramsey Mere, the Forty Foot Cut to Chatteris, and the Sixteen Foot Cut towards Well Creek, were carried direct into the Ouze. They were discharged into this stream at St. German's (about three miles above Lynn) by the Middle Level Sluice, which has so recently been destroyed, and which was constructed in 1847.

This sluice was built in three arches, each of 20 feet span, with self-acting tidal valves of oak. The masonry was substantial, and the wing walls of ample size. The whole was ultimately supported on piling driven deep, the cill of the sluice being fixed at 6 feet below the low-water mark at "Free Bridge," to allow for the gradual deepening of the bed of the Ouze.

How far the present misfortune is attributable to the treacherous nature of the bottom, how far to the lowering of the bed of the Ouze, or whether it may in any degree have been accelerated by the deepening of the Middle Level Drain, which was effected in 1857, it would be perhaps premature to inquire. Several leading engineers have visited the spot, some of whom have been consulted; and it cannot be doubted that a matter so full of interest and instruction in this important department of professional science will be fully and competently discussed. A gap, at first sight trifling, inside the eastern bank of the drain, which was soon made good with clay, was followed in a few weeks by a settlement of the whole bank. Great exertions were made to stop the leak which ensued; but, notwithstanding all that could be done, the backing of the south-eastern wing was sapped; and at about 10 P.M. on Sunday, 4th of May, the eastern wings and the two adjacent arches suddenly fell over, allowing the tide in the Ouze (which had then from 10 to 15 feet head) to rush over the ruins into the Middle Level Drain. Fortunately this occurred at neap tides, or the flood might have overflowed the banks of the drain and laid the levels under water without the inhabitants having any warning or time to save their property. The danger more immediately to be apprehended was the giving way of the banks of the drain under the great pressure of the tidal stream rushing in through a gap, which had increased on the Monday to a width of 120 feet, with a depth of 20 feet, and meeting the inland waters.

An attempt was made to dam the outfall at a point higher up the stream by means of bags of clay, some clay being even used without bags, and of course washed away immediately, and some sunk in lighters, of which the fate may be readily guessed. This work, after going on for about a week, was abandoned, and all vestiges of the dam went to sea.

On the morning of Monday the 12th of May, the rising tide effected a breach in the west bank of the drain. This was promptly made good by piling sacks of earth, with clay between.

At the same time a second breach occurred, also in the west bank, and about a mile higher up. It is deeply to be regretted that this was neglected, and nothing attempted in the way of stemming the tide, which flowed in a torrent down the bank, and laid the adjacent country under water. The breach increased with each returning tide; and on Wednesday, the 14th, measured upwards of 70 yards in length; and Marshland Fen, Broad Fen, and parts of the neighbouring fens, comprising several thousand acres, were already drowned by the salt water.

The attempt to form an earth dam having been for the time abandoned, it was decided to pile on both sides of St. Mary's Bridge (about half a mile above the junction with the Ouze); taking advantage of the bridge as a platform for placing the pile engines, and filling in the space between the two rows of piles, so as to form a dam as thick as the bridge was broad.

This very feasible plan appears to have failed mainly through the want of a sufficient number of pile engines to carry forward the work with the necessary despatch. Mr. James Walker's remarks on this matter at the Court of Sewers at Lynn (reported in a well-informed local paper*) were so practical, and so fully borne out by the event, that we quote them.

"Mr. JAS. WALKER said that having had a little experience at that sort of work, he saw that they had been working from last Sunday week (4th May) until now (14th *id.*) at one dam. They had now abandoned that dam and it had all gone to sea; and being down at the work yesterday, he saw they had four pile engines to drive these piles. Instead of those four they wanted twenty or thirty. If pile engines had been set as thick as they could be upon that bridge, each engine driving a pile an hour, would not have more than five piles to drive to complete that dam. That would have done something. But everybody knew that as you began to curtail the water it went more sharply; and with these four engines (and if doubled to eight or ten it would have the same effect,) it would scour down; and before to-morrow night that bridge would be in the river with the other. Nothing on earth could stop it, but speed. If they wished to stop it they had better leave these engines standing still (because every pile they drove would do damage), and get twenty or thirty engines before they struck one blow. In five hours then the dam could be stopped.

Mr. BAGGE asked whether that bridge would stand the thumping of twelve of those engines at the same time.

* Those who wish to study the interesting history of the Great Level may refer to Well's 'History of the Bedford Level.' Elstobb's 'Historical Account of the Great Level of the Fens.' Baderlade's 'History of King's Lynn'; and Smiles' 'Lives of the Engineers.'

* 'The Lynn Advertiser.'

Mr. WALKER said it would.

Mr. JACKSON was afraid they could hardly work together. The space was so confined.

Mr. WALKER said he had gone on it, and measured it with his eye. He would put the engines as thick as they could stand, and have the whole working together, and the bridge underneath filled with bags of clay. He would be bound it would then stand a 15 feet tide on one side. There might be some soakage, but that would be trifling. There was no other way than that in which it could possibly be done. Throwing earth in and sinking boats was like nothing. Piling was the only thing, and the bridge was the platform for it."

On the following morning (15th May) the piling at St. Mary's Bridge was carried away as predicted, and with it the pile-engines, and the platform of the bridge itself. Northerly winds had caused a high flood-tide (although some tides past the springs), and the drifting of a barge which had broken loose against the outer (or down-stream) row of piles occasioned the complete destruction of the whole.

The efforts to form a barrier aginst the tide were, however, not relaxed. The Commissioners of the Middle Level Drainage gave Mr. Hawkshaw full authority for carrying out the necessary works. And although at first some time appears to have been unavoidably consumed in collecting a proper staff and suitable materials, that gentleman reported to the Commissioners on the 20th May that everything that human agency could do in the matter was being done. The original earth-dam was being pushed forward as fast as possible, having due regard to its security; and to guard against the contingency of its failure a cofferdam was being constructed below St. Mary's Bridge. It is to be hoped that these preparations will prove effectual in stemming the coming spring tides, so as to avert the danger of a more extensive inundation from the sea, and enable the making up of the great gap in the west bank of the drain to be undertaken with a reasonable prospect of success.

At the same time it is impossible to forget that when the tide shall have been successfully excluded, the principal work will yet remain to be undertaken. Such an emergency as the present allows barely time for the construction of a "dead" dam, which will of course keep in the inland waters as effectually as it keeps out the flood tide. There will consequently be a stoppage of the drainage of 150,000 acres in the Middle Level until the reconstruction of a tidal sluice for the outfall, or the provision of sufficient engine-power to throw out the water. At such a juncture, the benefit of a catch-water system would have proved incalculable; as the upland drainage, being intercepted, might have been discharged by a separate outlet, instead of swelling the mass of waters behind the dam. There can be little doubt that Mr. Rennie's plan, if carried out in its integrity, would have afforded the best safeguard against the dangers that now threaten the district. The construction of the Middle Level Drain effected a marked improvement in the drainage, and most of the pumping engines were accordingly removed. But the security since entertained has after all proved deceptive, on account of the main drainage of the entire district depending on a single outlet.

Protection of Inventions at the International Exhibition 1862.—An act of Parliament has been recently passed for the protection of inventions and designs exhibited at the International Exhibition 1862, to be known as "*The Protection of Inventions and Designs Amendment Act*, 1862," by which it is enacted that "the exhibition of any new invention at the said International Exhibition shall not, nor shall the publication, during the period of the holding of such exhibition, of any description of such invention, nor shall the user of such invention, under the direction of the said commissioners, prejudice the right of any person to register provisionally such invention, or invalidate any letters patent that may be granted for such invention." It is further provided for the protection of designs that "the exhibition at the International Exhibition of any new design capable of being registered provisionally under the Designs Act, 1850, or of any article to which such design is applied, shall not, nor shall the publication during the period of the holding of such Exhibition of any description of such design, prejudice the right of any person to register provisionally or otherwise such design, or invalidate any provisional or other registration that may be granted for such design."

The Chapter House, Westminster Abbey.—We are glad to be able to state that effort is about to be made for the purpose of restoring the ancient Chapter House at Westminster. An influential meeting, convened by the Dean and Chapter, was held within the building on the 24th ult., Lord Ashburton presiding. Mr. G. G. Scott pointed out the features of the building. He said that he found the building had been finished in the year 1253. At that period this was the finest specimen of octagonal chapter-houses. That of Lincoln was as large, but not so good; that of Salisbury built twenty years later. Its size was the same as those of Lincoln and Salisbury. The windows were of stained glass, and the roof vaulted, with a central column of Purbeck marble still remaining. He had occupied several months in tracing out the whole of the building, and from that investigation he thought it possible to restore every portion of the design with the most perfect certainty. The only window which had been thoroughly destroyed was that over the doorway, which must have been of a different design. The decorations with which the walls had been covered were in the most beautiful style of art. The paintings were not quite coeval with the building, being painted in the beginning of the fourteenth century—half a century later than the building itself. There was nothing in this country equal to those that remained, and they were nearly, if not fully, as fine as the Italian paintings of the same period. The first represented Our Lord, as if after the crucifixion, surrounded by angels. The side compartments were entirely composed of groups of angels, there being one large figure in each group, on the feathers of whose wings were inscribed the principal virtues. Those happily remained perfect. The floor presented the very finest specimen of encaustic tiles. The exact sections of the ribs of the vaults were discoverable, so that the whole of the structure and the size of the windows were a matter of certainty, and, though in a mutilated form, there were all the paintings and decorations. The following resolutions were passed:—"That this meeting views with regret the ruinous condition of a building so rich in historical interest and in architectural beauty as the Chapter-house at Westminster." "That this meeting is impressed with the desirableness of bringing the question of the restoration of the Chapter-house under the consideration of Her Majesty's Government." A committee consisting of the Duke of Buccleuch, Lord Ashburton, Lord Stratford de Redcliffe, Bishop of Oxford, Lord Taunton, Lord Stanhope, Mr. Monckton Milnes, M.P., Mr. Akroyd, Mr. Dasent, Mr. Tite, M.P., Mr. Reeve, Mr. Beresford Hope, Mr. Cochrane, M.P., Mr. Sala, and the Dean of Westminster, was then appointed "to wait upon the Chancellor of the Exchequer, and otherwise to promote the object of the meeting."

Drainage and Paving of Odessa.—Mr. George Furness, the contractor for the great outfall works at Plaistow in connection with the Metropolitan Railway, has contracted to pave and drain Odessa. The cost is estimated at £800,000. The contract was negotiated by Mr. Bayliss, C.E.

Single Shaft Collieries.—A return to the House of Commons recently published contains copies of the replies of the inspectors of mines to a circular letter, addressed to them by the Home Secretary, on the subject of shafts. The reply of Mr. Dickinson, dated from Manchester, on the 28th of February last, embraces information respecting the single or bratticed shafts at seventeen collieries and mines in the Manchester district. In point of numbers, the single-shaft collieries form a small percentage of the whole. There are at work in this district 348 pumping and winding shafts, 6 entrances by engine planes, 66 entrances by levels, 198 air and ladder pits, and 46 shafts which are being sunk, making a total of 664 openings from the surface at present in use. Deducting from these the 16 single or bratticed shafts, and the 46 sinking shafts, making 62 together, there remain 602 entrances which are not single or bratticed. The production of coal in the district is at the rate of 6,379,500 tons per annum, of which 6,280,500 tons are steam and house coal, and 99,000 tons cannel coal. Of this total quantity about 240,000 tons per annum are raised from the single or bratticed shafts. Mr. Dickinson stated his opinion that it must be enacted, first, that every coal and iron-stone working should in future be provided with proper means of egress for persons, by two distinct shafts or outlets, separated from each other by a secure division of natural strata; secondly, that in case of any working previously in operation, which was not so provided with two distinct outlets, the working might be continued, provided the means were being carried on with due diligence to make the second outlet; thirdly, that for the purpose of exploring or proving ground, or connecting two or more distinct means of egress, or working a small tract of coal or ironstone, a single or bratticed entrance might be used, provided that not more than ten persons should be allowed to be below ground at the same time; and, fourthly, that after the 31st December, 1862, every winding pit or shaft, worked by steam or water-power, should be provided with a proper self-acting fence at the top.

CLASSIFIED LIST OF PATENTS SEALED IN MAY 1862.

2918 Thomas, L.—Improved wrought-iron ordnance—November 20
2908 Brooman, R. A.—Fire-arms, breech loading (com.)—November 9
2780 Love, J. B.—Armour plates for vessels—November 5
2884 Hay, W. J.—Improvement in coating ships, &c.—November 12
2788 Ramsell, W.—Improvement in construction of boats—November 6
2895 Rogers, M.D.—Improved cable stopper—November 18

2776 Hayes, C. F.—Improved apparatus for generating steam—November 5
2778 Brooman, R. A.—Improved apparatus for generating steam—(com.)—November 5
2794 Williamson, A. W.—Improvement in steam boilers—November 7
3209 Allchin, W. L. and W.—Improvements in superheating steam—December 21
2940 Henry, W.—Improvement in steam-engines—(com.)—November 22
2979 Standfield, J.—Steam governors—November 27
2772 Wilson, R.—Steam hammers—November 5
2886 Stewart, D.—Hydraulic steam cotton presses—November 16
2928 Newton, W. E.—Rotary engine—(com.)—November 21
2797 Schwarts, T.—Air engines—November 7
3270 Newton, W. E.—Obtaining power from explosive compounds—(com.)—Dec. 31

225 Ridder, G. J. N, D.—Railway carriages—January 28, 1862
2817 Fisher, J.—Railway signals—November 9
3222 Vickers, I. E.—Railway engine wheels—December 24
2836 Davidson, J.—Railway communicators—November 12
3227 Birkbeck, G. H.—Railway brakes, &c. (com.)—December 24
3000 Rowan, J. N.—Railway wheels—November 28
240 Newton, W. E.—Railway axle boxes (com.)—January 29, 1862

151 Knight, J. A.—Permanent way (com.)—January 21, 1862

2931 Jarrow, A. F.—Locomotives for common roads—November 22
2811 Cowan, D.—Pneumatic railway or tubes—November 9
2933 De Clercq, R.—Apparatus for supplying water to boilers—November 22
2898 Prodon, M. G.—Rolling metals—November 18

2883 Goodall, J. C.—Machinery for folding envelopes—November 16
2946 Johnson, J. H.—Toothed wheels (com.)—November 23
3029 Burrows, J.—Drums and Pullies—December 3
3164 Newton, A. V.—Hoisting apparatus (com.)—December 17
668 Latham, W. H. and F. C. W.—Paper cutting machine—March 12, 1862
667 Latham, W. H. and F. C. W.—Ticket numbering machine—March 12, 1862
2814 McNair, R.—Casings for stitching machines—November 9
2958 Willcox, J.—Sewing machines (com.)—November 25
2970 Sellers, W.—Sewing machines (com.)—November 26
3269 Bailey, W. H.—Sewing machines (com.)—December 31
2888 Else, J.—Washing machines—November 16
829 Loft, J. T.—Machinery for covering wire &c.—March 25, 1862
2981 Dumarchay, F. F.—Crushing machine—November 27

2813 Simpson, G.—Boring apparatus for mining &c.—November 9
2902 Hemingway, J.—Working coal mines—November 19
2977 Donnisthorp, G. E.—Working coal mines—November 26
2975 Firth, W.—Working coal mines—November 26
2875 Nixon, J.—Ventilating mines—November 15
2787 Prince, A.—Furnace for zinc ores (com)—November 6
275 Daehne, F. W.—Manufacture of zinc, and furnace for ditto—February 1, 1862
309 Smith, E. F.—Manufacture of coke—February 5, 1862
2845 Henry, M.—Composition for treating iron and steel (com.)—November 12
2827 Stewart, D. G.—Manufacture of cast-iron pipes—November 11
3271 Newton, W. E.—Boring apparatus (com.)—December 31

2758 Jarrow, A. F.—Steam cultivators—November 2
2884 Gibson, M.—Mowing Machines—November 16
2854 Procter, T.—Straw stackers—November 13
475 Bousfield, G. T.—Hay elevator—(com.)—February 22, 1862
2989 Newton, A.V.—Mowing machines—November 27
2896 Brooman, R. A.—Reaping machines—(com.)—November 18
598 Hensman, W.—Steam ploughs—March 5
2948 Bray, W.—Agricultural locomotives—November 23
2957 Burgess, W.—Reaping machines—November 25

2798 Gibson, H. G.—Apparatus for drying grain, hops, &c.—(com.)—November 17
2960 Johnson, J. H.—Apparatus for cleaning grain, hops, &c.—(com.)—November 25

2816 Hague, S.—Manufacture of hoes, adzes, &c.—November 9
567 Kendall, J. B.—Horse shoes—March 1, 1862

2763 Spencer, T.—Earthenware pipes—November 2

2830 Shedlock, J. J.—Gas meters—November 11
571 Bowen, H.—Gas meters—March 1, 1862
727 Clark, W.—Water-meters—March 17, 1862

2847 Kemp, E. C.—Gas-fittings, glasses, &c.—November 13

3078 Varley, C. F.—Electric telegraphs—December 9
2991 Clark, W.—Electric telegraphs—(com.)—November 27

2742 Higgins, J.—Preparing cotton—November 1
2757 French, J.—Spinning machines—November 2
2792 Walmsley, J.—Looms for weaving—November 7
99 Marshall, J. G.—Preparation of flax and hemp—January 18, 1862
2777 Fetchney, R.—Spinning machines—November 5
2848 Hodgkinson, J.—Preparing cotton for spinning—November 13
355 Lyall W.—Machinery for preparing flax—February 11, 1862
2809 Byrne. J.—Scutching machines—November 8
2847 Collingwood, T. B., and Butterworth, A.—Spinning machines—November 13
2882 Chambers, J. B. L. W. and Chambers, J.—Looms for weaving—November 16
2894 Paeton, F. C.—Apparatus for finishing fabrics—(com.)—Nov. 18
752 Tongue, W.—Preparing flax and other materials—March 18, 1862
2980 Calvert, F. A.—Carding machine—November 27
3037 Stead, I.—Spinning machines—December 4
685 Ermen, G.—Cotton spinning—March 18, 1862
2955 Ronald, J.—Spinning machines—November 25
2995 Rowan, W.—Scutching machines—November 27
3181 Bourne, I.—Cotton gin—(com.)—Dec. 19

111 Marshall, J. G.—Producing fibre from woven fabrics—January 14

2775 Hall, W.—Manufacture of lace—November 5
2779 Bowra, E.—Manufacture of elastic fabrics—November 5
2799 Hancock, J.—Manufacture of looped fabrics—November 7
2899 Nundella, A. J.—Manufacture of looped fabrics—November 18
2883 Crosby, C. O.—Manufacture of pointed trimmings—November 11
882 Wilson, J.—Hotpressing plaids, &c.—March 26, 1862

2726 Bassano, E. D., Brudenne, A.—Manufacture of stearine—October 30
2754 Wilson, J. C.—Manufacture of sugar—November 2
2844 Duval, L. F. and Beaudit, L. A.—New process of tanning—November 12
3127 Beaulieu, E. C.—Distilling spirits &c.—December 13
3142 Beaulieu, E. C. B. D.—Extracting gold dust from auriferous sands—Dec. 14
2801 Barrow, J.—Manufacture of Benzole, naptha, napthaline, &c.—November 7
2819 Brooman, R. A.—Obtaining alkaline phosphates (com.)—November 9
587 Standen, B.—Utilising manures—March 4, 1862
2893 Richard, J. P.—Artificial fuel—November 16
395 Valentin, W. G.—Coking coal—February 13, 1862
2901 Smith, L. and M.—Brewing—November 19
2903 Redwood, I.—Manufacture of starch—November 19
2861 Bird, H.—Bottles for holding poisons—November 13
583 Bunning, H.—Anti-friction grease—March 3, 1862
2789 Schroder, F. H.—Improvements in evaporating—November 6
2783 Orth, H.—An improved soap—November 5
66 Tatum, J. H. and Williams, W. J.—Manufacture of candles—January 9, 1862
2917 Puls, F.—Treating fatty and oily matters—November 20
35 Pochin, H. D.—Rosin, soap, and size—January 4, 1862
2964 Cowan, P.—Manufacture of animal charcoal—November 25
2994 Henry, M.—Manufacture of soap (com.)—November 27
3112 Mennons, M. A. F.—Manufacture of sugar (com.)—December 12
2944 Weems, J.—Plating metals—November 23
722 Avery, J.—Purifying coal (com.)—March 15, 1862
3002 Spence P.—Treatment of ores with sulphuric acid—November 28
3257 Newton, W. E.—Manufacture of sugar (com.)—December 30

2770 Weston, W. T.—Spring or door fastener—November 4
2862 Carter, A. E.—Screw cocks—November 13
3006 Pitt, B.—Cocks or valves—November 26
2869 Wyzell, M.—Nails and screws—November 14
357 Johnson, J. H.—Smoothing irons (com.)—February 11, 1862
405 Avery, W.—Manufacture of nails, screws, and rivets—February 15, 1862
509 Imray, J.—Hinges—February 25, 1862
2969 Harcourt, R.—Knobs and door handles—November 26
537 Fangye, J.—Hydraulic lifting jacks—February 27, 1862
2915 Croxford, J. C.—Door fastenings—November 20
844 Greenway, W.—Door fastenings—March 27, 1862

603 Newton, W. E.—Improvement in manufacture of pulp for paper (com.)—March 5, 1862.
2950 De Wylde, F.—Improvement in paper making machinery—November 22

528 Bruzand, E. G.—Pianofortes—February 26, 1862
2887 Warton, R, T.—Pianofortes—November 16
3026 Anderson, R.—Pianoforte cases.

2752 Brooks, J. S.—Braces—November 2
2759 Osborne, S.—Hooped skirts—November 2
206 Carpenter, S.A.—Crinoline—January 27, 1862
2857 Wilson, C. E.—An article of wearing apparel for ladies—November 13
2935 Cole, S., Davenport, T. W.—Composition for buttons, &c—November 27
2923 Jeff, J. H.—Collars, cuffs, fronts, &c.—November 21
2870 Heath, R.—Umbrellas and parasols—November 14

2990 Clarke, W.—Fastenings of purses, bags, &c.—(com.)—November 27
2909 Schloss, J.—Pouches—November 19

3008 Carle, L. H. C. J.—Billiard score—November 29
2972 Stevens, C.—Manufacture of ink—(com.)—November 26

2860 Brooman, R. A.—Photographic albums—(com.)—November 13
3080 Mennons, M. A. F.—Microscopic photographs—(com.)—December 9
2924 Polyblank, G. H.—New method for preserving photographic prints, &c.—Nov. 21

2952 Hulard, J. B.—Hardening plaster, &c.—November 25
2119 Peyton, E.—Manufacture of bedsteads—November 20
396 Whitfield, S. B.—Manufacture of bedsteads—February 14, 1862
2938 Peyton, E.—Manufacture of bedsteads—November 22
2825 O'Reilly, F.—Tailors' work-benches—Nov. 9

2916 Bayliss, W. P.—Apparatus for extinguishing fires.—November 20
3135 Newton, A. V.—Fire escape—(com.)—December 13
2963 Clarke, G.—Fire escape—November 25
2835 Bellis, R.—Improved method of laying wood floors—November 12
2859 Coney, F.—Stock for brooms—November 13

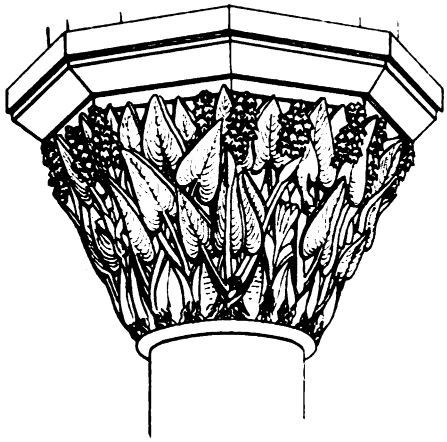
2891 Hawkins, J.—Horses' bits—November 18
380 Hewitt, W. Rein holders—February 13
2885 D'Estangue, E.—Dental instrument—November 16
3034 Newton, W. E.—Improvement in artificial teeth—December 3
2976 Johnson, J. H.—Surgical bandages—(com.)—November 26
2865 Fricker, H. R.—Improvement in cleansing sewers, &c.—November 13
2876 Spratt, J.—Improvement in preparation of food for animals—November 15

910 Henry, M.—Furnace for iron ore—(com.)—April 1, 1862

NOTICES TO CORRESPONDENTS.

Sir JOHN RENNIE's letter did not reach us in time for publication in the present number; but will appear next month.

1



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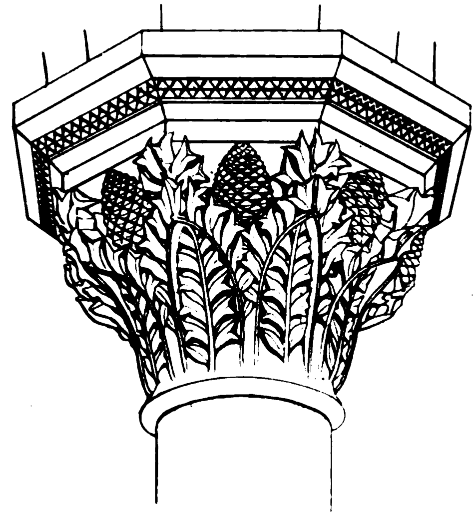

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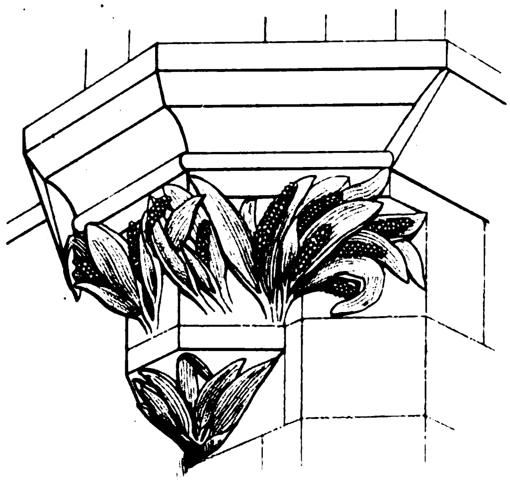

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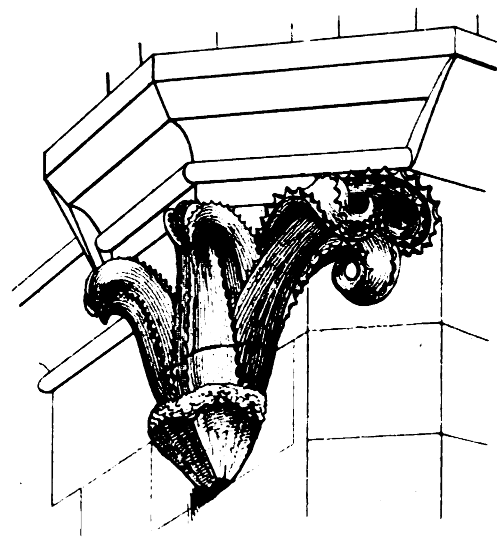

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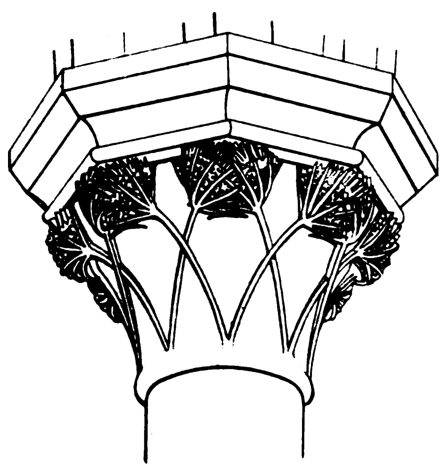

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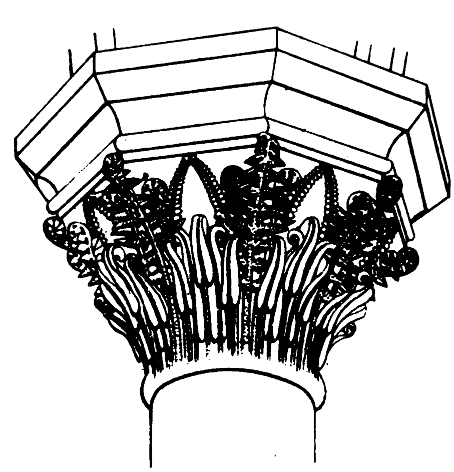

CAPITALS AND CORBELS, FROM THE NEW MUSEUM, OXFORD.

July 1862

J.R. Jobbins

CARVING FROM THE NEW MUSEUM, OXFORD.

(With Engravings.)

The accompanying illustrations exhibit several capitals and corbels selected from those which support the arches of the cloisters inclosing the glazed central court of the New Museum at Oxford. A want had been long felt in the University of Oxford for a building to contain science schools, laboratories, theatres, and accommodation for the Ashmolean museum, the geological and mineralogical collections, the apparatus of the Reader in Experimental Philosophy, and other objects which had been very inadequately housed. The result of the effort made to meet this want was the erection of the New Oxford Museum, under the superintendence of the late Benjamin Woodward, of the firm of Sir J. Deane and Woodward, of Dublin, architects of the Dublin Museum. The opportunity was taken advantage of to attempt the introduction of a then novel style of architecture—the Lombardo-Gothic—into this country. The attempt was nobly carried out and highly successful, and not only has the style become popular, but the example has been largely copied in one at least of our great provincial buildings. The carvings before us are interesting not only on account of their beauty, but from the fact that in them we have the native production of the highly-skilled artisan, who, working almost independently of the architect, has produced from his own love of nature, works which in some respects will bear comparison with the finest mediæval carvings similarly derived, and in no way are inferior, except in the conventionalising character which results from a severely restrained course of study bound to the development of architectonic sculpture, rather than what we are accustomed to style sculpture *per se*. It is imperative in all perfect work, as we see not alone in the Gothic, but the Grecian and even the coarser Roman schools, that decoration should not be imitative, but, having a functional purpose as connected with the architecture, that it should partake of the character of that art which is abstracted from and representative of principles, rather than direct and positive in the reproduction of forms. A large number of these carvings are now completed. They are the work of a family of Irish descent named O'Shea, and of Edward Whelan, their relative. If modern buildings are to be decorated on sound principles and with perfect beauty, the carvers must be obtained from among such able artisans as love their work well enough to devote their mental energies to it, and who scorn copying the template or the pattern of the decorator.

FRENCH ENGINEERING AND BUILDING IN THE INTERNATIONAL EXHIBITION, 1862.

To an engineer or an architect the collection in Class 10, exhibited in the French Court, will be one of the most interesting portions of the International collection: it comprises a certain amount of building materials and contrivances, though in this department it is perhaps inferior to what might have been expected, but it makes up for any deficiency in this respect by a superb collection of models, plans, and photographs of the most interesting engineering works in France, collected by the efforts of the Minister of Agriculture, Commerce, and Public Works, and indeed for the most part exhibited by the government.

A descriptive catalogue has been prepared for this collection, and contains admirable condensed accounts of the works illustrated by the objects in the Exhibition. Some of these accounts we may lay before our readers on a future occasion; and indeed they are all so well drawn up, and the subjects of them are all so worthy of notice, that in selecting one or two for mention we must do so almost at random, preferring, perhaps, some of the less prominent objects, as being those which a visitor might be more likely to overlook.

In a compartment looking on to the nave the models in question are arranged, the most conspicuous objects being two models—one of large size—of catadioptric apparatus for lighthouses, which may serve to indicate the locality of the collection. There are ten sections in the catalogue, and appropriated as follows:—roads and bridges, hydraulic works (irrigation), river works, canals, marine works (breakwaters, docks, &c.), lighthouses, railway works, mines, works connected with the city of Paris, and miscellaneous articles. Under the last head, miscellaneous, we may notice easing the centres of bridges by means of sand, which has the merit of extreme simplicity and certainty, and of doing the work at much less expense than where large screws are employed, and much more steadily and evenly than when wedges are used. The sand is placed in small open wrought-iron cylinders—the putting together of which is, by the bye, worth looking at, on account of its simplicity—of about a foot diameter and the same height. Each of these cylinders has four lateral openings, each of ¾ of an inch in diameter, 1 inch from its base, which are secured by wooden plugs. The cylinders, being filled about ¾ of their height with sand, are placed on solid timber bearings, and cylindrical uprights of wood, which fit loosely into them, carry the whole superstructure of the centre.

Should it be anticipated that the centres thus supported will have to remain up a long time, the joint between each cylinder and the upright timber resting on the sand within it, is protected by a rendering of cement to keep the sand dry.

Whenever the centres have to be eased the stoppers are withdrawn, and the sand is allowed to flow out through the orifices, or, if caked, is released by a hook and by tapping the side of the cylinder; the flow (the orifice being kept clear) is uniform, and the descent of the centres is equally uniform and gradual, and perfectly under control. The first bridge where this contrivance was employed was the Pont d'Austerlitz, in 1854, by M. Bouziat. Since that period it has been repeatedly used, and with uniform success.

Another object exhibited is the published account of the general levelling of France, contained in a large folio volume. This consists of a very detailed and exact survey of the whole of France for the purpose of ascertaining the levels, and of establishing permanent bench-marks, which can be referred to at any time. As this system was intended to be available for public use in drainage, irrigation, and other public works, very great accuracy and very great detail was necessary; and the volume before us contains accounts of the precautions taken, specimens of the mode of entering, verifying, and comparing the observations, representations of the instruments, and the bench-marks used, and a map of the main base lines, as well as a table of results.

The metallic bench-marks were fixed at distances of one kilometre apart along all the base lines, and the differences of level were determined by measurements executed along these lines. Each of these differences of level was determined *at least* six times, three operations being taken in one direction and three in the opposite—there being two surveyors at each level, one to take the readings, and another to enter them. Should any discrepancy appear between these six operations, the line is gone over again by independent surveyors till the error is detected.

It is believed that the levels thus taken, and which have already been carried over upwards of 5000 miles, are exact within *three centimetres* (or 1·18 inches). The precautions by which this extraordinary amount of precision has been secured are worth observing. The most important, in addition to the repeated measurements already referred to, were the following:—

Any line of whatever length in which a discrepancy of more than two inches appeared was measured afresh by a different staff of surveyors.

No surveyor was allowed to take the levels of any line which is connected at either extremity to another line already levelled by him.

The readings as entered are transmitted daily by post to the central office, and the levels are there calculated and entered. The results of the calculations are in no instance transmitted to the surveyors.

The method of keeping and tabulating the entries and working out the results is most complete: it is shown in detail, and must have contributed not a little to insure accuracy. Lastly, the work being paid for by the different communes, payment is only made after the portions of work in each commune have been so far completed that their exact accuracy can be tested.

It only remains to add that the whole scheme, down to the construction of the instruments and bench-marks, is arranged by M. Bourdelone, and superintended by M. Breton.

To refer only to one other portfolio, we may draw attention to the one showing by drawings and photographs the Bois de Boulogne near Paris, the beautiful scenery of the place being well given in the photographs; while the picturesque lodges, gates, and other architectural works are illustrated partly by the same means, and partly by numerous drawings of that exquisite finish in which the French so much excel.

In the same folio may be found two photographic views of a paving-stone quarry at Marcoussis, belonging to the city of Paris. The working of this quarry has been altogether remodelled since it came into the hands of the municipality; and one photograph represents the confusion and waste incident to working entirely by hand; while the second shows the regularity introduced by the employment of a large and very peculiar iron-traveller, with a steam ram for splitting the rock, and every appliance for the removal of the *débris* and the quarried stone. There is a model of the traveller exhibited; and while it strikes an English eye as unnecessarily complicated and too highly finished, it also reminds us of the great probability that in an English quarry of the same size no such appliance at all would have been introduced. When however we state that, notwithstanding all the extra expense inseparable from a first attempt, the saving can be shown to be nearly 20 per cent. upon the cost of working on the old method, we have said enough to induce those interested in quarries to look for themselves at the model, and read the description of it.

These specimens are all, as we before observed, among the least prominent out of more than fifty models or objects included in the descriptive catalogue. The more prominent include the famous Cherbourg breakwater; the Kehl, Bordeaux, Fribourg, and other viaducts; the port of Marseilles, basins, graving docks; geological and other maps; a section of the Artesian well at Passy; a map of the water supply of Paris (and a collection of articles connected with that supply); and a survey of the whole of the vast labyrinth of excavations under Paris, which includes the celebrated catacombs. Some of these objects will be described in a future notice.

Turning now to the exhibited building materials and contrivances, the most important are unquestionably objects of metal work. Monduit and Bechet exhibit photographs of the Flèche of Notre Dame—a work the progress and completion of which we have already referred to in our notices of Foreign Works and Publications—and send several specimens of its ornamental features, including two colossal statues, one in beaten copper and a second in beaten lead. These are extremely good, and as illustrating perhaps the most important modern work in metal executed or proposed, are interesting. The same firm also exhibits crestings, finials, and other ornaments, and the facility with which lead can be wrought into the forms desirable for such purposes is abundantly illustrated by these objects. It is to be regretted that our own metal-workers do not more frequently resort to leadwork.

Ornamental work in zinc and other similar metals is exhibited abundantly; some of the specimens are very good, especially those of Michelet. Iron-castings intended for external ornamentation are also shown in considerable numbers by Barbedienne, and some others. They are not however what would be considered here in uniform good taste, although some of them are ornamental enough.

Of fire-proof construction little or nothing seems to be exhibited, although the French now make constant use of various forms of wrought-iron joist, with tile filling-in, a construction which we should have desired to see fully illustrated here; some specimens may, however, be seen by the curious in the adjoining South Kensington Museum. A few excellent fire-bricks are exhibited; but the perforated bricks, flooring and roofing tiles and drain tiles are far inferior to the specimens sent by the best English makers.

Here are also a few specimens of stone and marble, one of the most remarkable being a specimen of marble from a quarry in the Jura, employed in Paris for the balustrade of one or two new bridges; and possibly available for some such purposes in this country. Some, but not all or nearly all, of the fine marble of the Pyrennees are exhibited, and a few specimens of artificial stones and marbles, objects which the French manufacture well, can be contrasted with them. A specimen or two of béton, some applications of asphalte to pipes, sheet-lead and lead in pipes, stoves, calorifères, and a large close cooking-range, are among the miscellaneous objects of this part of the collection.

It may not be passing altogether out of the province of this notice to draw attention to the magnificent exhibition of photography in the gallery over the French court. As belonging to an art auxiliary in many ways to architecture, sculpture, and even engineering, the objects exhibited here would deserve notice, both for their size and their beauty; and among the portfolios and on the walls will be found so many buildings, both ancient and modern, that the visitor will find himself well repaid for his trouble in seeking out and examining this collection.

FOREIGN PUBLICATIONS.

The *Encyclopédie d'Architecture* for the early months of this year contains an interesting and beautifully-executed series of illustrations of the Mediæval buildings at Pisa, accompanied by an essay, in which the history and the peculiarities of those buildings is treated at some length. This series is still in hand, and will render the volume of the Encyclopédie for the present year an attractive one. From the May number of this journal we learn that a new system of teaching drawing—that of Madame Cavé—is being experimentally adopted in some of the French schools. The peculiarities of the system is that the student, whether working from the round or the flat, is made to draw three copies of each object. In the first instance he is allowed the use of a tracing from the original, which he may from time to time lay over his drawing so as to see the errors he has made, and correct them. A very accurate copy having been by this time made, the student is next required to make a copy from memory only; and lastly, the original is again placed before him, the tracing being however withheld, and he is required for the third time to make a copy. The system seems thorough, and would deserve a trial from those engaged in teaching drawing in this country; though great care must be necessary to prevent its becoming wearisome to the students.

Palais, Châteaux, Hotels, et Maisons de France (Sauvageot).—This book, now in course of publication in parts, treats of an architecture for which France is particularly famous—the domestic architecture of the 15th, 16th, 17th and 18th centuries, the choice of examples being limited to the period embraced by them. To some in this country the work would be of little interest or value; but there are many who admire, and some who practice, the styles of French Renaissance. To such persons a collection of good examples will be welcome; and the specimens, so far as the work has proceeded, seem well selected, and drawn and engraved with all the accuracy, delicacy, and completeness which are so characteristic of French architectural publications. This book, which has been now going on for some months, is not unreasonable in price; and the illustrations and descriptive text belonging to each building will be made complete in themselves and sold separately.

From *Nouvelles Annales de la Construction* we learn that the Emperor of the French has sanctioned a project for the introduction into Paris of water from the springs of the Dhuis. This proposal has been much canvassed, and it is only after a long inquiry that it has been adopted. The estimated expense is 18 millions of francs, or about £720,000 sterling; and the time allowed for the completion of the works is five years. The May number of this very practical journal contains a long and comprehensive account of the manufacture of paper, together with plans of a paper-mill, and a statement of the cost of the building.

ARCHITECTURE AT THE ROYAL ACADEMY.

(Concluded from page 158.)

Notwithstanding the prevalent revival of Gothic features, as applied to modern domestic architecture, it has not gained as yet such a hold as to thoroughly displace a predilection for that old-fashioned though not so ancient a phase of art, which, founded on classic principles, flourished in the days of Elizabeth and James I. A large proportion of the mansions which are dotted about the country were either built or enlarged about this period, and it is consequently not to be wondered at that a lingering *prestige* should attach to edifices of this class, and that, even in the present day, new ones should arise more or less faithful to such precedents, and, it must in the general way be confessed, more or less successful in proportion to such adherence, or the contrary. There is however one kind of Jacobœan Classic to which we can never reconcile our ideas of correct taste, although it was much in favour a century or more ago, when that skilful architect, the Earl of Burlington, led the public to admire fanciful rustications in place of genuine ornament, and absurdly rusticated columns (as they are called) as a substitute for the noble simplicity of orthodox examples. There is such a real perversion of true principles in all this, that we are persuaded that it can only be a desire to produce a comparative novelty that nowadays prompts the occasional resuscitation of such anomalies. Several of the exhibited designs for buildings, important in size at least, are inoculated with this fancy, and will be readily perceived without further allusion on our part; others, contented with pursuing the more legitimate path, are deserving of individual mention.

We may specify, for instance, (871) "Pinnington Hall, Cheshire," by Mr. E. A. Heffer, which appears to be of the strictly Palladian school, but is hung too high up for critical examination. (849) "Stowlangtoft Hall, Suffolk," is another building, of a plainer kind, and more in the modern Italian style. It depends for its good effect mainly on the cleverly-disposed outline of its plan, and the well-studied arrangement of its windows, which in themselves are of the most unpretending character. In Professor Kerr's "Design for the Palais de Justice at Brussels" (876), prepared for last year's competition, there is a lavish profusion of columnar display, for the most part coupled, and in orders above orders;—very similar in idea, if we mistake not, to his design for the Government Offices in 1857. In the centre of the façade rises the verisimilitude of the tambour and dome of St. Paul's Cathedral, into the subsidiary details of which are engrafted sundry gleanings from St. Peter's. Probably in this category, too, may be included Captain Fowkes' "Industrial Museum of Scotland" (892), which, if not so large as the now notorious building from the same hands at South Kensington, appears nevertheless to be of gigantic proportions; and if not so uncompromisingly ugly as its sister, has little to recommend it on the score of either well-developed proportions, or sound architectural skill.

While referring to this subject we may also call attention to the scheme submitted by Mr. Godfrey Sykes, and shown in (902) as a sketch for decorating the panels of the permanent buildings for the International Exhibition with wall mosaics. It is proposed to fill these panels with figure-groups in this material, the subjects of course to be varied, and to bear allusion to the purposes of the building. Thus, in the portion shown in the drawing we have illustrations of iron-forging, agriculture, and sugar-planting; while in each of the spandrils between the architraves of the large arches is a circular panel, enriched with shields containing the arms of various countries, cities, and corporations. In point of colour these sketches show a predominance of blue, which though an excellent decorative medium internally, should be used more sparingly for outside work. The cost of such a mode of enrichment would necessarily be enormous, and far beyond what the intrinsic merits of the building could claim; but even this does not appear to be all that is contemplated, for we observe that "the completion of other parts of the exterior, according to the Italian practice, is left until sufficient funds are provided." The "City and County Bank, Worcester" (911), now nearly completed from the designs of Mr. E. W. Elmslie, is shown only by an interior view of the principal apartment, whose chief architectural feature is the arcade all round, springing from Roman Doric columns, and which is treated in the ordinary manner, without any attempt at design or novelty, so far as we can perceive. This observation would not apply to the exterior, which really proves an acquisition to the street architecture of Worcester. The "Interior of the Hall at High Clere Castle," shown by Mr. T. Allom in (916), is an artistic composition, if we regard only the general effect. A closer scrutiny betrays manifold questionable details, although the style of the leading features—that of the florid Gothic—admits of considerable latitude, as we are aware.

The "Memorial to William Tyndale" (859), proposed to be erected at Nibley, Gloucestershire, though unassuming in design, has common sense to recommend it. It consists simply of a square tower, battering in its height, and banded at frequent intervals with a different coloured stone. It is finished with a low roof, hipped on all sides. The design for the "Banstead Schools," submitted by Mr. G. Somers Clarke, is a very poor specimen of domestic Gothic, and, such as it is, is not made the most of in the drawing. There is a straining at originality in the groupings of the windows, which happens to turn out unfortunately, and exception may be taken to many similar things interspersed throughout the elevation. Mr. J. L. Pearson has two charming little drawings. One (864), the interior of a new church which he has erected at Scarborough, near Beverley, is quite a gem in its way. Though by no means ornate, there is enough enrichment to render it as a whole highly effective. Much of this is due to a dog-tooth ornament which is introduced on each side of the curved principals of the roof, as well as by the perforated wing-braces which are carried from the wall-plate to the underside of the lower purlin. Nor must we omit to refer to the elegant shafted corbels of marble which support these roof principals, and to the nicely-proportioned triplet at the east end of the chancel, with a sexfoil window over. The other (880) presents an exterior view of another church near Beverley—Dalton-Holme—which is in the Decorated style, and particularly noticeable for its well-studied tower and spire.

Mr. G. Godwin shows a bird's-eye view of a bailiff's house, with stabling, &c., as erected by him at Stanley Farm, Somersetshire (865). In a subject like this, any attempt at architectural pretension would have been out of place, and there is consequently little for the eye to rest on, especially in the absence of any key-plan to the arrangements. The question of covering the merchants' area of the Royal Exchange, which was mooted some time since, would seem to be, for the present at least, in abeyance. Several of the competitors' designs have been previously exhibited, and now Mr. Sang, in (866), displays his "first prize design," which it must be confessed makes the best of a thankless scheme. The covering is entirely of glass, fixed in a light framework adapted to architectural forms, and transversely in section consisting of a lower and a higher or secondary curve, with a flat surface continued extending over the centre, the monotony of which is relieved by devices at intervals in coloured glass—an ingenious application under such circumstances, but one which might be expected to produce a satisfactory result.

The mention of Mr. S. S. Teulon's name is quite sufficient to prepare one for seeing some curious achievement, in the way of novelty at any rate. But novelty is not to be sought at any risk; and redundance of ornamentation, however good in itself, is not conducive to beauty,—far from it. How much less worthy then is that fertility of mere whim which can claim little else than this facility! Yet under this ban we are forced to include many of Mr. Teulon's productions. Not but that there has been occasionally, of late, a more pruning hand exercised, by which such designs are proportionately benefited. We are, therefore, inclined to look more favourably on his "Water-tower, and engineer's residence at Elvetham Park" (867), which is decidedly a picturesque as well as original composition; almost wholly of red brick, but deteriorated in effect by the over-elaborateness of the patterns which cover the lofty slated roofs. "St. Katherine's Church," lately built for the Marchioness of Ailesbury, by Mr. T. H. Wyatt (868), is a memorial church to her mother, and is modelled on the same architect's well-known church at Wilton, so far as the Byzantine style and a few features are concerned; but the mass, as a whole, looks cumbrous and ill-proportioned, and sadly needs a tower, to impart some amount of character. Mr. H. E. Kendall, in his "Mansion in the old English style," now erecting (869), presents such an extensive range of building, and so richly elaborated, that one cannot but regret that the locality which is to boast such a pile, and its owner's name, have not been mentioned; but, while giving every credit for good intentions where so much ingenuity has been exercised, we cannot think the result is satisfactory, or that the plan looks a convenient one, apart from the question of the desirableness of reviving the half-timber work system of construction in so lavish a manner.

There is cause for regret that more than one promising looking drawing is hung so much above the eye that it cannot be properly examined. Such is the case with (870), a simple and well proportioned "Swimming Bath," to be built at Finchley, the architect being Mr. E. Roberts. The over-crowded state of metropolitan traffic has induced Mr. Naden to put forth a suggestion—one of the many—for its relief. This consists of a second roadway above the ordinary one, carried by three arches spanning the whole width between the houses. The general outline above is a flat segmental arch, the materials being iron, with granite piers and abutments, crowned with groups of sculpture. The design by Mr. Scott, R.A., for the "New East Window and Reredos for St. George's Chapel" (877), is intended as a memorial of the late Prince Consort, and is a commission from Her Majesty. The window is an unusually large one, embracing the full width of the chapel, to the style of architecture of which it is assimilated. Its noble size, and the marked forms of its subdivisions, render it an excellent field for stained glass, which it is contemplated to insert. The reredos continues downwards the leading lines of the window mullions, the spaces between being filled with richly-crocketted perpendicular niches, having elaborate canopies and sculpture. Mr. Scott also exhibits (883), an exterior and interior view of his proposed new covered market for Preston,—a large structure of the iron and glass kind, and which, though essentially constructional, is nevertheless not devoid of ornament judiciously introduced. Adjoining the e drawings is a skilful interior view, by Mr. Street (878), of his new church in Garden-street, Westminster, the merits of which it is needless here to recapitulate: while (879) shows us another cleverly-executed pen-and-ink drawing of the "New District Church of St. Cuthbert, Durham," by Messrs. Walton and Robson. This design is chiefly noticeable for its bold simplicity, an important feature being made of a large rose window in the west gable, the dignity of which is enhanced by the diminutive scale of the three lancets below. There is a plain square tower flush with this end northwards, and crowned by a packsaddle-roof; it has moreover, on its outer angle, a square staircase-turret, the upper half of which is terminated circularly, its capping being pyramidal, and dying against the angle of the tower. Within the same frame are also two small vignette views, one of which illustrates the interior of this church, with its rich arcading round the east wall; and the other the exterior, as seen from the north-east, and showing the composition of the apsidal end of the building.

A "Garden Seat" (891), by Mr. C. J. Richardson, is in his favorite Elizabethan style, and is certainly a happy version of some of its eccentric anomalies. It is designed for Castle Combe, Wilts. A portion of the detail of the never-tiring Westminster Abbey, showing part of the triforium of the south transept, proves an excellent subject for the clever pen-and-ink sketching of Mr. Johnson: who also shows (908) a view of the choir of the same edifice, as seen from the chapel of St. Paul. (898), "St. Bartholomew's Hospital at Chatham," by Mr. R. P. Pope, is a thoroughly characteristic work, handsome yet plain, because it at once identifies itself with its purpose, and so satisfies the eye. The new offices lately built in Bishopsgate-street, by Mr. Wilkinson of Oxford, may be quoted as among the best specimens of the revived pointed Italian style in London. The design has become tolerably familiar through various illustrations of it, and its detail is clearly shown in the large drawing now in the Academy (899). In the "Façade of Nos. 24 and 25, Grafton-street, Dublin" (900), Mr. Digby Wyatt displays what he terms a "first attempt" at a revival of some of the characteristics of ancient Irish architecture, not that we can perceive any such marked features; certainly none more peculiar than some of the fancies which have heretofore proceeded from the same hand. The "New Library, University College, Oxford" (901), is carefully detailed by Mr. J. H. Le Keux; as is another drawing of a totally different class (905), being an outline view of St. Paul's Cathedral, by Mr. Tait. As a specimen of well-considered and successful decoration, we may point to an organ, by Messrs. Prichard and Seddon, executed for the International Exhibition, and of which a clever drawing is contributed to these walls in (910).

The extensive restorations at Lichfield Cathedral have frequently been adverted to in these pages, and we have given several illustrations in connection with the subject. The large view of the choir, however, by Mr. J. Drayton Wyatt, which is before us (904), carries these alterations down to the present time, and even beyond, inasmuch as the reredos and side grilles behind the stalls are as yet unfixed, though we believe they are in preparation. The minutiæ of every part being carefully defined, drawings such as these, besides the proofs of their authenticity, are especially valuable. Messrs. Salter and Perron may be congratulated on their satisfactory version of a rather hackneyed subject—a "monumental tower." It appears that a structure of this kind was contemplated to be erected at Penzance as a memorial to the late Sir Humphrey Davy, and that in the competition a column designed by these gentlemen had been at first chosen, but that subsequently the tower to which we refer was resolved on for adoption by the committee, and in their preference we decidedly concur. Both designs are shown side by side in (912). Nos. (917) and (918), which are the concluding numbers in the architectural portion of this exhibition, are attached respectively to the south-west and south-east views of the New Godolphin Schools at Hammersmith, a building of no great pretensions, unless it be on account of its size. but of which the most has been made here as well as elsewhere.

The Academy Exhibition will terminate in the course of the present month.

THE ECONOMIC CONSTRUCTION OF GIRDERS.*

Girders of Great Spans.

It was our intention to have given in the present paper some general account of the principles to be employed in investigating the economic merits of girders of spans so great, that most of their strength is absorbed in supporting their own weights; and we naturally chose the Conway Tubular Girder Bridge as an existing example with which to compare the results for other methods of construction; for as that bridge has only one large span, the calculations were free from the complications which continuity over the piers would introduce, and Mr. Edwin Clark's descriptive work afforded us that complete insight into its construction so necessary for our purpose.

But a careful examination of the stresses acting on the material of the Conway tubes has led us to the conclusion, that these stresses are far in excess of what has on every hand been considered judicious. In no case has it ever been thought prudent to place the material of a bridge under a greater stress than one-third of that which would break it, but the result we have arrived at in the case of the Conway tube is, that were it loaded at the rate of one ton per foot run, in addition to the bare weight of the tube itself, and at the same time subjected to the effects of a wind-storm equivalent to a force of 30 pounds on the superficial foot; then, taking the most favourable view of the action of the parts, the stress per inch would be fully one-half of that which would cause rupture.

Impressed with the importance of the subject, and with a view also to urging the adoption of a means of partially remedying this unsatisfactory proportion of the stresses, we make the strength of the Conway tubes the subject of our present paper; postponing to our next the more general treatment of the subject of girders of great spans.

THE STRESSES ON THE CONWAY BRIDGE TUBES.

We take the standard work of Mr. Edwin Clark as our textbook in treating on this subject; and although the results of our own calculations differ widely from his, and we are constrained to point out some errors into which he has unaccountably fallen —unless it be from the difficulties in the way of revision of such investigations and hurry for the press—we beg to record our high appreciation of his work generally, and our admiration for the spirit in which it for the most part is written, and for the great amount of valuable practical information, and the important original views and investigations which it contains.

We shall, in the first place, point out what we consider the sources of error in Mr. Clark's two principal calculations of the strength of the Conway tubes. Next, we will give our own investigations of the stresses thereon, exclusive of the effects of wind-pressure. Third, we shall point out what amount of light the large experimental girder is capable of throwing upon the subject. Fourth, we shall treat of the additional stresses resulting from the lateral action of the wind—omitted in all the previous calculations; and, fifth, conclude with suggestions for strengthening the tubes.

1.—Mr. Clark's Calculations of the Strength of the Conway Tubes.

As both the calculations which Mr. Clark gives (see pages 748 and 754 of his work) employ a constant derived from the experiments made upon the large model girder of 75 feet span, it will be best in the first place to inquire into the nature of this constant. The description of the experiments is given at pages 158-189, and the constant, which we represent by the letter Q, is thus derived—

$$Q = \frac{WS}{8DA} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where W is the total distributed, or twice the central breaking weight in tons, S = the span, D = the depth for calculation, and A = the sectional area of the bottom in inches; and by this formula in another dress, Mr. Clark (187) obtains the values for Q in the following table, from the experiments numbered I., III., and IV., or those in which the failure took place by the rending of the bottom :—

Table I.—*Experimental Girder, 75 feet span.*

	Sec. of Top.	Sec. of Sides.	Sec. of Bottom, or A.	Value of Q.
Experiment I.	23·4	9 or 9·6	8·8	19·0
„ III.	23·4	9 or 9·6	12·8	20·3
„ IV.	23·4	9 or 9·6	18·31	16·6
Average				18·6

This average value 18·6 tons of the constant Q is at page 748 denominated the "ultimate tensile strain of rivetted plates"; and from having been looked upon in this light it has vitiated both calculations; it is, in fact, an expression for the whole tensive action of the section referred to the same leverage ... Mr. C

* Continued from page 164.

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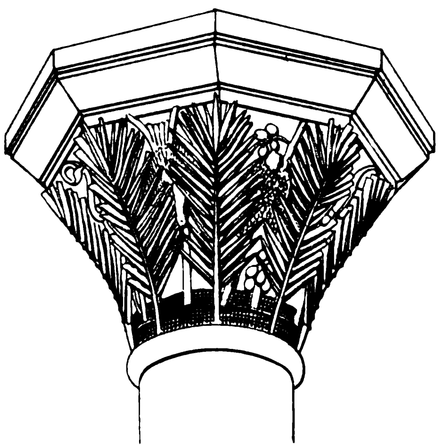

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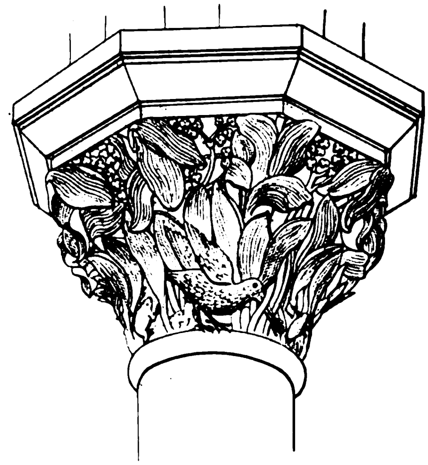

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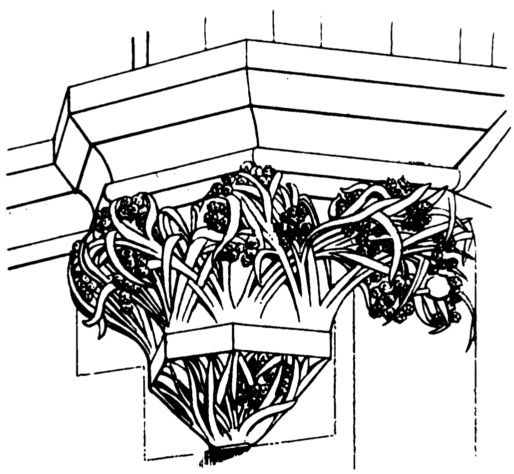

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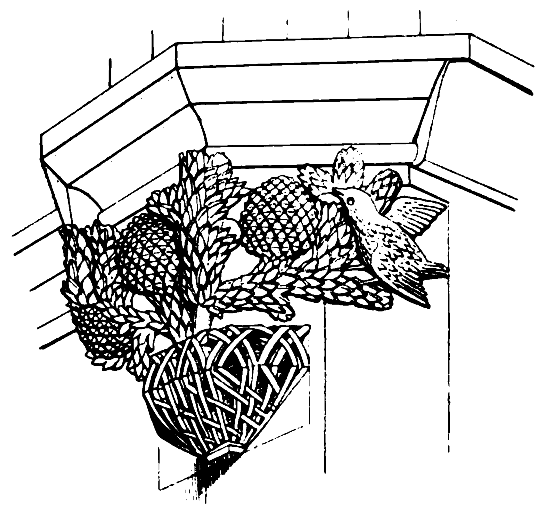

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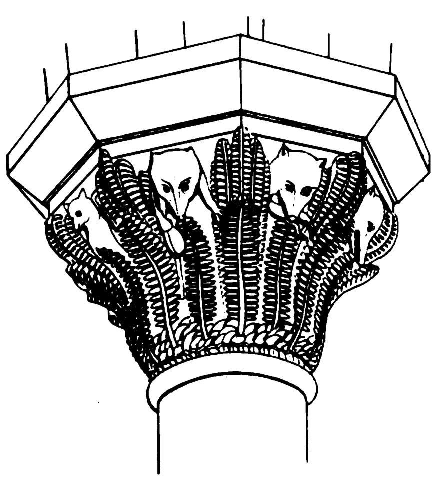

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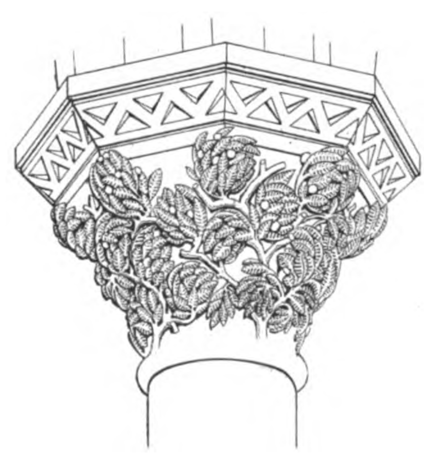


CAPITALS AND CORBELS, FROM THE NEW MUSEUM, OXFORD.

which the bottoms acts, compared with the sectional area A of the bottom; and by heaping on material to the sides and top, without altering A, any value may be obtained for Q; in fact, this is virtually done in the experiments I. and III., in which the sides and top are in excess compared with the bottom. The 4th experiment, for which Q = 16·6, is the only one with an approach to the proportions of the Conway tube. But when the sides are made unduly thick, as in I. and III., the proportionate aid derived from their resistance to rupture is increased; and when the top is made unduly heavy as in the same experiments, the position of the neutral axis is raised higher, so as to afford a longer leverage to the tensive stresses in the sides and bottom; in fact, as we shall have occasion to show, the actual stress on the material of the bottom in experiment No I. was, when it gave way, *less* per inch than in experiment No. IV.

There could be no strong objection to employing a constant of the nature of Q in the comparison of structures of different dimensions, if their cross sections were exactly similar; but even here the last experiment fails to be altogether applicable to the case of the Conway bridge, since the constructions of the bottom differ considerably.

Mr. Clark's first calculation of the Conway is analogous to that employed in deriving the values of Q in the table; there is therefore no material objection, except that just referred to, to be taken to it so far as it goes, if the value of Q as derived from experiment No. IV. be employed—that is 16·6 instead of 18·6 tons. It is to be regretted, however, when a near approach to the best proportion of section was attained in the large girder, that then more experiments were not made upon it.

Mr. Clark's second investigation is of a more elaborate character, taking into account the influence of the sides, and made with a view to calculating the actual stresses per sectional inch brought upon the extreme top and bottom plates by given loadings. Passing over minor objections, we are at once arrested by the manner in which the first results arrived at are applied—not with a reference to the actual strengths of plates as given by the direct experiments recorded at page 376, after a proper deduction being made from these for rivet holes—but by employing the unfortunate *constant* Q, derived in such an objectionable manner from the girder experiments, and by a mode of treatment that ignores the sides. Had a constant been deduced from these experiments by a treatment in accordance with the principles of the second investigation, and that constant been employed instead of Q, little would have remained to object to, except that the difference in the constructions of the bottoms would—as we shall afterwards explain—have told unfavourably upon the constant so obtained. If, on the other hand, we take the average result given for absolute strength at page 376—viz., 19·6 tons on the solid inch, and estimate the metal lost by rivet holes at only 15 per cent. of the total section, this leaves ·85 of solid plate out of every inch of section, and (supposing the plates to receive no injury except in the rivet holes, and to act all harmoniously together) the absolute strength estimated over the whole plate will be = 0·85×19·6 = 16·66 tons; the correct constant, according to these views, to be used with the primary results of Mr. Clark's second and more complete investigation, instead of the incompatible so-called *constant* 18·6.

2.—Our Calculation of the Stresses on the Conway Tubes.

The sectional areas at the midspan of the tube as given by Mr. Clark at page 589, are, for the top = 645·30, for the sides = 257, for the bottom = 535·65; total = 1437·95.

No details of the calculations of these areas are given, but the plans and descriptions afford sufficient information for making an independent estimate, and since the sectional areas we so arrive at differ somewhat from those given by Mr. Clark, we add the particulars:

Estimate of the sectional area of the top of the Conway, including all the attached angle irons.

		Square inches.
A and B plates = 14′ 9″×1¼″	=	265·5
X plates = No. 9×21″×⅜″	=	141·75
Strips = No. 16×9″×½″	=	72·0
Angle irons, No. 40, 4½ in. sec.	=	180·0
Total	=	659·25

Estimate of the sectional area of the Sides.

Two Sides, each 21′ 7″×½″	=	259·5

Estimate of the sectional area of the bottom, including all the attached angle irons.

		Square inches.
D and E plates = 14′ 8″×2″	=	352·0
V plates = No. 7×21×½″	=	73·5
Angle-irons, No. 28, 2·7 in sec.	=	75·6
„ No. 4, 4·5 „	=	18·0
Two packings P, not continuous	=	0·0
		519·1

Let us suppose the horizontal plates A, B, D and E, together with their attached angle-irons, to become concentrated into the lines passing through the centres of their thicknesses, as in diagram 2; let also all the X and V plates be brought together, as also the side plates, as in the diagram. Further, let the sides be completed by material taken from the angle-irons that connect

Diagram 1, showing the plates, &c. in half of the mid-span section of the Conway Tube.

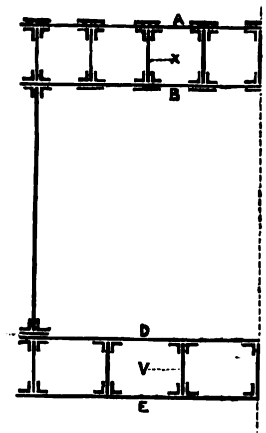
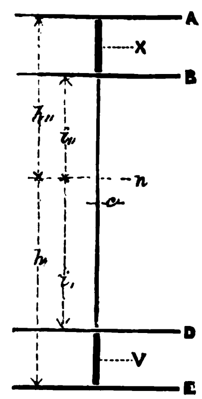


Diagram 2.



them with the B and D plates, so as to make up the length to BD without affecting their combined thickness, which is equal to one inch. Let *c* be the centre of the depth XV between the centres of the cells, and let *n* be the position of the neutral axis,

The measurements carefully obtained from the plates are. AE=25·343 feet, BD=21·698, AB=1·813, DE=1·833, CV or CX=11·760. The sectional areas, after making the adjustments, indicated above are, A plates, &c.=254·25; B plates, 267,375; X plates=141·750; whole of top=663·375; D plates=230·80; E plates=213·80; V plates=73·50; whole of bottom=518·10; whole of sides, 260·38. Then by a sufficiently accurate calculation we find the centre of gravity *n* of the section* to be 1·185 feet above the centre *c*, hence we have h_1=13·862, h_{11}=11·482; i_1=12·029, i_{11}=9·669;

$$\frac{i_1^2}{h_1} = 10\cdot4384, \text{ and } \frac{i_{11}^2}{h_{11}} = 8\cdot1423.$$

We may now deduce a general formula for the moments of the various stresses on the parts measured round the neutral axis *n*. Let us deal, in the first instance, with the moments of the parts in a state of tension, that is, those below the neutral axis. Let T be used to represent the greatest tension per sectional inch on the solid metal of the weakest section; or in other words on the sections of the extreme plates E as above given, but having a deduction made from that section on account of the loss by rivet holes. Let the proportion of solid metal to the total area at the weakest section be as *e*l, so that *e*T will express the tension per square inch as measured over the total section without deduction of rivet holes; *e*T is the tension we have to do with in relation to the position of the neutral axis, when the slight influence of the rivet holes thereon is neglected. The corresponding compressions per sectional inch at the extreme layers of the material on the other side of the axis will be expressed by the letter C, and this will be equal to $\frac{h_{11}}{h_1}$ *e*T.

* An interesting question here presents itself as to the effect the rivet holes in the bottom and sides will have upon the height of the neutral axis. In the text, we follow with regard to the position of the neutral surface, the ordinary rule of taking it at the height of the centre of gravity of the section; and though we believe this is by the above cause rendered not quite exact, it must be sufficiently so for this and ordinary calculations.

For the moments of the parts in tension we have then the following formulæ:—

For plates E, area = E, degree of tension = eT, leverage = h_1; ∴ moment = eT . Eh_1.

For plates D, area = D, degree of tension = $e\text{T}\frac{i}{h}$, leverage = i_1;

$$\therefore \text{ moment} = e\text{T} . \text{D}\,\frac{i^2}{h}$$

For Side Plates.—For any horizontal layer of these distant x from the neutral axis, and dx thick, the breadth being 1 inch, the area = dxb, degree of tension = $e\text{T}\frac{x}{h}$, leverage = x; therefore the moment = $e\text{T}b\frac{x^2}{h}\,dx$. Integrating this between the limits $x=o$ and $x=i$, we have (noting that the i which arises from the summation of the thicknesses of the layers must be taken in inches) moment = $e\text{T}b\frac{i^2}{3h}\,12i = 4e\text{T}bi\,\frac{i^2}{h}$

For Plates V.—Without altering the sectional area of these plates we will suppose them to become stretched out to the full extent of DE, the united thicknesses becoming = t. The moment of any layer dx thick, and distant x from the neutral axis, is = $e\text{T}t\frac{x^2}{h}\,dx$; integrating this between the limits $x = i$, and $x=h_1$, we have moment = $e\text{T}t\frac{12}{3h}(h^3-i^3) = e\text{T}12t(h-i)\frac{1}{3h}(h^2+hi+i^2)$ and putting V = the sectional area, moment = $e\text{TV}\frac{1}{3}\left(h+i+\frac{i^2}{h}\right)$

So that the sum of the moments of the plates, &c. below the neutral axis is =

$$e\text{T}\left\{\text{E}h_1+\text{D}\frac{i^2}{h_1}+4bi_1\frac{i^2}{h}+\tfrac{1}{3}\text{V}\left(h_1+i_1+\frac{i^2}{h_1}\right)\right\} \quad \ldots (2)$$

And similarly, the moments of the parts above the neutral axis are=

$$\text{C}\left\{\text{A}h_{11}+\text{B}\frac{i^2}{h_{11}}+4bi_{11}\,\frac{i^2}{h}+\tfrac{1}{3}\text{X}\left(h_{11}+i_{11}+\frac{i^2}{h_{11}}\right)\right\} \ldots (3)$$

Applying these formulæ to the Conway bridge, with the values given above for the various factors, and noting that $b=i^{11}$, we have

$$\left.\begin{array}{l}\text{Moments of parts}\\ \text{under tension}\end{array}\right\} = \begin{array}{l}e\text{T}(213{\cdot}8\times13{\cdot}862+230{\cdot}8\times10{\cdot}4384+4\times\\ 12{\cdot}029\times10{\cdot}4384+73{\cdot}5\times12{\cdot}11) = e\text{T}\,6765{\cdot}3\end{array}$$

$$\left.\begin{array}{l}\text{Moments of parts}\\ \text{under compression}\end{array}\right\} = \begin{array}{l}\text{C}(254{\cdot}25\times11{\cdot}482+267{\cdot}375\times8{\cdot}1423+4\times\\ 9{\cdot}669\times8{\cdot}1423+141{\cdot}75\times9{\cdot}764) = \text{C}6790{\cdot}3\end{array}$$

$$\text{But C} = \frac{h_{11}}{h_1}\,e\text{T} = 0{\cdot}8283e\text{T} \;\therefore$$

Total moment of section = $e\text{T}(6765{\cdot}3+0{\cdot}8283\times6790{\cdot}3) = 12390e\text{T}$.

Now the resulting moments of the loading on half of the span, and the reaction of the pier must be made equal to this; this moment is equal to $\frac{1}{8}$ WS, W being the total distributed weight over the span S, and if we take S=400 feet, this becomes=50W;

$$\left.\begin{array}{l}\therefore\ \text{W}=247{\cdot}8e\text{T},\ 50\text{W}=12390e\text{T},\ e\text{T}=\dfrac{\text{W}}{247{\cdot}8}\\ \qquad\text{and C} = 0{\cdot}8283e\text{T}\end{array}\right\} \ldots (4)\,*$$

We may remark upon the above calculation, that it is made favourable to the strength of the bridge; 1st, on account of the full sectional area of the angle-irons being taken instead of that of their covers, which would be the more correct course; 2nd, the span S as above is the *clear* span, but the span for calculating the moment of the reaction of the pier, &c. should be the distance from the centre of pressure on one pier or abutment to the centre of pressure on the other, or probably here about 405 feet; 3rd, the weight of structure and loading is, of course, equally underrated with S; and 4th, the material composing the sides has been estimated at the same standard as the bottom, to withstand tension; the sides should however be considered inferior, both on account of being single riveted, and from the plates composing them being placed with the fibre vertically, or at right angles to the tensive longitudinal stress. The experiments given at page 377 of Mr. Clark's work show the absolute strength, when the stress is parallel to the fibre of the plate, to be about three tons greater than when at right angles thereto; but when the sides proper do not descend to the lowest part of the girder, their absolute strength is not called forth, and it may be that they therefore contribute as much to the support of the structure as though of better material and workmanship.* When however, as in the large experimental girder of 75 feet clear span, the sides descend to the bottom, and have therefore their lowest layers subjected to the same extremes of tension with the bottom plates, their absolute strength and ultimate extensibility become important points. If, with the same ultimate extensibilities, the net strength of the side plates is inferior to that of the bottom, a deduction should be made from the moment expressing their efficiency; and if the ultimate extensibility of the side plates be inferior to that of the bottom, rupture will begin in the sides before the bottom plates give out their full strength. In accordance with these views, we do not think it necessary to make any deduction from the moments of the Conway section; but when we come to treat of the experimental tube, it will appear that some such deduction is required in its case, the effect of which will be to slightly augment the ultimate values of eT, T, and C, deduced from the experiments.

TABLE II.—*Stresses per sectional inch produced in the extreme top and bottom plates of the Conway section, from the action of the load alone (the additional stress from the action of the wind not being here included). Calculated by formulæ* (4), *e being taken* = 0·85.

Total distributed load in Tons.			eT in Tons.	T in Tons.	C in Tons.
Tube alone	=	1112	4·488	5·280	3·717
Tube + 200	=	1312	5·295	6·229	4·386
Tube + 400	=	1512	6·102	7·179	5·054
Tube + 600	=	1712	6·909	8·128	5·723
Tube + 800	=	1912	7·716	9·078	6·391

We will suppose that the 1112 tons in the above table represent the total dead weight of the Conway tube (although it appears to be that of the bare girder alone, without allowances for permanent way, planking, roof, &c). Then the added weights will represent the movable loading: 200 tons may be taken as an actual daily test, 400 tons is the ordinary estimate of the heaviest possible load, 600 tons the same when the factor of safety for the movable load is taken equal to 1½ times that for the dead weight; 800 tons represents the same loading when the factor of safety for a movable load is taken double that for the fixed load—as at page 584 of Professor Rankine's *Civil Engineering*.

3.—Calculation of the Stresses on the Large Experimental Girder,† *in Experiments numbered I., III., and IV., in which the Girder failed by the rending of the bottom.*

We have noted that Mr. Clark derives from the results of these experiments a measure of strength which we have

* We do not put much stress upon the difference in the values we have employed for the sectional areas of the parts from those given by Mr. Clark, for the results when his values are used are almost the same. Thus, taking the sections in the table at page 589, we find h_1 = 13·577, h_{11} = 11·777, i_1 = 11·744, and i_{11} = 9·944; and proceeding with the calculation as in the text, with the following values of the parts A = 250, B = 254, X = 140, Sides = 260 or 1 inch thick, D = 237, V = 75, and E = 222, we get these results:—

$$\text{W}=248{\cdot}42\,e\text{T},\ e\text{T}=\frac{\text{W}}{248{\cdot}42},\ \text{and C}=0{\cdot}82653\,e\text{T},$$

only differing from the results in the text by about one-quarter per cent.

* This supposes the elasticity to be the same as for the bottom plates. If we once open up the question of using iron of different elasticities, numerous interesting, but complicated, problems present themselves. Good results would, for instance, be obtained by choosing and placing the plates so that those with the greatest powers of ultimate extension would be situated further from the neutral axis, and those with least elasticity nearest to it.

† It is too much the custom to represent a load at the centre of a girder as equivalent to twice that load spread uniformly over the span. It is so only as regards the longitudinal stresses at the mid-span, in so far as these are not affected by the stresses induced in the web. But in all other directions the effects of these loadings differ very materially: and therefore the one cannot be correctly substituted as a test in place of the other. But let us confine ourselves to the question as regards the model tube (we may leave out of consideration the weight of the tube itself). When a test-load is placed on the midspan, the whole length of the web is nearly equally subjected to certain oblique compressions and tensions occupied in transferring from the midspan to each pier half of the central load.

denoted by the letter Q, and which approximately gives the total tensive moment in terms of the sectional area of the bottom, and its depth below the neutral axis; and is therefore only applicable to girders having sides, top, and bottom all exactly in the same proportion one to another; so that the last experiment, or No. IV., is the only one having the appearance of being at all useful in this form. We therefore propose calculating the actual stress per inch on the extreme fibres in each of the experiments, so as to render them all to some extent valuable.

When we come to the actual calculation, we are unfortunately met by some discrepancies as to the dimensions of the parts. Thus, on page 160, the information given in the upper half does not tally with the measurements used in the estimates at the lower half; and the angle-irons, which are stated in pages 158-9 to have sectional areas of ·175 and ·325, are in the estimate made equal to the sum of the sides multiplied by these values, as mean the thicknesses; this again cannot be accepted without doubt, since Fig. 2, on page 159, shows an average thickness of the stronger angle-iron equal to 0·2 instead 0·325. It is therefore

DIAGRAM 3, showing plates and angle-irons in half of the mid-span section of the Experimental Girder, 75 feet span.

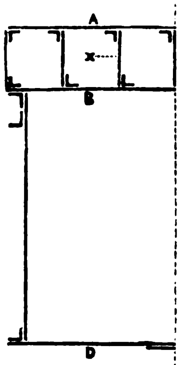
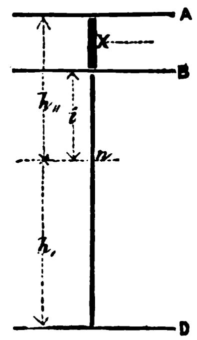


DIAGRAM 4.



with very little confidence in the correctness of the following dimensions that we proceed to calculate the stresses. As, however, the total sectional area of the girder appears to be not very far wrong, being checked by the test of weighing, we will correct the side areas at the expense of the top.*

Let the various plates, with their attached angle-irons, be supposed to become concentrated in their central lines on the same principles as described for diagram 2, of the Conway tube; this is shown by diagram 4.

The dimensions are AD=4·530, XD=4·275; BD or $h_1 + i$ = 4·015; AB or $h_{11} - i$=0·515. The sectional areas are assumed to be, A plates=8·7; B plates=8·7; X plates=6·0: sides, 4·015 ×2×0·1=9·636; D plates=8·8 in Experiment I_1, =12·8 in Experiment III_1, and=18·31 in Experiment IV. From these we are enabled to calculate the positions of the neutral axis, and hence the following values of h and i.

In Experiment I.	...	$h_1=2·854$	...	$h_{11}=1·677$	...	$i=1·161$
„ III.	...	$h_1=2·605$	...	$h_{11}=1·925$	...	$i=1·410$
„ IV.	...	$h_1=2·325$	...	$h_{11}=2·205$	...	$i=1·690$

The formula for the moments of the compressions will be the same as obtained for the Conway, viz.,

$$=C\left\{Ah_{11}+B\frac{i^2}{h_{11}}+4bi\frac{i^2}{h_{11}}+X\tfrac{1}{3}\left(h_{11}+i+\frac{i^2}{h_{11}}\right)\right\}$$

and for the parts under tension the moments are simply = eT ($Dh_1+4\,bh_1^2$). Substituting in these formulæ the values given above for the factors, we get in Experiment I. the total moment of the section=eT49·023; in Experiment III. the moment of the section =eT65·107; and in Experiment IV. the moment of the section=eT87·278. In the three experiments the equivalent distributed loadings, that is, the weights of the girder added to double the central breaking weights, are respectively=76·175 tons, 118·053 tons, and 137·948 tons. And the moments of these loadings at the mid-span are respectively=714·1, 1106·74, and 1293·26. Equating these moments with those obtained for the sections, we arrive at the values of the stresses, which are as in Table III.

TABLE III.—*Stresses on the Experimental Girder.*

		e T		T when e = ·85		e
Experiment I.	...	14·567	...	17·138	...	8·559
„ III.	...	16·999	...	20·000	...	12·562
„ IV.	..	14·818	...	17·433	...	14·053
Average		15·461	...	18·190		

18·2 tons is then the absolute tensive strength of the plates calculated on the suppositions embodied in the above principles. Why this is less than the ultimate strength obtained by direct experiment (see page 376, where this is given as varying from 18 to 22 tons, with an average of about 19·6) may not be beyond explanation. The value assigned to e may be too high; if we take it=0·8, that is, suppose one-fifth of the whole section to be destroyed by the rivet-holes, T comes out=19·326. But there is a cause at work which we will endeavour to explain. The sides or webs of all such girders and tubes must necessarily have an inferior ultimate tensive strength against a stress in the direction of the length of the girder, on account of the inferior character of the rivetted joints and the direction of the fibres of the plates; we may, however, assume them to be equally *stiff* with the bottom. The consequence will be that the sides and top will only work harmoniously together up to the point at which the stress in either of them attains the ultimate value; so that in cases like this experimental girder, wherein the side plates descend to nearly as low a level as the bottom plates, rupture will begin at the lower edges of the side-plates considerably before the plates of the bottom have given out their full strength. And if we suppose the lower edges of the side-plates to be exactly at the same level as the bottom of the girder, their failure will begin when the bottom-plates are stretched to an extent corresponding with the ultimate stretch and strength of the side-plates; and—unless the bottom-plates be of such large sectional area, that the 3 or 4 tons per inch more of strength that they may put forth after failure in the sides has begun, will more than make up for the loss of the strength previously given out by the side-plates—complete rupture will ensue. If, as we have supposed, the elasticities be exactly the same for bottom and side-plates, let h be the extreme distance of the bottom from the neutral axis, and m equal to the distance from that axis of the point to which the sides become split up when the bottom attains its greatest elongation; then, if eT and e_1T_1 be the respective ultimate resistances to tension of the bottom and sides, we have when the bottom is fully stretched $m=\frac{e_1T_1}{eT}h$, so that when the full value of eT is counted upon, the tensive moments will be=eT (section of bottom×h+ thickness of sides ×$4\frac{m^3}{h}$), m and h being measured in feet, and the areas in inches. In addition to the above causes of weakness we have the slight warpings and irregularities unavoidably produced in rivetting up such thin plates, which must tell against the general tensive strength.

It will now be obvious that no very direct use can be made of the experiments in helping us to the value to be assigned to T for the Conway, but as some of the prejudicial causes noted above will also be present in some degree in the case of the Conway tube, we may be allowed to assign a value to T slightly less than that obtained from the direct experiments upon the plates used in its construction. Let T, then, be taken = 19 tons, instead of 18·2 as derived from the experimental tube, or of 19·6 from the direct experiments on the uninjured plates.

So that, when the Conway is loaded at the rate of one ton per foot run, and the same factor of safety is employed for movable as for fixed loading, that common factor will be = 19 ÷ 7·18 (Table II.) = 2·65 only; and if the factor for movable load be taken equal to 1½ times that for fixed, we have the respective factors equal to 3·506 and 2·337.

These factors are very unsatisfactory. But the correct factors,

By a correct test-loading, or one of double the former amount, spread uniformly over the girder, the stresses in the web are very different, the part at the mid-span is nearly free from stress; but the parts near the supports are stressed to *double* the degree caused by the former load. The experiments cannot, therefore, be accepted as a proper test of the strength of the web, they overstrain it at the mid-span, but only apply half the proper stresses to its extremities.

* In the estimate of the top, at page 160, the attached *arch* of angle-iron is omitted, and *overlaps* are included which do not appear in the detail drawings. (See Dr. Fairbairn's 'Narrative.') Further, the thicknesses of the plates A and B, which are given in the upper part of the page as ·179 and ·151, appear respectively as 0·151 and 0·153 in the estimate. As to the side plates, their depth is 4 feet, not 3′ 9″ as in the estimate. Their sectional area is correctly given as =9·6 at page 163.

which must be obtained after allowing for the effects of the wind, are still more so. We now proceed to calculate the additional stresses produced thereby.

4.—The Stresses produced in the Top and Bottom of the Tube, by the lateral pressure of the Wind.

By the lateral pressure of the wind one side of the tube is thrown into a state of tension (compared with its normal condition), and the other into a state of compression. It does not appear to have occurred to those investigating the question that the edges of the top and bottom of the tube participate, to the full extent at least, in these stresses; and that the wind-induced stresses must therefore be added to the previously existing stresses produced by the action of gravitation. And the greatness of this addition can, we think, never have been calculated. Mr. Clark does not give any such calculation for the Conway tube, misled probably as to its importance by a serious error that occurs in that for the Britannia tube, at page 787. The investigation there given is correct enough in principle, the error occurs in the final arithmetical operation; he gives the formulæ $\frac{\mu z}{f}=0{\cdot}621$, wherein μz expresses the total pressure of the wind on one side of the tube = 120 tons, when the force is taken at only 20 lbs. per superficial foot; f = the stress per square *foot* induced on the material of the sides; we consequently have $f=\frac{\mu z}{0{\cdot}621}=\frac{120}{0{\cdot}621}$ =193·4 tons per foot=1·34 tons per inch. Mr. Clark makes this = 74·5 tons per foot, or about half a ton per inch. Now when we consider that the sides are not very well suited to withstand either tension or compression in the direction of the span, it is apparent that the edges of the top and bottom will receive more than their just shares of the total stress, that is, there will be more than one-and-a-third ton per inch to be added to the previously existing tension on the leeward-edge of the bottom, and to the compression on the windward-side of the top. The fact of the windward-edge of the bottom being relieved of tension to the same extent does not affect the question as regards the leeward-edge, the stress from gravitation being brought upon it by that side of the tube to which it is attached, quite independently of the other. Furthermore, 20 lbs. must be looked upon as an under-estimate of the force of the wind, allowance should be made for the effects of suddenness of application, or even for the possibility of the gusts being isochronous with the lateral oscillations of the tube. At page 470, indeed, we find the pressure estimated at 46 lbs. per superficial foot, and in Dr. Fairbairn's 'Narrative,' at page 120, 50 lbs. is the estimate: of course the stress to be added will be in proportion to the pressure per foot, at 50 lbs. the stress would be=3·35 tons in the Britannia tube, according to Mr. Clark's own formulæ quoted above, which however does not take into consideration the modifying effects of continuity past the piers.

Let us now investigate the stresses occasioned in the *Conway* from the lateral action of the wind. Let F = the force of the wind in lbs. on each superficial foot. The tube being three feet deeper at the centre than at the ends, the pressure is more serious than if uniformly spread over the length; to have the equivalent uniform load we must somewhat increase the area. The actual area, omitting the roof, is = 400 feet × 24·5; let us take it equal to 10,000 feet, we have then for the moment of the wind-pressure,

$$\frac{10{,}000\ F \times 400}{8}=50{,}000\ F\ \text{lbs.}=223{\cdot}21\ F\ \text{tons} \ldots \quad (5)$$

To resist this, we have,

$$e\,T \times 14{\cdot}667\ (\text{area of one side}+\tfrac{1}{3}\text{ areas of top and bottom})\ldots(6)$$

And taking the areas from page 589, and equating the moments, we have,

$$223{\cdot}2F=eT\,(128{\cdot}5+196{\cdot}8)\ 14{\cdot}667,\ \text{whence}\ eT=F\div 21{\cdot}34\ \ldots(7)$$

But from the inferior quality of the rivetting of the sides, a low value must be taken for e, say = 0·75, so that

$$T=F\div 16 \quad \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ (8)$$

When F=20 lb. per foot,	T=1·25	tons per sectional inch.
,, F=30 lb.	,, T=1·875	,, ,,
,, F=40 lb.	,, T=2·50	,, ,,
,, F=50 lb.	,, T=3·125	,, ,,

By adding these results to those given in Table II. we arrive at a near approach to the actual stress, to which the leeward-edge of the bottom of the tube is subjected under the given circumstances of wind and load. Thus, with a loading of one ton per foot run, and the effect of the wind taken as equivalent to 30 lbs. per foot, we have the tensive stress on the solid inch of iron = 7·178+1·875=9·053 tons, or half of what we have been led to consider the ultimate strength of the plates.* And this result, it must be borne in mind, is obtained with an over-estimate of the efficiency of the angle-irons, and an under-estimate of the span and loading. It does, then, appear that the stresses greatly exceed what has been considered the limit of safety—viz., from 5 to 6 tons of tension, and considerably less of compression: it is therefore with some earnestness that we would press upon the consideration of those entrusted with the care of the structure the propriety of employing the means which the connecting of the pair of tubes together offers of alleviating in some degree this serious excess of stress.

5.—Connecting the Tubes together as a means of Diminishing the Stresses from the Wind.

The connection of the tubes together may be carried out in two different ways. The least perfect of these is by the simple introduction of struts between them to retain them strictly parallel, so that the leeward tube will assume the same amount of lateral curvature as the other, and so take on itself half the duty of resisting the wind. This arrangement would reduce the foregoing tension from 9·053 to 8·116 tons, supposing that the wind takes no hold on the second tube.

But the more perfect way of connecting the tubes is by introducing between them efficient systems of horizontal bracing, thus rendering the whole structure as it were one girder nearly 38 feet deep, to resist the lateral pressure: by this means the stress per inch produced by the wind, calculated approximately, will be less than one-fifth of that on the windward tube when unconnected; or the total stress above given as 9·053 in the unconnected tube is reduced to about 7·511 tons—a reduction so evidently necessary and important as not to need any further insisting upon on our part.

Edinburgh. R. H. B.

NEW GAS ENGINE.

It is stated that M. Lenoir and MM. Mays Brothers have succeeded in constructing engines from ½-horse to 3 or 4-horse power actuated by means of the expansion of ordinary coal gas, inflamed by electricity so as to act by its dilatation on each side of the piston alternately, without any steam. As this is not an experiment, but actually in practice with economy, the idea is neither "speculative" nor chimerical; so it deserves notice. A M. Révillon says, "I had four men to turn grindstones; they cost me 12 francs per day; I placed in their stead one of these auxiliary engines of 1-horse power, which does all the work of the four men willingly and noiselessly for 6 or 7 francs a day."

Another, M. Bourgerie, states the working of a larger engine than the latter. "I wanted," he says, "a motive power, and I was not authorised to put up a steam engine; I have placed in my factory an engine (of the above nature) of 3-horse power, which has relieved me from the *embarras* in which I was placed. A machine like this can render the same service, in a thousand similar circumstances, to the industry of our populous quarters."

The following is a description of the engine; it consists of a horizontal cylinder on a bed of cast-iron, as in ordinary steam engines, the connecting rod driving a crank upon the shafting, with flywheel and the usual gearing for distributing the motive power. By the usual eccentric and slide valve the gas is admitted above and below the piston. Two of Bunsen's batteries are put into communication with Ruhmkorff's induction coil, whence the electric current is conducted by two isolated wires to a distributor of electricity placed in front of the cylinder, so that the movement of the piston regulates the communication of the wires to the "inflamers" (*inflammateurs*) placed inside each disk of the cylinder, so that an alternate illumination takes place above and below the piston, and produces the required horizontal movements. The conserved gases are driven off by a waste pipe from the valve box. The whole is kept cool by a stream of water, the cylinder in a jacket. To set it in motion all that is necessary is to turn on the gas and give a help to the flywheel. As M. Leon Foucault says, it can be set in motion or stopped "*avec la même facilité qu'on allume ou qu'on souffle une bougie.*"

* On the windward side of the top the addition would tell still more unfavourably.

LECTURES ON ARCHITECTURE AT THE ROYAL ACADEMY.*

By SYDNEY SMIRKE, R.A.

LECTURE IV.

WE have hitherto, this season, been engaged in discussing various, and, truth to say, somewhat miscellaneous subjects connected with architecture, suggested by a reference to some of the literary treasures contained in two public libraries. I have but dipped very cursorily and superficially into these collections. Much profit might, no doubt, be derived from the prosecution of a deeper, closer, and more systematic examination of them, but I do not consider myself justified in pursuing the inquiry farther, at least for the present. So brief is my appointed course, that it is now quite time I should quit the mere literature of our subject, and proceed at once to the consideration of the principles that should regulate the practice of the art,

We must remember that architecture is strictly a practical art; far more so than either of the sister arts of painting and sculpture. Reading and thinking are, no doubt, processes well adapted to clear up and make straight the path before us; they enable us to see our way and understand the course we should take; but it behoves us also to accustom our minds to the carrying out of the principles so acquired. We may learn much of a country by studying geographical treatises; but it is as a wayfarer on its actual roads that we best become acquainted with it.

Let us, then, enter upon a detailed and practical consideration of the art of architectural design. Such a consideration seems naturally to divide itself into two very distinct general heads; namely, design as it affects exterior architecture, and design as it affects interior architecture; each being very different from the other in its aim and object. It would, however, be a serious error to suppose that the exterior and interior of a building should not be designed strictly in relation to each other. I hold it to be a serious defect in design to so shape the exterior of a building as not to convey, to the mind of one viewing it, at least some general idea of the form, and, when possible, even of the general arrangement, of its interior. Still, the treatment and the nature of the effects and impressions to be produced must necessarily be so different, that I think it will be very convenient and proper to regard these two subjects distinctly and separately.

Let us, then, devote this evening to the consideration of the principles of design as they affect the exterior form of a building; and next week we will deal with the interior. I need not insist on the paramount importance to an architectof a careful study of external architecture. There are few considerations that lead our mind so forcibly to a sense of the importance of a right cultivation of our art as the consideration of the permanence and durability of her works. Fifteen generations of men have passed away since the erection of those buildings which date from the decadence of Mediæval art; and there are buildings still surviving the wreck of time since the erection of which a hundred generations have passed away. How grave a responsibility, then, it is which the architect takes upon himself. If his work be one of ordinary solidity, he must count upon a succession of critics, and be prepared to submit his handiwork to a varying standard of taste,—varying to an extent that can scarcely fall to the lot of either of the sister arts. The sculptor's labour is bestowed on objects of comparatively little magnitude: and their defects as well as their beauties have to be searched out in order to be appreciated, or even observed. The painter's field of labour is, perhaps, still more limited and still less conspicuous; and it is painful to contemplate the perishable nature of the productions of his genius. All the love and reverence with which a picture may be regarded can but prolong its existence through a few centuries; and all the care with which it may be cherished may be thwarted and set at nought by an imperceptible worm, a careless spark, or even a neglected window-blind!

Again, if the hand of a master have failed the painter in the execution of his task; or should he, by one of those caprices from which even the highest genius is not always exempt, have produced a work with which, on after reflection or on further study, he feels himself dissatisfied, he can turn his picture to the wall, or even paint it out. Not so the votaries of architecture. To them alone is it given to occupy the highways and public places, and perpetuate their glory or their disgrace in monuments which are at once conspicuous and durable. Is there any consideration better calculated than this to make us earnest diffident, and studious? Is there any consideration more powerful to warn us from an indulgence in foolish excesses, or puerile *capriccios*; or to induce us to proceed with a measured and a cautious step? to see that every line is founded on sound reason and just calculations? This is a duty which we owe alike to ourselves, to our patrons, and to our art. Let no seeking after present, but very evanescent, praise render us unmindful that our work however crudely considered or hastily conceived, stands, and will stand, exposed to the unsparing judgment of successive generations.

It is obvious, then, that the composition of external architecture is of the utmost importance to the character of the architect, and demands, therefore, his first and most earnest attention.

Now, in the mechanical construction of a building, what consideration may be regarded as the most important of all? Undoubtedly its foundations. Let your superstructure be ever so just in its proportions, or beautiful in its decorations; if its foundations be faulty the architect can gather no laurels; the structure may drag on its unseemly existence for years, but it can win for him no applause. Nor is this regard to the foundation a mere consideration of mechanical construction: it is also a question of æsthetics.

If your basement be plainly adequate to the superstructure; if it be of fitting character and of competent proportions; you will have gone far to secure a successful result for your whole design.

I believe that in the kindred arts all masters agree in regarding the pose of a figure, or of a statue, a subject of essential importance; and I believe it to be a fundamental rule that the feet should be readily traceable; that there should be no doubt in the mind of a spectator as to how or upon what the human body is supported; and, of course, the eye demands that the footing shall be adequate to its task.

So also is it in our art. The eye must be satisfied that a building has a firm, visible, and competent basis.

Sir J. Reynolds compares the background of a picture to the base of a building: the comparison is certainly felicitous, and conveys an important lesson both to the painter and to the architect. Each should be quiet and solid; not forcibly obtruding itself upon the notice of the observer—in the one case by any inordinate brightness and glitter, nor in the other case by any needless multiplication of parts or obtrusive enrichment. Like the setting of a gem, the background of a picture may greatly enhance the effect of the subject, or seriously detract from it, according to the degree of judgment exercised in its treatment. So may great value be given to the superstructure of a building by the judicious treatment of its base. But, besides these æsthetic considerations, there appears to be a peculiar practical propriety in giving to a building a base obviously competent to receive and support it. It is not enough to surmise, or presume, that a building has an adequate foundation: it is not enough to know as a practical man that a building has an adequate foundation: the eye needs to be satisfied as well as the mind—the fact should be patent and palpable; otherwise a sort of uneasiness is produced on the mind of the observer, which it is the duty of true art to avoid; for it is one of the most legitimate ends of all art to yield pleasure, not pain, to the intelligent observer.

I need scarcely remind you of the elaborate attention paid to this especial subject by the accomplished architects of ancient Greece. Confined as the Greek temple ordinarily was within its τεμενος or sacred inclosure, and therefore having its façade fully seen only from a point of view somewhat near, no very lofty substructure was necessary in order to give it dignity; but that the Greeks were fully sensible of the value of an adequate base, and of the importance of giving a due elevation and spread to the visible footing of a building, is manifest in all their works that remain to us.

The graduated plinths are a peculiar characteristic of most—I believe of all—of their temples, and seem to give great propriety and significance to the term "Nascentia templa," used by Martial. The spreading steps of a temple seem truly to link the structure with the earth it rests upon; and thus the building may well be, figuratively, said to grow out of it.

Instances are not wanting of casual irregularities of site having been made subservient to the production of very noble substructures.

It is true our knowledge of Greek exterior architecture is mainly derived from sacred edifices; but so attached were they, apparently, to the type presented by the temples, that they were

* Continued from page 137.

satisfied to build their basilicas externally in conformity with it. The basilica at Pœstum, for example, has its substructure perfectly similar to the temples adjacent to it. The tombs in Lycia, with which of late years we have become familiar, are remarkable for the character of stability and permanence given to them by their bases.

Generally, we may with truth say that the remnants of Greek art which survive for our instruction are amply sufficient to prove that the refined eye of Greek artists failed not to recognise the æsthetic importance of a competent substructure.

In Roman buildings the general use of a podium is an evident recognition of the same feeling. Vitruvius treats the podium as an important, if not essential, feature in the composition of an order; and he gives us the proportions that were held in his day to be proper for this member.

The interruption of the podium of a colonnade, and the forming a break in it under each column, naturally led to the suggestion of the pedestal, which eventually became an integral part of every order. This pedestal may be regarded as a strictly Roman feature; nor am I aware of a single purely Greek example, the nearest approach to it being at the singular temple at Segesta, where breaking of the upper plinth or step on which the columns stood, forms under each column a cubical block of masonry resembling a plinth; but even this there is reason to believe, is rather due to the unfinished state of the building than to design.

When once adopted in the architecture of Rome, the pedestal became well-nigh universal, and continued as long as Classic architecture retained any of its ancient purity. In the grand style of Roman art, that art which it has been too much the fashion, both of the ultra Greek on the one hand, and of the ultra Goth on the other, to contemn; but which was an art, in its best days, most impressively marked by the greatness of manner which well became the masters of the civilised world;—in that art nothing is more striking than the skill shown in the advantageous placing of their buildings. The eye of the artist is everywhere apparent when we examine the topography of ancient Rome; whilst the Villa of Mœcenas, the Temple at Tivoli, and many other familiar examples might be adduced as evidences of the judgment and taste which guided the Romans in determining the sites of their more important buildings.

The practice of Mediæval art fully concurred with that of the ancients in attaching importance to the mode of placing their buildings, and in the due appreciation of the advantage of a bold and massive substructure. It would, indeed, be difficult to find an example, during the best period of Mediæval art, where the basement has not been plainly made the object of especial study and design; although it is certainly obvious, from the great diversity of their practice, that our ancestors had no very fixed rule for their guidance in proportioning their podium to the superstructure. They evidently felt however, very strongly, the good effect produced by marking forcibly the base lines; indeed those lines are, perhaps, the only very strongly marked horizontal lines in a building of the best age: the stringcourses were held of little account, and the cornices were often very moderately pronounced and constantly interrupted in various ways, but the base lines very rarely. Deeply shadowed and prominently marked, they never fail to arrest attention.

When we carry down our survey to that period in the history of our art which immediately succeeded the prevalence of mediæval forms, we shall still find a full recognition of the importance of the base in every architectural composition. In the Venetian buildings of the quatro-cento period notable instances might be adduced; and there is no better evidence of the refined taste of the very early master Alberti, than the noble basements which he gave to his works. The new front he gave to the Church of St. Francesco, at Rimini, appears to me to exhibit a very fine feeling in this respect. In the works of Bramante, of Raffaelle, of Giulio Romano, and of Palladio, you will find the dignified pose of their buildings well worthy of most careful study—a study which it is very certain those distinguished artists never failed to bestow on the subject themselves.

Descending in our view from the period of the early Renaissance down to the less refined, though perhaps still more picturesque, manner that succeeded, we still find the best artists never neglecting that important part of their compositions, the base. Indeed, they amplified the idea; and we find terraces worked up with extreme ingenuity, so as to combine with and enhance the effect of their architecture; spreading out as it were the base of a building so as to connect it with the ground it stands on; rendering it sometimes scarcely obvious where the domain of the architect ends and where that of the gardener begins.

But I hope that enough now has been said to satisfy you of the attention that is due to the preliminary subject of basements; and I feel confident you will concur with me in what I said at the outset; that in order to afford unmixed pleasure to the critical eye in viewing a building, the mind must feel satisfied of its stability; and that there are no means so proper for that purpose as providing a good and sufficient visible foundation.

The subject now leads us naturally upwards to the superstructure; and, without entering at present into any question of style, I think that our first business is to consider architectural character in its broadest sense. When we propose to ourselves to design a building, the very first question that should present itself ought to be, what character will it be most fitting to impart to our work? For we may be well assured of this,—that however exactly our building may be in accordance with the ordinances of architecture; whatever may be its merits as a composition; however unexceptionable may be its details; if the general character of the building be not in harmony with its purpose, a fundamental defect exists, for which no amount of art will compensate. Whereas, if the character of the building be in accordance with its purpose and destination, a favourable impression is produced which reconciles us to many blemishes of detail.

I would cite, for example, the principal front of the Imperial Palace at Vienna,—a building which has all the worst vices of the most corrupt German school; yet possesses in its well supported character the great redeeming merit of appearing really like what it is,—a great imperial residence.

I would cite, also, the garden front of Versailles,—a subject familiar probably to most of you: as an architectural composition it is, I think, sadly deficient in character, with little claim to the attribute of grandeur beyond its enormous length, and but feebly suggesting the idea of a great monarch's residence.

To seek for an illustration nearer home, I might point to Whitehall Chapel, a building the architecture of which seems remarkably expressive of the festive purposes for which it was originally designed: and this illustration is the more instructive when we have regard to the manifest unfitness of the building in all its features, internal and external, to its present purpose. There never was a more grievous misapplication of a fine piece of architectural composition.

I feel the extreme difficulty of defining this quality of character with that precision at which one who assumes the office of a teacher ought ever to aim: but it appears to me to be a consideration involving so much more of feeling and judgment than of abstract reason, or of what logicans term dialectics, that I fear it would be a hopeless attempt to lay down definite rules for insuring propriety of architectural character. We have neither numbers nor figures nor words by which the relative merits or the essential attributes of art can be gauged or compared with mathematical exactness. We want, and shall never find, a golden mete-wand, which shall serve to reduce genius to a matter of calculation, or to supply an unfailing criterion of good taste.

We may however safely say generally of a building, that its character is well conceived, if the intelligent observer be at once impressed by the congruity of its aspect with its destination. I do not mean that an hospital should look lugubrious; or that statues of maniacs should decorate the portals of a lunatic asylum, as was the case at old Bedlam: that would be a gross misapplication of the principle; yet, in such structures as these there is a plain propriety which forbids the architect to admit an air of levity into his work, or to indulge in fanciful decoration.

To give to a court of justice the riant air of a place of public amusement; or to give to a private gentleman's residence the aspect of an ecclesiastical structure, or of a crenellated fortress in the days of catapults and cross-bows, would be to commit a solecism which no abstract ingenuity of design, nor antiquarian correctness, could possibly justify.

Quite irrespective of style, much of the character of a building depends on its general treatment. I apprehend that a painter who takes in hand some great historical picture would adopt a mode of treatment widely different from that which would guide him in painting some humble piece of *genre* painting, or of still life. So also the architect should certainly adopt his mode of treating his subject to the nature of the building. To design a small village church like a miniature cathedral would be a vulgar error, and the formal, dignified simplicity of a Greek temple would be grossly misplaced in the suburban villa.

To enforce so plain a truth seems almost to demand of me an apology, and yet experience proves that this congruity of style is not seldom lost sight of.

At Potsdam, for instance, we see the elegant and stately shaft of a Mahommedan minaret, decked with all the graces of oriental architecture, degraded to the vulgar uses of a steam engine chimney, built for the supply of water to the royal kitchen-garden.

So we find, nearer home, that these freaks of genius are not wholly wanting. An admirably-designed Egyptian temple, with with its richly-sculptured decorations, illustrating the triumphs of Sesostris, forms the façade of a cotton-mill.

In all cases, I should say, let the purpose of a building determine its external character; and although the forms of architectural composition may not be so eloquent as always to express very distinctly the nature of those purposes for which a building was erected; yet let the architect have a care lest he invite ridicule by those flagrant inconsistencies which result from an indiscriminating adoption of an architectural style, in total forgetfulness or disregard of the future destination of his work.

Besides the influence that the uses and destination of a building should exercise on the mind of a designer in determining its architectural character, there is yet another consideration which should never be overlooked by him in making his design. It is with truth that Pope teaches us to

"Consult the genius of the place in all."

This *genius loci*—the local circumstances of the spot—should not fail to have its due weight in the selection of style and character. For example, amidst picturesque and varied natural scenery, a flat, formal, rectangular façade appears inharmonious and misplaced. On the other hand, in the streets of a city, some uniformity of outline seems preferable to that endless miscellany of houses of varied heights, shapes, and sizes, which make some of our large streets so pre-eminently ugly. It is no uncommon error to design a street façade wholly regardless of this consideration. We too often see, in the midst of the irregularity of ordinary street architecture, an elevation with its centre and wings, a pediment here and a projection there; the whole presenting a complex composition, all crowded into a small compass, producing painful confusion instead of that repose which, amid such discrepancies of form and fashion, the distracted eye so much desires to dwell upon. And this is often done to the serious disparagement of the building itself, by detracting from its individual importance.

A simple unbroken front might have claimed our attention at least, if not our admiration; whereas, with its front broken up into wings and centres, the building loses its unity and individuality; and each fragment of its composition adds but to the general disorder of the scene. We shall find this distinction steadily kept in view by the best masters.

I need but to remind you of the noble specimens of civic architecture with which Florence, Vicenza, Verona, and other great cities in the north of Italy abound; where you will never find a fantastic variety of outline aimed at; but rather that broad simplicity of treatment which is so well calculated to impart individual dignity to each structure.

When we turn to the works of the very same masters amidst the beautiful hills of the Brienza, or on the banks of the Po and the Brenta, we see them there relaxing that severity of manner, giving to their plans a playful variety, and to their outlines a picturesque freedom.

Now with regard to exterior design, the most prominent and important principle of design is form. It is form that is mainly instrumental in giving expression to works of architecture. Colour, ornament, the elaboration of the smaller features of a building, such as doors, windows and the like,—all these are no doubt useful contributories to the great object of giving character and expression to a building, but they are not alone and of themselves sufficient. It is the dome, the spire, the portico, the arcade: these, and such as these, are the forms on which a building mainly depends for its effect.

When these main features affecting the outline of the building are right and true in their proportion and collocation, the design is sure to be successful in securing our respect at least, and fixing our attention; but if these fail,—if these great and leading features be disproportioned or out of keeping with the plan and purpose of the buildings, or otherwise mismanaged; then all the enrichments of art are exhausted on it in vain, and the most laborious and ingenious details are but labour lost.

In this respect, as in many others, architecture and sculpture are kindred arts. The most beautiful details, the most exquisite finish, the highest polish, would fail to invest a statue with the true character of high art, if it be wanting in fine form; whilst the rudest sketch, the simplest outline, from the hand of a Michael Angelo or a Flaxman, is stamped with immortality.

I would by no means inculcate negligence of detail or of finish, nor would I have you in the least degree regardless of the charms of ornamentation. Sir Joshua Reynolds says, with his wonted truth, "as life would be imperfect without its highest ornaments the arts; so these arts themselves would be imperfect without their ornaments." I do not, I say, seek to depreciate the value of ornamental details. They may most legitimately excite our admiration, by their individual beauty or by their happy adaption to their place; or by their rich abundance; or by the judicious parsimony with which they are introduced; and they may act with the utmost effect in giving scale to our work. On this latter ground, indeed, rests the main justification of that crowding together of minute details which characterises the later schools of Mediæval architecture.

But ornament, like a highly tempered weapon, needs much caution in the handling. Not only must it be of a kind suited to the character and purpose of the building; but in quantity also it must be carefully apportioned.

These considerations should induce you to attach much importance and value to the proper study of ornamental details; but do not forget that such details should take a secondary place in your professional estimation. It is, I repeat it, the leading and prominent features of your design which are of paramount importance. The experience of every one must be able to afford illustration of this truth,—viz., that the most impressive effects of architecture are irrespective of mere ornamental details. After having imperfectly seen a building for the first time at night, or in the shades of evening, and having been deeply impressed with a sense of its grandeur; how often are we surprised (perhaps indeed disappointed) on the morrow by finding it of insignificant dimensions, or of mean construction! I have even found in the morning that I have been looking over-night with much interest, perhaps with admiration, at what has turned out to be a temporary scaffolding of poles and tarpaulins. It was its fine outlines, its broad *chiaroscuro*, its deep shadows, which had produced this profound impression. Such is the magic of form, and of an effective management of lights and shadows in our art.

I have but little doubt that the striking effect of a Gothic cathedral is mainly due, not to its intricate enrichments, not to that exquisite elaboration of its detail, upon which indiscriminating admirers of middle age art are too apt to lavish their exclusive praise (and to which students, allow me to say, are too apt to bestow their exclusive attention); but to the breadth of its main features, to the variety of its masses, and to the grand and surprising effects produced by its lights and shadows.

I am the more led to dwell on this point, because ornament exercises an extremely seductive power over the mind of younger students. Florid beauty in architecture may be well compared to an over-ornate style in oratory. We are dazzled by the splendour of phrases, by the flow of brilliant words: the flowers are strewed before us in such charming abundance, that we are led away by our admiration of them, and forget to exercise a calm and rational judgment on the main merits of the production, as a work either of logic or of rhetoric; and we are in no mind to inquire into the fitness or propriety of the decorative adjuncts.

So it is that the younger practitioner in our art (and, perhaps, in the sister arts) is easily reduced, through an erroneous estimate of the value of this secondary object, or by a latent desire to display his dexterity in superficial embellishment, to impair the breadth and solidity of his essential design.

I trust that I have said enough to establish in your minds my position that the vital principle of architectural design is form.

I think that there are three principal and very distinct sources of beauty in architectural composition:—

1st. There is a beauty in the aptitude of a form; that sense of satisfaction which the mind experiences when perceiving the nice adaptation of any object to its purpose.

2nd. There is the beauty of symmetry; that pleasing impression produced, I know not why, by regularity of arrangement, and by exact correspondence of the several parts. Perhaps this sense of the beauty of symmetry may be founded on the almost universal prevalence of unsymmetrical arrangement in the works of nature, whether in animate or inanimate creation.

3rd. There is the beauty of the picturesque;—a pleasing impression (differing very widely from the last, and sometimes almost opposed to it, and equally difficult to account for), which is made on the mind by irregular but not confused or discordant combinations of form.

I do not pretend that under these three heads all kinds of formative beauty can be classed; but they may be quite sufficient to engage our attention on the present occasion.

It is not only good taste, but common sense, that teaches us that a form should be fitted to its purpose; and as I have said, the fulfilment of this first great condition is in itself an element of beauty. But I am afraid that the mere dry unimpassioned beauty resulting from the quality of fitness, however it may satisfy the engineer, will hardly suffice to meet the aspirations of the architect.

As sensible men, we cannot admit the beauty of any object that is irrational, or idle, or inapplicable to its purpose; yet, as artists, or intelligent observers of art, we desire this, and something more. I think that this kind of beauty, and the distinction which I am endeavouring to draw, may be illustrated by a very simple comparison between two familiar forms, that of the early Classic, and that of the early Mediæval arch. Both are so far beautiful, inasmuch as both are perfectly adapted to their purpose: both convey in the simplest and most effective manner the vertical pressure of the superimposed weight down on to the circular shaft, whose office it is to bear that pressure.

Both are alike honest and simple; but an absence of refinement, not to say a rudeness, characterises the Norman capital; while the more ancient type, although honest and simple enough, gives evidence of a more refined feeling, a more skilful working out of an idea, a quality which distinguishes the Greek artists from all others. The parabolic curve of the echinus shows a nicety of execution which the mathematician only can fully appreciate, or even comprehend, but the higher merit of which all can feel.

It is said by Cicero, "Venustas et pulchritudo corporis secerni non potest à valetudine." We in like manner might say that it is difficult to distinguish clearly between the beauty of an architectural form and its strength or ability to fulfil it task. This quality of suitability of form will ever be held in popular esteem; for it can be understood and perceived by all; whilst it is the privilege of the few only to estimate æsthetic beauty at its true value. In this country especially, where the general mind loves to hover in the lower atmosphere of practical science, and soars reluctantly into the higher regions of æsthesis, this utilitarian quality has peculiar attractions. There are thousands of otherwise highly-educated minds which distinguish no superiority in a Greek vase over an ordinary garden-pot. Both, they will say, are alike adapted to their purpose: both fulfil their destinies with equal efficiency; therefore both are alike worthy of our approval. I have known a critic of this school condemn to utter ridicule a colonnade of finely-proportioned stone columns, as being a clumsy contrivance, inasmuch as they are, perhaps, 4 or 5 feet in diameter; whereas plain iron posts, a few inches only in diameter, would have answered every purpose. To answer such criticism is but labour lost; and the sorrowing artist has but to sigh and pass on.

"Misericordia e justizia gli sdegna,
Non ragionam 'di lor, ma guarda e passa."

I now proceed to the second source of beauty, Symmetry.

Our great master Vitruvius thus instructs us: "Symmetry," he says, "results from proportion. Proportion is the commensuration of the various constituent facts with the whole, in the existence of which symmetry is found to consist; for no building," he says, "can possess the attribute of composition in which symmetry and proportion are disregarded."

It may be difficult in few words to express all that is intended to be comprised in that word symmetry; but there can be no doubt that the great balance and correspondence of component parts, and the regularity of their general arrangement, which constitute the essence of symmetry, is a never-failing source of pleasure to the critical eye; and here we perceive (what I have already adverted to) an instance of the analogy which our works bear to those of nature; who, in her greatest work—man, the human frame—has set before us an eminent example of perfect symmetry.

This quality has ever been eminently architectural. We recognise the attribute of symmetry in the avenue of Sphinxes at Memphis; in the façade of a Greek temple; in the long-drawn aisles of a Gothic cathedral; in the stately colonnades which surround the cortile of St. Peter's. We find it in its highest condition in the works of the best Italian masters: pre-eminently, perhaps, in the works of Palladio. A want of symmetry in parts, where its want is patent, is a fundamental defect which no art can hide, and for which no beauty of individual parts can compensate.

The want of due proportion between the dome of St. Peter's and the body of the building has been often remarked by critics, and not without ground, as an instance of this defect; and I might cite an example of a like defect, although under very different circumstances, at Munich. There the enormous statue of Bavaria crushes into Liliputian insignificance the otherwise pleasing colonnade which accompanies it. In this case, had it been the artist's purpose by this interchange to enhance the size of his statue (whose bulk may be comprehended from the fact that twenty persons can find sitting room in the head) he might have been welcome to sacrifice a whole hecatomb of life-size statues around the feet of his colossal image, but it was treason to architecture thus to reduce a fine Doric portico to the proportions of a plaything, and to sacrifice the dignity of our art in order to magnify the vastness of his figure.

I proceed now to the third source of architectural beauty; viz., that resulting from the Picturesque.

If there is difficulty in defining symmetry in few words, a succinct definition, or rather description, of the word picturesque is far more difficult. As I have said last week, there is no quality which it is more dangerous to affect than this; for the spell is at once broken, and the author loses the reward of his art, as soon as it is perceived that there has been a laboured effort made to produce it;—like the Spartan rogue, who only gained a lawful exemption from punishment for his theft by the dexterity with which he contrived to commit it.

The ecclesiastical and castellated piles of the Middle Ages are perhaps the most striking as well as the most familiar illustrations of this high quality of art,—if art it may called, where concealment of art is the best proof of its influence. But I last week sufficiently discussed this subject of the picturesque.

But there is a principle which I should notice here as being applicable to all large architectural compositions, and to none more so than to those of picturesque character. I refer to a certain subordination of the various parts of a composition to one predominant feature or group.

In every large composition, whether it be a building, or (as I believe) a picture, a kind of unity should be preserved by concentrating effect,—by giving, not indeed an unduly absorbing interest to any one portion of the design, but a decided and clearly marked preponderance to one portion; for I think it is a remark of very general application that where interest is scattered it is sure to be weakened.

Our own St. Paul's is an instance especially in point, and affords a remarkable example of happy adjustment of its various parts; giving to the dome just importance enough to secure its preponderance without overwhelming the subordinate parts of the design.

The superiority of the effect of those cathedrals, such as Salisbury, Lincoln, Lichfield, and others, which have main central spires, over those where that main feature is wanting, such as Westminster, Winchester, and Peterborough, is also an obvious illustration.

It was, no doubt, to some æsthetic consideration of this nature that we owe the noble gate towers of our colleges, and some of our old baronial residences, such as Burleigh, Knowle, and the like. These central features, rendered forcible by their superior height and enrichment, connect, as it were, the various parts of the composition; giving it that unity which, as I have said, adds so much value to a design. I might name Greenwich Hospital as a building which must be regarded as very deficient in this respect; and I can hardly doubt that this building, as we now see it, is but part of a larger and more connected design, which its distinguished author was unfortunately unable to realize.

You will have observed that in the somewhat desultory remarks I have addressed to you this evening, the subject of styles has been but slightly touched upon.

This has arisen from no want of due appreciation of the importance of that subject. There is no doubt whatever that a thorough, discriminating knowledge of the several recognised styles that have prevailed in the more highly civilized countries of different ages forms an essential part of the education of an architect. But I believe I shall be best fulfilling my duties here by drawing your special attention to those broad principles of design that seem alike applicable to all styles; to a right understanding of which principles the acquirement of a knowledge of details must, as it seems to me, be always subordinate.

It would, doubtless, be taking a very narrow view of the study of the art to confine our admiration or to limit our attention to any one style: whether it be that which flourished under Pericles or that which reached its culminating point under St. Louis or our Edwards; or that which left in the great municipalities of North Italy enduring monuments of originality and genius.

The time may come when architecture, unencumbered by prejudice or pedantry, may cease to feed on the past, and take a loftier and nobler flight.

Two revivals have marked the history of modern art. There was a great revival in the fifteenth century. Nothing could exceed the enthusiasm of the artistic world when Lorenzo assembled around him the scholars and artists who effected that great change; but with all their ardour there was no want of discriminating judgment. They dug up, and measured and studied with minutest care the works of the Classic ages; but they wrought themselves in an unfettered spirit.

The style of antiquity was by them so modified to suit the wants and habits of modern civilization, that their works became as much marked by originality as by beauty. It may be indeed questioned whether the world has yet seen men altogether equal to some of the quatrocentists.

Let us have a care that the second revival—that of the nineteenth century—is not marked by a narrow, sectarian spirit, and by the ignoble results inevitably attendant on a blind, servile, superstitious adherence to precedent,—a feeling from which the great movement of the fifteenth century was so entirely free.

No doubt the arts have advanced much since painters habitually drew the heads of men and women with their elongated eyes placed somewhere about their temples, and represented their horses stepping out with both legs together on the same side. But it is undeniable that in our art we have yet much to unlearn, many prejudices to dismiss, much rust to rub off, before architecture can take its true place.

It may be long before a Giotto or a Bacon arises in our art, but we may look forward hopefully to the result of a combination of many minds acting in an earnest spirit and guided by right principles.

THE HARTLEY COLLIERY ACCIDENT.

Shortly after the frightful occurrence at the Hartley Colliery, in January last, by which 199 persons were stifled to death in consequence of the single shaft of the mine having been blocked up, the Home Secretary requested the inspectors of mines to give information respecting the condition of the shafts of mines in their several districts. The points on which information was required were,—the number of accidents caused by the falling in of insufficient shafts; the number of collieries having single shafts; whether communications could not be made with other existing modes of egress in the same proprietorship; and the practicability and cost of providing double-shafts. The replies of the inspectors to those inquiries were presented to Parliament on the 29th of April, and they have just been published, together with the report of Mr. Blackwell respecting the calamitous event at Hartley, and were very briefly noticed in the last number of the Journal.

It appears from the replies of the inspectors, in England and Wales, that comparatively very few of the collieries are worked with single shafts, and in the majority of those cases preparations are making for giving other inlets to the workings. In Scotland however the proportions are reversed, for single shafts, divided by wooden brattices, are more numerous than double-shafts, in the proportion of 530 to 446. It is a curious fact however, that in Scotland there were, during the last three years, only two accidents reported as having occurred by the falling-in or obstruction of shafts; while in the West Lancashire and North Wales district, where the number of mines without two entrances is very small, there were in the same period 52 accidents from those causes. Mr. Dickinson, the inspector for the East Lancashire district, in which the production of coal amounts to 6,379,500 tons per annum, states his opinion, after conferring with seven other inspectors, that the following provisions should be introduced in any Act passed for the regulation of mines:—That they should be provided with proper means of egress by two distinct shafts, separated from each other by a secure division of natural strata; that for the purpose of exploring or proving ground, or for working a small tract of coal or ironstone, a single bratticed entrance may be used, provided that not more than 10 persons be allowed to be below ground at the same time; and that after the 31st of December, 1862, every shaft worked by steam or water-power should be provided with a proper self-acting fence at the top. In the South Durham district, within which the Hartley colliery is situated, there are 26 mines worked with single-shafts, and 113 that have two means of egress. In South Staffordshire the proportion of single to double-shafts is only 20 to 460; and in South Lancashire the proportion of single-shafts is only 3 per cent. All the inspectors agree that single-bratticed shafts are very dangerous, and several of them have been endeavouring for some years past to induce the proprietors to make separate entrances to the workings. The cost of making a second shaft is very variously estimated by the inspectors, and it would depend, of course, on the depth of the mines, and the nature of the strata. The cost in the South Durham district is estimated, for a mine 50 yards deep, at £300; for the Adelaide's colliery, 344 yards deep, £8000; and for the Ryhope colliery, not 100 yards deeper, the estimated cost is £25,000. It is not improbable, that in some works of small value, to compel the sinking of a second shaft might put a stop to the working altogether, and throw many men out of work in that locality; but the danger of single-shafts has been so fatally proved, that it is necessary to adopt some measure to obtain a second means of egress, whether by a regularly constructed shaft, or, at least, by a sinking of smaller diameter, which in the mining districts is called a "trumpet." How far it would be practicable to enforce such a regulation in Scotland it is difficult to foresee, though the danger seems to be greater there than in England, for it is not only a general practice to work mines with a single shaft, but mineral tenants work their mines through neighbouring properties by paying a right of way, to avoid the expense of sinking separate shafts. The cost of sinking shafts in that district is however estimated by the inspector at a very small sum, not more on an average than £300 each.

The report of Mr. Blackwell on the Hartley colliery accident, gives a detailed description of the condition of the shaft and of the pumps and engine, and traces its cause to the mal-construction of the pumps, which were so arranged as to accumulate the entire resistance alternately in opposite directions to the action of the steam, without any check on the other side; so that when the engine lost its load by the breakage of the spears in the shaft, the piston was rapidly forced down, and a concussion ensued which snapped the engine-beam. The beam, which weighed more than 40 tons, was broken through its centre, and the portion that fell down the shaft carried with it in its descent parts of the pump-spears, the buntons and collars that retained the pumps and the spears in their places, the brattice by which the shaft was divided, and portions of the timber lining of the shaft. The following description is given of the construction of the shaft, and of the nature of the pit:—

"The Hartley pit was sunk about seventeen years ago. The shaft is 12 ft. 3 in. diameter; it is 200 yards in depth, namely, 72 yards from the surface to the high-main seam; 66 yards from the high-main to the yard seam; 49 yards from the yard to the stone-drift leading to the workings in the low main seam; and 13 yards from the stone drift to the bottom of the sump.

The high-main seam at this pit had been exhausted by former workings; there are workings, but to a very limited extent, in the yard seam; the workings in progress at the time of this accident were almost exclusively in the low main seam.

The shaft of the Hartley pit had not been walled except for a short distance below the surface; under this the strata, where considered liable to give way, were secured by a lining of planks, kept in their places by round timber cribs or curbs of from 4 to 5 inches scantling. These cribs were cleaded or sheeted toward the interior of the shaft with deal battens.

The shaft was divided through its centre, from east to west, by a timber brattice or partition formed of planks. The northern half of the shaft was occupied by the bottom and middle sets of pumps which were connected with the outside end of the pumping engine beam. This side of the shaft formed the upcast; the ventilating furnace drift, through which the return air from all the workings passed, entered the shaft on its north side in the yard seam. The southern half of the shaft was occupied by the winding cages; it formed the downcast.

The top set of pumps occupied a staple or small shaft situated under the inside or steam end of the pumping-engine beam, to which this set of pumps was connected.

The quantity of water at the Hartley pit was very large; it found its way into the pit almost entirely through the workings in the low main seam. The quantity amounted to from 1400 to 1500 gallons per minute.

From the level at which this water entered the pit it was necessary to raise it from the depth of 200 yards; to effect this required the use of great engine power."

The pumping-engine, and the construction and arrangement of the pumps—to which principally the cause of the breakage is attributed—are then noticed as follows:—

"The pumping-engine at this pit had a steam cylinder of 86½ inches in diameter; the pressure of the steam used was 14 lbs. per square inch; the steam was condensed on both sides of the steam piston; the engine was of the estimated force of 300 horse-power.

The length of the beam of the engine was 34 ft. 6 in. from centre to centre of the outside gudgeons; the sectional dimensions of each of the two sides of which it was composed, taken through the centre gudgeon-hole, were 8 feet in the vertical by 4¾ inches in the cross section, exclusive of the metal in the ribs and in the boss.

The centre gudgeon, forming the centre of motion of the beam, was situated 8 inches nearer to the outside or pumping end than the middle of the beam; its stroke was thus 10 feet at the inside or steam end, and 9 ft. 3 in. at the outside or pumping end, situated over the pit-shaft.

The pumps connected with this engine were divided into three sets. The bottom set, lifting the water from the sump in the shaft below the low main to the yard seam was 52 yards, and the middle set, lifting from the yard to the high main seam, was 66 yards in height. These two sets of pumps and the spears connecting them with the outside end of the pumping engine beam, were situated in the northern half of the shaft. They were both bucket sets. The buckets were 2 feet in diameter, working strokes of 9 ft. 3 in. The main dry spear, extending from the engine-beam to the top of the middle set of pumps, was 14 inches square. Below this point, from the Y to the top of the bottom set of pumps, it was 10 inches square. These spears were of Memel timber. The wood in the bottom dry spear, near the place where it had parted, was found to be not perfectly sound.

The bottom set of pumps stood on the bottom of the sump, that is, that portion of the shaft below the stone drift leading to the workings in the low-main seam. The middle set stood upon oak buntons of great strength, which were placed side by side, and in tiers over each other, extending nearly half-way across the shaft of the pit. The top set of pumps lifting from the high main seam to the surface, a height of 72 yards, was situated in the staple sunk to this seam, near the inside or steam end of the engine-beam. This set also, as the others, was a set of bucket pumps; the buckets were 2 ft. 6 in. diameter, working a stroke of 6 ft. 3 in.

The weight of the dry and wet spears, of the buckets, and of the columns of water in the bottom and middle sets of pumps lifted from the outside end of the pumping engine beam, when the engine made its inside stroke, appears from calculation to have been about 55 tons. The smaller weight of the top set in the staple, which was connected with the engine-beam on the opposite side of its centre of motion to the bottom and middle sets, was compensated by the difference in the length of the two ends of the engine-beam from the centre of motion, the weight of the steam-piston, piston-rod cross-head, and iron catch-pin attached to the beam.

The steam in this pumping engine being condensed on both sides of the piston, the speed with which it would travel through its inside and outside strokes would, so long as the connexion of the beam with the pumps at each end was maintained, be equal; but this arrangement rendered this engine liable in the event of the breakage of its connexion with the outside or inside set of pumps, and more particularly with the outside, to serious damage.

All the sets of pumps in connexion with this engine being bucket pumps, the entire resistance to its motion was accumulated alternately in opposite directions to the action of the steam, without any check to that action existing on the other side, and in the event of this resistance ceasing by the breakage of the pump connexions, it was inevitable that the engine should destroy itself, as, in fact, occurred.

Mr. Blackwell then points out the difference between the engine at the Hartley colliery and a Cornish engine, in which he observes the same circumstances of danger do not exist, for the steam, being condensed on the under side only of the piston, the total force brought into action in the inside stroke is confined to that which is required to lift the spears and plungers, without the additional weight of the column of water. Respecting the use of bucket-pumps, and the immediate cause of the accident, he observes:—

"The use of bucket pumps of large dimensions, to form all the sets of pumps in connexion with a powerful pumping engine, is evidently a source of much danger. In such cases, the engine having to lift at the same time, not only the weight of the spears but that also of the water resting upon the buckets, the tendency is to economise weight as much as possible, and consequently to reduce the dimensions of the spears by which the connexion of this weight with the engine is maintained.

There are special causes of breakage connected with the action of bucket pumps. The whole power of the engine must be applied to them as a direct strain tending to sever their connexion with the engine. The buckets are liable to become fast in their working barrels from various causes, such as the bursting of a bucket hoop, or the entrance into the pump of dirt along with the water. The blast holes through which the water enters the pumps may become choked up with dirt, and this would throw an excessive strain on the spears.

It was proved that the sump at the bottom of the shaft of the Hartley pit had not been cleansed out for a great length of time. The timber forming the spears was probably rendered brittle by the elevated temperature of the pumping half of the shaft, which was used as the upcast. That liability to breakage existed at this engine was proved by a former accident, which occured in 1858, when its speed was only 4½ strokes per minute instead of 7½ strokes, as at the period of this accident. On this occasion the main spear in the pumping shaft broke, and the connexion of the piston rod with the engine-beam appears in consequence to have been nearly severed.

It was necessary under those circumstances which existed at Hartley pit, namely, the constant influx of large volumes of water, with the possibility of its increase, while there was only very limited standage room for it below the level of the pumps, that the bottom set should be bucket pumps, the buckets and clacks of which can be drawn out and replaced from above through the pumps, in case of their being temporarily overpowered by water; but the upper sets of pumps, namely, the middle set in the shaft connected with the outside end of the engine-beam, and the top set in the staple connected with the inside end, should have been plunger pumps; these two last sets being situated above the level to which it was probable that the water in the pit could rise.

This arrangement of the pumps would in all probability have prevented such an accident as that which occurred, since, under it, the entire resistance to the motion of the engine would not, as under that which was adopted, have been accumulated alternately in one direction and on one side only of the centre of motion of the engine-beam, during each stroke of the engine; but a balanced resistance on each side would have been presented to the action of the steam, in whichever direction the piston might travel.

It appeared from the evidence of men who were being wound up in the shaft at the time of this accident, that a breakage of the spears in the shaft, by which the engine lost its load wholly or in part, did occur prior to the breakage of the beam and the fall of its broken half into the pit. It appeared that when this breakage of the spears occurred the engine was commencing its inside stroke. The resistance to the descent of the piston in the steam cylinder being thus removed, the piston would be carried downwards by the pressure of the steam on its upper surface augmented by the vacuum below, amounting to a force of about 62 tons, and would rapidly acquire momentum in its descent through a stroke of 10 feet in length, until both the piston and that end of the beam connected to it were suddenly arrested by the iron catch-pin fixed upon the beam at that point coming down upon the spring beams where they were rendered perfectly rigid in their resistance by vertical cast-iron columns which were firmly bolted to them beneath.

The engine-beam, the breakage of which was the immediate cause of the loss of life which resulted from this accident, was made of iron of fair quality. It was of the full ordinary sectional dimensions of beams used in engines of similar power to this. The over-wedging of the centre gudgeon of the beam and the occurrence of severe frost at the time of the accident, may have contributed to render it somewhat more liable to fracture than it would otherwise have been, but these circumstances were not alone sufficient to account for this occurrence. The beam had been at work under the load it was carrying for about seven years.

The breakage of the beam must be attributed to the violent concussion to which it was subjected when it, together with the steam piston connected to it, were suddenly arrested after descending through a stroke of 10 feet with the velocity acquired under the pressure of the steam, by coming in contact with the spring beams beneath, after the counterbalancing load in the shaft was partially or wholly lost."

Notwithstanding the fracture of this cast-iron beam, Mr. Blackwell contends that it ought not to prevent the use of such material for similar purposes, for, in his opinion, the defects of cast-iron may in almost all cases be guarded against by a judicious combination of wrought-iron in the construction of beams. Had the engine-beam at Hartley, he observes, been trussed with wrought-iron rods 2½ or 3 inches in diameter, applied to the upper and under edges of each of the sides, it would in all probability have sustained the effects of the violent concussion. Mr. Blackwell concludes his report by animadverting on the danger of working mines with a single shaft. He estimates the cost of labour and materials required for sinking two shafts in place of one, the sectional area of the two together being equal to that of the single shaft, at from 10 to 25 per cent. With regard to deep mines now in operation, where large quantities of water have been stopped back, and where the strata present unusual difficulties, Mr. Blackwell thinks that the sinking of a second shaft would involve so serious an outlay that the effect of any legislative enactment enforcing the formation of a second shaft, would cause the stoppage of the works, and throw a large number of miners out of work.

There is, indeed, less danger in working in mines with a single shaft that are free from fire-damp, than in double-shafted fiery mines; and it is only the strong impression of the dreadful consequences of the extraordinary accident at the Hartley colliery that has directed attention to the necessity of having more than one means of escape. The question is, not whether men should be allowed to risk their lives in procuring coal, but whether it is not the duty of the coal proprietors, and of the legislature, to take the known precautions that will diminish the danger to which miners must always be exposed? It may be a hardship to the proprietor of a coal-mine, to enforce conditions that would render his property valueless; but, as regards the men, they would in all probability be able to find employment in other mines, where they might work with less danger.

WENLOCK PRIORY, SALOP.

(*Continued from page* 167.)

The south transept is in some respects peculiar; up to this part we may consider we have been examining the works of, within a very short limit, one period, though there are indications of slight variation of date here and there, just enough to show that the works which were begun to the east were continued westward, and, in accordance with the characteristic principles of the age, carried with it what was at the time, perhaps with justice, thought to be progress and improvement in art. We may therefore justly reverence those who have shown their appreciation of the beautiful works of the preceding age, and who by their arrangements endeavoured to preserve that of the ornamental chapter house adjoining, and continued it in their works. The arcading of the transept encroached on the chapter house; and to preserve the uniformity of these arches, and at the same time not destroy the chapter house, they have recessed the old wall, the arch and pier of the new work being actually within the wall, necessitating ingenious arrangements and mouldings. In like manner, the arcading at the south end is carried on piers built into the old wall, and it will be found that the wall is really thicker in the aisle than in the main transept. This transept has but one aisle on the east side, the other is occupied by a triple vaulted recess open to the cloister, for what purpose is not absolutely known. We shall however revert to this presently. The only instance I am acquainted with of any arrangement at all approaching this, is the south transept of Westminster Abbey, where the cloister runs under the lower part of the west aisle of the south transept. Returning to the transept, we find, on the west side next the nave-aisle, a triple arcade, with the mouldings in the head of the centre arch cut away for the reception of the head of a former statue, and in the two outer compartments are small brackets, so that this formed a group about a shrine. There is a drain from the centre compartment, by which we infer that there was a piscina. Adjoining this was a newel staircase, part of which now exists.

On the opposite side, in the aisle, were some chapels to the east, divided by wooden screens. The mortices for a parclose are still visible in the shafts; and a piscina of later construction is in fair preservation, in the lower part is built a Norman capital. Here was at least one altar, probably two or three; the base of one is distinctly marked.

Retracing our steps to the great central tower, we turn again eastward, and are merely able to point out the position of the piers of the once choir. There were seven bays. It is curious, however, to observe that the eastern is within a few inches the same length as the western limb; one is divided into seven bays by six pillars, the other, as already stated, is divided into eight bays by seven pillars.

In the choir, also, the few remnants of the bases are circular, while those in the nave are elaborately indented into shafts; and although those in the choir are slightly smaller in diameter, to the sight they are practically larger, and I feel no hesitation in attributing to an earlier age the construction of the choir than to the nave and tower. This indeed is the part which would be of Earl Roger's constructing. The south wall has the evidence of a doorway, probably the abbot's private door, and at the east end of the south aisle was a window corresponding apparently with that at the extreme west end of the same aisle, with an altar beneath it. The choir was a few inches wider than the nave, and with equally wide aisles; the arcading was of wider opening than in the nave, and was probably of semi-circular arches.

The lady-chapel, still further to the east, is just indicated by the foundation; it was about 41 feet long by 25 feet wide* and without aisles. Of its character and height we can form no conjecture, except by comparison with the parts immediately adjoining; but the buttresses show that it could not have been earlier than the middle of the twelfth century. We shall complete our examination of the church by taking notice of the exterior before proceeding to the domestic departments.

The west end exhibits sufficient to enable us to as clearly define its former appearance as the interior of the nave. There was a centraldoor with a large western window over it, and a small window lighting the south aisle; whether a similar window was in the north aisle it is impossible now to say, but as there was nothing similar in the internal arrangements, with the common disregard for balancing an elevation, a different window may have been placed in the north aisle. The side of the great west window partly remains, with the blank arcading on the face of the wall beside it. The north front has nothing beyond a few portions of nearly bare wall, with the masonry of the same age as the internal parts, that is, of Early English construction, and with the shallow projections which was the first form of buttresses, and supplied the place of the previously thicker walls to resist the thrust of the groined vaulting or roof trusses.

Of the eastern end nothing remains, nor indeed any thing to note, until we reach the south transept, upon which we must bestow our chief attention to arrive at any conclusion. Here it is made evident that the nave and transepts were of equal height and form: the string-course under the clerestory windows still exists, under which commenced the roof over the triforium. These clerestory windows are single lights with a continuous label. The south window of the transept is a triple window with a single narrow light over it in the gable, the latter lighting the space between the vaulting and the roof. The remaining square-headed openings below these ranges of windows communicate between the triforium and a gallery which ran all round the building, and was the place whence the draperies were hung on such festivals as required those decorations, and formed also the means of communication with other parts of the buildings.

The conventual buildings are on the south side of the church. Making our way to those of the earlier buildings, we begin with the beautiful chapter-house with its interlaced wall decorations tier above tier. Until recently it has always been called a chapel, and had rubbish within it to the depth of several feet. This is the only portion remaining of the structures commenced by Roger de Montgomery but not completed by him, for the date of its erection is certainly not within sixty years of his rebuilding. It is a beautiful specimen of the semi-Norman or transitional period, which prevailed only during the reign of Henry the Second; before which time Earl Roger had long been dead.† There is no record yet discovered by which we can ascertain the designer of this or indeed of any other part of the priory. It must have been in the abbacy of Humbald or that of Peter de Leja, the latter of whom was promoted to Saint David's in 1176. The walling is very elaborately ornamented with the interlaced arcading which has by some been supposed to have given rise to the invention of the pointed arch. There are innumerable examples of interlacing, but none so elaborate and beautiful as this. It is divided lengthwise into three bays by blocks of six shafts, these bays again being subdivided each into five spaces by columns, from which spring the arches in three tiers intersecting each other in every tier. Almost every shaft has a differently-carved capital. Each bay has been vaulted and groined with six roll-ribs, which may have been later than the walls. The diagonal masonry which fills the arch above the arcading is curious, and I should think of a date subsequent to the lower part. The clear size is 51 feet by 28 ft. 6 in. Dugdale gives it as 66 feet by 31 feet, and Britton 60 feet by 30 feet.

The entrance from the cloister to the chapter house is through a recessed circular-headed doorway, which may have been without doors, perhaps with a metal work gate, as the capitals run through to the inside. There is no way of ascertaining if the two

* Forty feet wide. Monasticon, v, 75.

† Vide p. 166 ante.

side arches, which are rather narrower, were glazed, because the inner portions are broken away; it may however be assumed that they were not glazed. In the spandrils were formerly the figures of Saint Peter and Saint Paul, to whom the church was dedicated when rebuilt. That of Saint Paul is entirely gone; but Saint Peter can be identified by his key, which is still to be made out. It does not appear to be so early as the chapter house by a century.

The east end has been partly reconstructed, and there is part of a shaft remaining in the upper part, which would lead to the notion that a window had been there in such a position as that it would light above the vaulting. In that case there may have been, as was most probable, a dormitory or library above the chapter house, which was lighted by this window. There is a string-course along the south end of the transept, from which a roof would lean, meeting the gutter of a roof over this chamber, and to which access would be obtained through the triforium gallery, where two openings show that they were for ingress; on the south side the lowest tier of arches have balls in the hollow of the archivolt, similar to the ballflower in application. In two of the bays also, as well as one on the north side, the columns instead of being of three shafts are of one column, with reveals carved into lozenges, with a raised quatrefoil flower in each lozenge; these are continued round the head.

There is likewise on the south side a fireplace inserted, and there has been a doorway, the shafts having been cut away for the purpose: the former would appear to have been done not very long after the original construction.

It may be well here to allude to an error of importance fallen into by Mr. Britton* and others in reference to the string-courses from which the columns spring. This has been repeatedly described as a seat, for which purpose it is much too narrow, and being also seven or eight feet from the floor, it is obvious that it was altogether above the monks' stalls. There may have been hangings or coats of arms in the recesses, as the mortices seem to show.

The origin of the assertion seems to have been derived from the author of the letterpress of the 'Beauties of England and Wales,'† and repeated by Britton in his later works; he probably never saw it, or he would at once have discovered that five feet of earth removed would alter the relative levels so much as to render impossible such a supposition. The view in the 'Beauties of England and Wales,'‡ shows the entrance buried to within a diameter of the level of the capitals of the shafts.

The great cloister exhibits only bare walls. The string-courses show the position of the former roof, by which we see that it was not vaulted; they further show the width of the ambulatory. The outer wall next the garth is entirely destroyed. There were the usual two doorways into the nave, one of which is no longer in existence; the other, which opens under the lower part of the aisle at the western end, is tolerably perfect. The cloister curiously diminishes in width toward the west. It is remarkable, that in the abbey of Cluny this part of the buildings has a similar departure from the rectangular plan.

We now proceed to the conventual buildings of the Early English period. Northward of the chapter house in the cloister is the triple groined recess before noticed. It is 4 feet 8 inches in clear depth, with the three front openings about 8 feet 3 inches wide, with corresponding recesses at the back. These last exactly match those in the chamber above the crypt of the north transept. I am disposed to regard the arrangement as purely accidental, arising from the increase of the size of the church, and the desire to preserve the chapter house, the line of which had to be continued to the former; and with the usual ingenuity of the age to which it belongs, the accident was turned to account, and something useful and beautiful at once produced. It was not the usual position for a lavatory, although, from the absence of any indication of it anywhere else, it may have been one; but its most probable use was that of a cupboard where the everyday books were kept, this being the exact position one would point to as complying with the descriptions of Dugdale§ and Viollet le Duc;‖ I therefore am inclined to consider it the "Petite Bibliothèque." It has, in almost all parts, what are technically termed straight-joints, which show that all but the main walls was built subsequently to the other parts.

The masonry and the doorways which now partly fill up the original archways are modern, the dressed stones having been re-applied from some other part of the building.

Facing the chapter-house was the dormitory, now altogether swept away. The guest-house was further to the west; nothing remains of it. From the north end rose the stair which led to the upper floors containing the dormitories and the chamber over the aisle, as well as to the gallery in the triforium, which, as there was no upper floor to the ambulatory of the cloister, will have been used as passage rooms, and the gallery as a means of communication. On the south side of the cloister was the refectory, two walls of which are yet tolerably perfect. It was a lofty room, too lofty apparently to have had any room over it, and it was groined in eight bays; it was thirty-two feet wide by eighty-five feet long. A noble room it must have appeared, with its lightly moulded ribs springing from carved corbels, while its lower part was hung probably with tapestries, or its walls covered with frescoes. Among the more distant buildings is one that can have been none other than the infirmary. It is at present used as a cow-house. There has been an entrance beside it. Of the other buildings there are several rooms adjoining the abbot's lodging, and on the north side of the smaller cloister; these were for offices, and are of early date.*

The tower at the present entrance has been always called a gate-tower; it is necessary however first to prove that the entrance was there. Of this I am not at all certain. There are no evidences of any gateway adjoining it, and it may just as likely have been a dove-cot. Some of the old walls of the grounds to the south are curiously loopholed. At the end of the wall in the rear of the abbot's lodging is an ancient garderobe.

The abbot's house, allowing for alterations, is the most perfect part of these remains, and is still habitable; its date however is more than two centuries later. It is Tudor—far from being of the best kind—and is diminished in extent. The upper floor still shows the abbot's refectory or hall, and the withdrawing room or parlour beyond. There are indications of a gallery at one end of the former. Both these rooms have large corbelled pedestals in all the window-jambs, which were intended for service, or side tables to fill the recesses; they do not touch the floor by upwards of an inch. The refectory has a water-drain and sink. There is also a double cupboard in the divisional wall, with ledges for shelves to be fitted in as mentioned for the windows. These rooms are accessible from a newel staircase, as well as from the open corridor. On the north side of the hall were the sleeping apartments. On the lower story are several rooms thoroughly modernised, and the antique appearance obliterated.

The chapel is in better preservation, and retains the stone altar and the worn steps, which have the marks of the former railing. A stone reading-desk was dug out of the ruins some few years ago; it is of Wenlock marble, sculptured with late Norman sculpture; there is only one other known. Parker figures this altar and lectern in his glossary.† There is here a small sitting statue of a saint, cross-legged, with a crown on her head, and holding either a closed book or a bag. This may be meant to represent St. Milburg, but it is a carving made long after the church was dedicated to St. Peter and St. Paul, and is therefore hardly probable. It may have been intended for Isabel de Sai, Lady of Clun. This carving, which is of the end of the thirteenth century, would be more consistent with that view than the other. Mr. Planché, at our Congress at Newbury in 1860, informed us that, in his opinion, the representation of cross-legged figures was indicative of the person represented having feudal jurisdiction, and that this power, and this manner of representing it, were not restricted to men. There is a garderobe on the ground floor, which is covered by a stone slab of earlier date, with carved panelling on the underside.

Parker‡ gives a tolerably accurate description of the abbot's lodging, though I cannot subscribe to all his suggestions or conclusions. His plans are not quite accurate. Several writers mention a former painting on the walls of the abbot's parlour; one is described to be a representation of St. George and the Dragon.

The front of the lodging consists of a wide two-storied corridor,

* Architectural Antiq., iv, p. 63.
† Vol. xiii, p. 200.
‡ Ib., p. 196.
§ Monasticon, v, p. vi. of introduction.
‖ Dictionnaire Raisonnée de l'Architect. Francaise, i, 268.

* Since the Congress, some of the facing has been removed, and very early doorways have been discovered.
† Vol. ii, plate 2. At page 17 it is described as of Early English workmanship, but he corrects this in his Domestic Architecture.
‡ Domestic Architecture, iii, 336.

extending the whole length, with continuous ranges of windows, which have been glazed on both stories. They are divided into bays of four windows by buttresses; the sub-divisions are made by smaller intermediate piers and buttresses. The roof, which commences from the eaves of the corridor, is enormously high. From the lower corridor there are some unusual and curiously splayed "squints" into the house; these are large enough to have been used for the passing of small parcels, but are more likely to have been used simply for looking from the inside to the outside.*

Of the seals of the priory few have been noticed. One is said to have been found at Clun Church in 1760, of which no particulars are given. Willis† mentions one of Arms *az.* 3 garbs, *or*, in pale a crozier, *arg.* Another mentioned by Dugdale‡ is a coarse representation of St. Milburga, sitting in a homely dress, with an instrument like a two-pronged fork on her right shoulder. A later one is a full length, with a book in the left hand and a bunch of flowers in the right. A fourth is a seal to a deed in the Harleian Collection (83 D, 3) 30° Henry VIII. It is oval, a Virgin and Child. Beneath, in two niches, are an armed figure, probably St. George with the dragon below, and a female figure. The reverse is a female half figure with a crozier. The inscriptions are "SIGILL' ECCL'... ..VALIS. MONACHORVM. D'WENLOK" and "SANCTA. MILBVRGA."§

One not hitherto mentioned I have been favoured with by the preent possessor, the Rev. T. F. More, of Linley Hall. It is as brass matrix coated with gold, and was found at Hopton Castle by Colonel L. More, in whose family it has been since retained. It consists of a representation of St. George and the dragon, within a *vesica piscis*, two inches and a half long, and one inch and a half broad. The figure is beneath a trefoiled canopy, which is supported on two slender columns; the wings and head of St. George fill the trefoils. It appears to be of the thirteenth century. The legend round is "S' ECCLIE: CONUENTUALIS: DE WENLOK: AD CAVSAS: TANTUM." The connection of this seal with the alleged painting on the wall and the previously named seal is obvious.

In the late Mr. Caley's collection of Howlett's drawings of ancient seals there were—

1. The common seal of Wenlock Priory, from a deed of the xii. *sæc.* 2. The seal of Prior Humbert, xii. *sæc.* 3. Seal and counterseal of the Priory, from conventual lease, 28th Henry VIII., in the Augmentation office. 4. From an early charter *s. d.* in the Chapter-house, Westminster. 5. Seal of Prior John Stratton, from a charter of the date of 1468 in the Augmentation office.‖

The ruins have been subjected to very rude treatment. Mr. Moore, writing in 1787, says that many years before, great part of the abbey was pulled down to rebuild some houses, and only four years prior one of the clustered pillars of the church was nearly levelled, and a cart was waiting to take it away. To the credit of the late Sir Watkin Williams Wynn it should be observed that he, as well as the subsequent owners, put a stop to further depredations.

In the grounds on the east of the church I observed a heap of worked stones gathered from the ruins, and on looking over these I discovered one which had been part of a base; on the upper surface were some very beautifully incised lines of Early English mouldings, which illustrate the subject of ancient architectural drawing; the lines show that they were cut as moulds, and not for the purpose of the stone itself; indeed they extend beyond the points where they could have been available, and there are other mouldings neither connected nor applicable. I believe this to be the only instance of the kind yet discovered.

There, also, I found a comparatively rare example of paving tile, a small portion of simply incised pottery. There are many pieces of tiles scattered about the ruins, bearing representations of shields, animals, and various emblems: one, two inches and three-quarters square, has a representation of the moon's face in incised lines; the tile is red.

There are no fish-ponds to be seen; indeed they seem to have been long destroyed, but there are appearances of some to the east of the abbot's lodging. Leland, in his *Itinerary*, folio 182, relates that there was formerly a little brooklet running west from the hills through the town, and called *Rhe*, which ran into the Severn two miles distant.

Of the Priors of Wenlock, the following is a list compiled from the most perfect as given by the Rev. Mr. Eyton:—

	Commenced.	Evidences of tenure occur	Terminated.
Peter	—	1120	—
Rainauld	—	1139, 1148	—
Humbald, or Wynebald	—	1155, 1160	1169, seceded to Paisley*
(Interregnum.)			
Peter de Leja	—	—	1176, promoted to St. David's.
Henry	—	—	—
Robert	—	1192, 1194	—
Joybert	—	1198, 1200	1216, died
Humbert, or Imbert	—	1221	1260, died
Aymo de Montibus	1261	1263	1272, died
John de Tycford, or Thifford	1272	—	—
Henry de Bonville	1285	—	—
Henry	—	1292, 1306	1319-20
Gwycard de Caro Loco	1320	1344	—
Humbert	—	1348	—
Henry de Myonna, or de Chay	—	1360, 1362	—
Otto de Floriaco	—	1371	—
William de Pontefract	—	1379	—
Roger Wyvil	—	1395	1397
John Stafford	1397	1422	—
William Brugge	—	1435	1437, resigned
Roger Barry	1438	—	1462, died
Roger Wenlock	1462	—	—
John Stratton	1468	—	—
John Shrewsbury	1471	—	1482, resigned
Thomas Sutbury	1482	1485	—
Richard Syngar, alias Wenloke	1485	1489	1521, superseded
Roland Gossenell	1521	1526	—
John Bayly	1527	—	1540, surrendered Christmas Day, 1553, died.

The site, says Mr. Blakeway, was granted to one Augustinis, whose name bespeaks him a foreigner. He was, perhaps, one of the king's physicians. He sold it in 1545 to Thomas Lawley, whose descendants again disposed of it to the family of Gage, from whom it passed to Sir J. Wynn. It is now owned by J. M. Gaskell, Esq., M.P.

THE RAVAGES OF THE LIMNORIA TEREBRANS ON CREOSOTED TIMBER.

By DAVID STEVENSON, F.R.S.E., M.I.C.E.

THE following is an abstract of a very useful paper recently read before the Royal Society of London:—

The author stated that it would be difficult to estimate the value of any chemical or mechanical process whereby timber might be rendered permanently impervious to the ravages of *Limnoria terebrans*, that small but sure destroyer of timber structures exposed to the action of the sea.

The ravages of that crustacean were first observed in 1810 by Mr. Robert Stevenson, the engineer of the Bell Rock Lighthouse, in the timber supports of the temporary beacon used by him in the erection of that work. Having forwarded specimens of the insect, and of the timber it had destroyed, to Dr. Leach, the eminent naturalist of the British Museum, Dr. Leach, in 1811, announced it as a "new and highly interesting species which had been sent to him by his friend Robert Stevenson, civil engineer, and assigned to it the name of *Limnoria terebrans* (Linnean Trans., vol. xi. p. 370; and Edinb. Ency., vol. vii. p. 433).

* Parker, in his account, altogether avoids mentioning these, although he shows them in his plan. The scale of my plan is too small to show them. The front of the Bablake College, Coventry, has a very similar two-storied corridor, with a similarly disproportioned roof. This is figured in the sixteenth part of Dollman and Jobbins's 'Analysis of Ancient Domestic Architecture.'

† Mitred Abbeys, ii, 192.

‡ Monasticon, v, 74.

§ Ib.

‖ The drawings, upon the death of Mr. Caley, were purchased by Mr. Thorpe, bookseller, in Piccadilly, and by him dispersed to various purchasers.

* Paisley was one of the priories affiliated to Wenlock.

The *Teredo navalis*, which was a larger and even more destructive enemy, was happily not so prevalent in northern seas as the Limnoria.

Experiments made at the Bell Rock by Mr. Robert Stevenson extending over a period of nearly thirty years, the detailed account of which was given in Mr. Thomas Stevenson's article on Harbours in the 'Encyclopædia Britannica,' had clearly proved that teak, African oak, English and American oak, mahogany, beech, ash, elm, and the different varieties of pine, were found sooner or later to become a prey to the Limnoria. Greenheart oak was alone found to withstand their attacks; and even this timber was said in some instances to have failed.

Mr. Stevenson's experiments also included the testing of the artificial processes of Kyan and Pain, the former being an injection of corrosive sublimate, and the latter of proto-sulphate of iron. Timber prepared by Kyan's process was attacked in two years and four months, and in four years and seven months was quite destroyed. Timber prepared by Payne's process was attacked in ten months, and destroyed in one year and ten months.

The justly approved creosote process, patented by Mr. Bethell, had been largely employed in railway works, with universally admitted success; and, in common with many of his professional brethren, the author adopted it in several marine works, in the expectation that it would prove an antidote to the Limnoria; but having now ascertained beyond all doubt that creosote was not a universal or permanent preservative of timber used in marine works, the author proposed in the present notice to state briefly the facts on which this opinion was grounded.

Before doing so, however, he wished it to be distinctly understood that he did not undervalue Mr. Bethell's highly important invention as a preservative of timber against all ordinary decay incident to railway sleepers, timber viaducts, and indeed all timber structures not exposed to sea-water infested with the *Limnoria terebrans*. His remarks referred exclusively to its application for marine works below half-tide level. For all other classes of works he believed it to be a most valuble preservative.

In 1859, in a discussion which followed a paper on the "Permanent Way of the Madras Railway," at the Institution of Civil Engineers, the author first stated that there were distinct evidences of the attack of the *Limnoria terebrans* on creosoted timber used at Scrabster Harbour, in Caithness; while Mr. Bethell the patentee, and others, expressed their conviction that creosoted timber could not be perforated by any worm or insect.

Subsequent experience and observation have satisfied the author that the statement which he then made was correct; the fact, as now ascertained, being that thoroughly creosoted timber is, in certain situations, readily perforated by the *Limnoria terebrans*.

The first instance to which he referred was the pier at Leith, which was executed about 1850, by the late Mr. Rendel. The whole of the timber employed was creosoted on the spot in the most careful manner. As the piers at Leith were washed by a constant admixture of fresh water from the Water of Leith, the author expected that the progress of devastation at that place would be so slow as to be hardly appreciable on creosoted timber. But having carefully examined the West Pier, he corroborated the evidence given by Mr. A. M. Rendel in 1860, before the Select Committee on Leith Docks Bill, that notwithstanding the most careful application of creosote, the timber work has been attacked by the insect to a great extent.

The second case to which he referred was Invergordon. Two steamboat jetties were constructed at that place from designs by Messrs. Stevenson. It was generally represented that there were little or no traces of marine insects in the Cromarty Frith, and it was resolved that it was a situation peculiarly suitable for employing timber pile-work protected by creosote. The timber used in the work was carefully selected at Leith, and dressed to the necessary scantlings and lengths, so as to avoid all cutting after it had undergone the process of creosoting, It was then creosoted by an agent sent by Mr. Bethell for the purpose, at the sight of a careful inspector employed by the engineers. Every piece of timber was weighed before being put into the tank, and the process of creosoting was continued until each piece had received, as nearly as possible, the specified quantity of 10 lb. of oil per cubic foot. Some experimental pieces were from time to time cut longitudinally, when it was found that the creosote had entered the ends of the logs 18 inches to 2 feet, and that it had saturated the timber some two or more inches all round. No greater precautions could possibly be used to insure perfection in carrying out the process, which involved an additional cost of about £450. The jetties were erected in 1858, and now the superintendent's report was, "that the blackened or creosoted portion of the timber is very much eaten and perforated. The timber perforated is just as it came from the creosoting tank, never having been cut. There is 1¼ inch wasted on some of the piles that have been perforated."

The third case to which he referred was Scrabster, which was also constructed under Messrs. Stevenson's directions. The timber employed in this instance was selected Memel of first-rate quality; it was carefully creosoted at Glasgow. On cutting up a timber that had been attacked by the Limnoria, it was found that the creosote had fully entered at the ends, and saturated the sides, and yet it was discovered to have been attacked after it had only been exposed thirteen months,—the insect perforating the blackened timber The whole of the creosoted portion of the timber work was now more or less worm-eaten and destroyed. Mr. Leslie had also directed the author's attention to similar results at Granton and Stranraer, at both of which places the creosoted timber had been perforated.

The author held that these instances were enough to prove that the failure was not peculiar to one spot or one isolated case. If it was said that the timber used at these places had not been properly creosoted, it might fairly be concluded, that if the process, even when conducted in the patentee's own works, to the satisfaction of careful inspectors, was so difficult and uncertain in its results, its general applicability would be greatly injured. All newly creosoted timber, whether it was well or ill done, presented the same appearance externally; and it was only by weight that the completeness of the saturation could be judged of; and if careful weighing before and after the timber had been creosoted was not to be held as an ample and satisfactory test that the process had been properly conducted, it seemed hopeless to expect that perfect satisfaction could be attained. But it was so far fortunate for Mr. Bethell's system, that it was not needful in the cases to which allusion had been made to call in question the extent of saturation which his process secured when properly executed. The timber at Scrabster and Invergordon, and he believed at the other places named, was undoubtedly thoroughly and properly saturated; and the author said that the explanation of the failure was to be found in the fact, that the Limnoria *perforated timber which had been thoroughly creosoted and blackened*—a fact which at once disproved the assumption, hitherto so generally made, that the poisonous nature of the creosote would prevent the insect from attacking it. As the Pholas perforated stone to procure shelter, the Limnoria might excavate timber for the same purpose, and obtain its food from the minute animalculæ with which the water of the ocean was charged. Dr. Coldstream, in his elaborate paper on the Limnoria in the 'Edinburgh New Philosophical Journal' for April 1834, had concluded that the Limnoria fed on the timber, and not on animal substances; but even if this were so, there seemed no reason to conclude that creosoted timber could not be eaten by insects, on account of the poisonous nature of the preparation employed. The author stated, that it had been ascertained that there were insects that lived and fattened on food that was to man a deadly poison. In the 'British Medical Journal' for April 1862, there was an interesting notice on the subject. Mr. Attfield had there shown that substances which are intensely poisonous to the higher animals do not affect Acari, which he found not only readily ate, but actually fattened on strychnine, morphine, and other deadly poisons. But the author stated that the specimens which he had laid before the Society proved conclusively that creosote does not act as a poison in preserving the timber, because it could be seen that the Limnoria were embedded in wood still highly charged with creosote.

After carefully considering the subject, the author had no doubt that the process of creosoting preserved timber from the attack of marine insects only so long as the oil existed as a film or coating on the outside of the timber. Whenever the attrition caused by the motion of the sea removed this outer film or coating, and exposed the fibrous surface of the timber, the insect would then attack and perforate it, whether it were creosoted or not, its search being for a fibrous substance in which to burrow. The time that might elapse before the timber became assailable to these insects depended on the situation. Wherever there was little abraiding action of the sea, the exterior film of creosote might be longer preserved; and where there was a considerable admixture of fresh water to check the growth, or at least the avidity of the insect, the effect of their ravages might be more gradual, or, in some situations, almost inappreciable. But the result of the author's observation and experience led him irresistibly to the conclusion, that on the northern shores of the country, where works are exposed to the open sea, creosoted timber was readily perforated by the Limnoria, and could not be safely employed in any important part of a marine structure at or below half-tide level, a fact of great importance to the civil engineer.

ON THE FORMATION OF A NATIONAL MUSEUM OF ARCHITECTURE VIEWED IN CONNEXION WITH ITS BEARINGS UPON MEDIÆVAL ART.*

By George Gilbert Scott, R.A.

Having been somewhat actively concerned in the first establishment of the Architectural Museum; and the collection there made having been, either temporarily or permanently, deposited in the hands of a Government department, who are supposed to have in contemplation the formation of a National Museum of Architecture; I have thought it not out of place to offer some suggestions as to what such a National Museum ought to be; but in doing so, to direct my attention more particularly to that part of it in which I feel most interest,—that which would illustrate the architecture and the arts of the Middle Ages.

A museum may be defined as a depository in which objects illustrative of science and art are collected and exhibited for purposes of instruction and study.

Its great uses are to facilitate the studies of those who cultivate the arts and sciences which they illustrate, and to excite interest in them in the minds of others. They have also a secondary use, as being places where objects of interest, which would otherwise be likely to be lost or dissipated, or to perish from decay or other causes, may be cared for and permanently preserved.

When the museum is public or national, it performs, or should perform, these duties on a grand scale, and for the use and benefit of the public.

Limiting our consideration to a museum of art, I would say that its directors ought to devote their energies primarily, to collecting such objects as are worthy of the study to the practical student of art, and as would tend to form the public taste upon a true and healthful standard. Secondarily, to the illustration of the history of art in its various schools and periods; and, thirdly, to the conservation of such movable specimens as would otherwise be in danger of being lost or destroyed, provided such works are of actual merit, or of value as bearing upon art-history.

Concentrating, again, our attention upon architecture and its subsidiary arts, let us endeavour to apply to it the general rules above stated. An architectural museum should illustrate the history of architecture; and it is hard to conceive of anything more interesting than a collection which would really and honestly perform so noble a duty.

The history of architecture is the history of the world; it is the history of the changing power and dominion of races and nations; it is the history of human thought, and of the growth, the fluctuations, the decay and the revival of human civilisation; and worthily to illustrate such a subject would be indeed a noble undertaking! This should not, however, be the primary aim. The great and vital object to be aimed at is the actual promotion of art amongst ourselves; and it is to this object that the best energies of those engaged in such a work should be directed. In the first place, it is pretty obvious that while illustrating in their degree other classes of architecture, such a museum should be mainly devoted to the two great classes of architecture which are actually practised amongst ourselves, and which are familiarly, though somewhat unmeaningly, known as "Classic" and "Gothic."

It may be asked why these two classes of art should be selected from among the multitude which have prevailed in different ages and countries. Is it merely from the accident of their chancing to be practised by us at the present day? By no means. The reasons are founded both upon history and upon intrinsic merit. Classic architecture founds its historical claims, firstly, upon the great fact that it originated among those nations of antiquity whose glorious privilege it was to unite in one main channel the several streams of the civilisation of the ancient world, to collect and concentrate all that was worthy of perpetuation in its previous course, and to bring it, with its arts, sciences, and literature, to the highest perfection which they attained; and, secondarily, upon the fact, not much less important, that what remained of the civilisation of these favoured nations of antiquity supplied the germ from which a second civilisation sprang—that of which we now enjoy the blessings.

Gothic architecture, on the other hand, founds its historical claims on the fact that it is the indigenous architecture of that family of nations to whose custody that new civilisation was committed, and that it belongs to ourselves as a leading member of that family; and that, though it has for some centuries been superseded by the revived architecture of the ancient world, it is now, in its own turn, revived by those nations among whom it originated, and is familiarly used by them side by side, and on equal terms, with that which had for a time supplanted it.

I will not dwell upon the former of these branches of art, but will now concentrate my attention upon that in which I personally feel the greatest interest; and the illustration of which through the medium of a national museum is the subject of my present paper.

I will first state what often seems to be lost sight of; that it was not the historical claims of this style of architecture—strong though they are—which brought about its revival. Its opponents often seem to suppose the converse of this, and to think that by directing their arguments against those claims they shall undermine a movement which, gloriously supported though it is by historical claims and associations, originated wholly in an appreciation of the merits and beauties of the architecture, and its suitableness to our wants. On this subject, however, I will not dwell further than to say, that if you do not feel the beauties and perceive the intrinsic merits of this wonderful style of architecture, I fear it would be hopeless for me to attempt to convince you of them. If you wish to know my views on this point in detail, I will take the liberty of referring you to the first and the last of my lectures at the Royal Academy. They are reported in the *Civil Engineer and Architect's Journal*, and elsewhere, in March and April, 1859.

Now let us digress for a short time to consider what are the means by which a practical art-like architecture is to be most successfully learned, and its advancement best promoted.

Architecture, it should never be forgotten, differs from the sister arts of sculpture and painting in this great and most important quality: that its productions are not the actual handiwork of the leading artist himself, but that it unites under its banner not only its two noble sister arts themselves, but also an almost innumerable train of subsidiary arts, each of which contributes its quota towards the perfection of the architect's work, and vies with others in rendering it noble and magnificent. When we speak, therefore, of architectural instruction we mean not only that of the architect himself, but of all the artists who work under his banner.

It is a general fault in England, at the present day, that those who follow a practical art take too low a view of its artistic as distinguished from its practical element. Thus, with our manufactures, the workmanship is often excellent, the taste very rarely so. Our artisans are often giants in mechanical skill, but pigmies in art.

The same has been the case with the arts subsidiary to architecture; and, though a great revival has taken place, those who have advanced the most best know how great is still the need of reformation.

This reformation must however begin at the fountain-head. The same precedence of the mechanical over the artistic which has obtained amongst our manufacturing and our architectural workmen has existed also amongst architects themselves. We do not wish to be less practical—far from it—but to be more artistic; and, if we aim at raising the architecture of our day as an art, we must begin by giving a more distinctly artistic tone to the education of our architects. The absence of any recognised and defined facility for obtaining the class of instruction required to supply this very general need is one of the greatest hindrances to the advancement of our art. The Institute of British Architects have been considering for a long time past the organising of a severe examination of young architects; but they have never, to my knowledge, taken any step to aid their education. The junior institution (the Architectural Association) have in some degree taken the matter up, and have established classes for mutual improvement: a step worthy of all praise, and the furtherance of which merits the serious attention of every lover of architecture.

* Read at the Architectural Museum on the 17th ult.

If there are present any students of architecture, let me earnestly and seriously press this subject upon their attention. In an architect's office you can learn the more mechanical and business-like parts of your art, and you there—and there alone—learn the application of such artistic skill as you may possess to actual and practical work; but that artistic skill itself must be acquired elsewhere, and by your own individual exertions. I wish it however to be distinctly understood that the artistic skill I am speaking of relates to applied, not pictorial art; that which will make your buildings noble works of art, as distinguished from that which only enables you to make pleasant pictures of them. This last-named class of art is not to be despised. It will further your interests; if you are also an artist, in the higher and more practical sense, it will do good by commending your good designs to public favour; while if you fail in skill of this higher class, it will do great harm, by obtaining favour for your bad designs.

When real architectural art was highest, this pictorial power was not much cultivated. It is not infant architectural skill, but only the means of promoting the adoption or the approval of your designs, whether good or bad. As bad designers often possess it, or can obtain its aid, do not by any means neglect it, or you will give them an advantage over you; but always remember that, like eloquence, it is a mighty engine of good or evil, according as that which it commends to popular favour is noble or vile.

The artistic power, however, which I am urging you to cultivate is the power of making noble designs, and of clothing them, when circumstances permit, with noble decoration, whether in the form of architectural carving, sculpture, painting or other decorative art. The first part, the parent of actual architectural design, cannot be acquired without the most careful, determined, and continued study of existing works, accompanied by a constant, though not a self-confident, criticism of their merits and their faults. It is ridiculous to suppose that such an art as architecture is to be learned without the most careful study of its existing productions, or that originality is likely to be developed upon a basis of ignorance; and it is equally unlikely that excellence will be attained solely through the medium of knowledge, without the most jealous and careful training of the eye to the most delicate and scrupulous perception of the right and the wrong in form and proportion. The want of this is the most crying sin in modern architecture, especially, I fear, in this country. Continually is the more cultivated eye offended by discords which in music would set the very teeth on edge. I know not how to advise you on this point. This delicacy of perception is in some degree intuitive; but that it is not wholly so is proved by the fact that the works of some periods are nearly all harmonious, while at other periods this harmony seems only occasionally to have been attained. The only rule I can suggest is the jealous cultivation of the eye. As the greatest of moralists has said, "Keep thy heart with all diligence, for out of it are the issues of life;" so may one say to the architect, "Keep thine eye with all diligence, for out of it are the issues of art." Never allow your eye to get accustomed to, or to condone, errors of proportion even, in works which in other respects you venerate for the noble art which clothes them; and much less allow of any deliberate error in your own designs. To avoid these blemishes, sketch your designs over and over again, no matter how slightly and roughly, rejecting rigorously everything against which the eye rebels, and never permitting a proportion which it has once condemned to remain even for a minute before you; for ocular perception is most delicate, and its instincts may be blunted by dwelling even for a few seconds upon what its first impression saw to be wrong. Never clothe a form with detail or with pleasant drawing till its proportions have been thoroughly sifted and rigorously corrected; and if you fear that you have, by dwelling too long or too indulgently upon what you have sketched, prejudiced your eye in its favour, put it away, and attend to something else, or take the opinion of some unprejudiced person in whose correctness of eye you have confidence; for first impressions of another will often correct your own.

As to obtaining a knowledge of architecture, I cannot too often or too strongly urge careful sketching from first-rate examples. The student of Classic architecture is under a disadvantage, as its original and best examples are in other lands; but with those who pursue the other great branch of architectural art, the case is very different; for though, in most parts of Europe, he will find constant and ever-varying objects of study, he can never go far from home without finding among the monuments of our own country productions equally deserving and equally instructive. To the student, then, of Gothic architecture I would concentrate my advice on this point in one word—"SKETCH." And if anyone advises the neglect of this, I assure you that he stands *ipso facto* self-condemned as a false teacher. I want you, however, to add to this a great deal more. I want you to obtain distinct and precise instruction in art in all its bearings upon architecture. I want to urge upon you to study figure-drawing, animal-drawing, the drawing of foliage whether natural or architectural, the combination of figures and animals with foliage, the designing of coloured decoration in all its branches, and of every other decorative art which bears upon architecture. I want to urge upon you the necessity for the systematic learning of all these kinds of drawing, and the obtaining of a perfect mastery of them; and not only this, but that you should learn, in some degree at least, the actual practice of these arts. Human life is not long enough to do the latter thoroughly; but now, in the days of your youth, you can do it to a certain extent, even at the sacrifice of a few frivolous amusements. You have embarked on a noble art,—make its cultivation take the precedence of all inferior pursuits. To effect this, I am disposed to think that combination is necessary. A society of students might be formed, and aided by others, for obtaining the best instructors in all these branches of art, which each student singly would find impossible. I earnestly commend this to your united consideration. And above all, do it at once, or your own individual share in the coming reformation will be lost.

I will only add one piece of advice to young architects:—Do not make *opinion* a substitute for art. There is at all times an ever-varying set of opinions afloat as to matters of art; and those who ride on the wave of the last-received opinion of their party, be it good or bad, are apt to be viewed by themselves and their companions as oracular, quite irrespective of their own attainments or skill. What I would, then, say is this:—Hold what opinions you like, so long as you make yourselves artists, and you will come right in the end; but hold what opinions you like, if you neglect to make yourselves artists, you will never be good for much.

I will add another suggestion. Never let your appreciation of the demerits of the present age in matters of art lead you into a sneering, supercilious, and contemptuous way of speaking and thinking of what you see; but rather let it impel you onwards all the more vehemently in making yourselves exceptions to the censure you pass upon others. We continually hear persons speaking in a discontented and hopeless tone of contempt of what others are doing, without exhibiting any very strong signs of exertion to acquire real powers of art themselves. I urge you to reverse this habit, and learn to think kindly and favourably of the efforts of others, while you keep up a rigorous censorship over yourselves. And make all you see in others, whether of success or of failure, act as only so many incentives to the determined pressing forward of your own artistic training.

What I have urged respecting the artistic education of the architect himself, applies almost precisely to that of the architectural art-workman. He has an easier task, because his efforts are concentrated upon a single art; while, on the other hand, he suffers severely from his very limited facilities of obtaining instructions and of seeing objects worthy of his study. The aim, however, is precisely the same; and I would say to the art-workman, as to the architectural student, make yourself really an artist; jealously cultivate a delicate accuracy of eye; diligently study the finest productions of your art in its best days; and add to all this (or I would rather say, unite with it, and thoroughly mix up with and knead into its very substance) a constant, devoted, and loving study of the productions of nature, whether animal or vegetable.

I think, with art-workmen as with architectural students, the greatest hope of obtaining a real artistic training would be in combination for self-improvement—a clubbing together to obtain instructions in drawing, &c. I would especially urge the cultivation of figure and animal drawing. In this our carvers, &c. are the most deficient, and to this they should direct their best attention; not so much with the direct object of becoming figure sculptors, as to facilitate the free introduction of animal life in combination with architectural carving, a power which our best carvers very rarely possess, but which is absolutely necessary to the perfecting of their art.

Now with the actual student, as distinguished from those who have made a certain degree of proficiency, there can be no doubt that the best training is frequent and careful copying (whether by drawing, modelling, or carving) from models of undoubted merit. Every art is acquired in the first instance by submitting implicitly to routine: no one would believe that the mechanical drilling which a soldier has to go through would do much to teach him actual fighting, yet it is found practically that success absolutely depends upon it; and so well did the ancient Romans know this, that—as Gibbon, I think, remarks—they called their army by a name not derived from their ultimate duty of fighting, but from their preparatory duty of exercising.

No one, again, would believe that the dumb-show called "position drill" would make a man a good rifle-shot; and a thousand parallel cases could be instanced to show how skill in any pursuit is to be attained by submitting for a time to what may be accounted as drudgery. Art is not an exception to this rule, and I would recommend its younger students (and perhaps others, if they have not already passed through the ordeal) to put themselves through a diligent course of the most careful drawing or modelling from the best examples they can find, before they venture upon a freer line of study. By this they will attain a correct appreciation of truthfulness of line and of the importance of precision of detail, and they will find that it will greatly facilitate their future and less mechanical studies, and in the end promote, rather than fetter, originality.

It may appear that I have been departing widely from the subject of my paper; the very contrary is the case. It is useless to treat of what a museum of architecture should be without first considering its necessity, and the uses it is to serve. I think what I have said respecting the art-education of architects and architectural workmen will make this pretty clear.

Architectural students may, it is true, visit the actual buildings which contain the objects of their study: they must do so indeed, and they do it; but, even with them, it is impossible to do this so often and so systematically as to form the staple of their studies. They need, in addition to this, facilities for constant practice and self-tuition; they want a place where they may continually refer to the finest examples, where they may pursue their studies and practise their hand and eye continually, and on all occasions when a spare hour is at their command.

And if this is so necessary for the student of architecture,—nay, for the architect himself,—how greatly more pressing is its necessity to the art-workman! Instead of wondering and saying ill-natured things about the deficiencies of our carvers, &c., it seems to me half miraculous that they should be able to learn their arts at all. Those who have aimed at Classic art would never have seen its original productions at all, were it not for the specimens collected in museums; and even those who follow the Gothic revival, though its original productions are around us, have usually neither time nor money for visiting any but those buildings immediately within their reach. This is still more emphatically the case with the young apprentice. His time is not at his own disposal, and the only opportunities he has for self-improvement are his evenings.

The formation of the Architectural Museum in 1852 was the first and has been the only step taken to aid him. Till we, the architects, who every day of our lives witnessed and experienced this pressing need, came forward ourselves to supply it, nothing was done to aid the neglected architectural workman, and to this moment we, in the main, stand alone as his helpers.

I do not wish to boast of what we have effected, but it would be unjust to our great cause to abstain from asserting that the good done by the formation of the Architectural Museum is beyond all calculation. From the time it was first opened in Canon Row, the improvement in architectural carving became most marked and indisputable; and the same influence for good was visible among such architectural students as availed themselves of it. Its influence has been somewhat reduced by the remoteness of its present habitation, but it still continues; and I think I see means of meeting this unavoidable disadvantage. It was our limited funds which led us to take up our quarters at South Kensington, and the same course has rendered us powerless to resist a series of circumstances which have brought us more directly than at first under the *régime* of its autocratic government. If that governing body should take up our work for us, and carry it out with a true appreciation of its importance and its necessity, we need not feel ourselves annoyed at the transference of our powers and our labours to a body so richly endowed with worldly goods. I warn them, however, with all seriousness, of the responsibility they incur. They have done their utmost to render practically powerless a body of men who, at a great sacrifice of time and money, have come forward to a work of the most urgent necessity, which the Government had always refused to do. They have the pecuniary means for carrying on this great work. If they neglect to do it, if they do it inefficiently, and if they refuse the aid and advice of those who have launched the Museum into existence, they are, in their own individual and personal reputation, answerable to the public and to posterity for the consequences. If, on the other hand, they will take it up in all honesty and heartiness, I can only say that we shall rejoice to aid their efforts in every possible way; and that they will, personally as well as collectively, earn the lasting gratitude of all who care for our noble art.

I cannot however omit here, respectfully, though in the most emphatic and in the strongest manner, to protest against any attempt to dismember our collection, otherwise than with the full permission and consent of those who have formed it. A collection like this must of necessity require periodical revision. That revision, however, must be effected by, or in full consent with, those who made the collection. I have personally taken an active part in doing this, and I will never consent to have it dismembered by parties who have taken no part in its formation.

I further enter my firm though respectful protest against any attempt to prevent us from increasing our collection as heretofore. We as architects have continual opportunities of adding specimens to our collection, and I protest against any attempt to deprive us of the power of doing so. I have no objection in all these matters to mutual and friendly co-operation, but I will never consent to abdicate our powers of adding to our store so long as we exist as a committee, and continue possessors of the collection. It is our best and our dearest privilege, and it will be treason to our cause to relinquish it.

In illustrating architecture through the medium of a museum, I should lay down, as a primary and fundamental rule, that it must mainly and on strict principle be effected by representations, rather than by collecting the actual works of art themselves. There are exceptions to this; but in case of each of such exceptions the onus lies upon the collector of proving the propriety and lawfulness of his departure from the rule, and of clearing himself of the charge of encouraging spoliation. Architectural objects belong to their own sites; and even where severed from their actual position in the building of which they formed parts, they ought as a rule to be preserved either on its site or in its vicinity, that their local associations may not be lost.

I call special attention to this, because I fear that a feeling exists in the minds who direct our national collections that plaster casts are worthless and contemptible objects, and are almost unworthy of admission; whereas, on the contrary, it is the actual objects of art that demand apology; and I will boldly say that any actual architectural objects in our own museum I would gladly see returned to more local habitations, if such can be shown to exist; and, at the risk of being pronounced a barbarian by the curators of the British Museum, I would almost go so far as to say that I should feel a satisfaction in learning that the Elgin marbles were to be restored to their places in the Parthenon, and that our great Museum should be content with casts of these glorious masterpieces of art, though perhaps made in some material more durable than plaster.

I will roughly classify the objects to be illustrated as follows:—

1. Actual architecture, by which I specially mean stonework, whether in the form of mouldings or other mechanically-formed details, or of architectural carving.
2. Sculpture forming a part of, or intended expressly as an accompaniment of, architecture.
3. Woodwork forming a part of, or connected with architecture.
4. Metal-work belonging to architecture.
5. Architectural decorations, whether inlaying, mosaic work, painting, or other cognate form of art.
6. Painted glass.
7. Pavements, whether of tile, mosaic work, or otherwise.
8. Monumental slabs, whether as brasses, incised sculpture, or inlaid stones.
9. Miscellaneous objects.

Each of these classes includes all its chronological and national varieties.

On the first class (actual architecture) I will first remark that it is not, as a general rule, necessary to go very far in illustrating its more mechanical forms, such as mouldings, &c., though a collection of them belonging to buildings of different dates would be highly useful. Generally, however, the architect may study these sufficiently from the actual buildings, and their sections can more accurately be represented on paper than in plaster. It is, however, of the utmost importance to obtain casts of them wherever they come in contact with sculpture or foliage, and where they are enriched in any degree by carving. Thus, where a cast is made of a capital, the abacus, a portion of the shaft, and perhaps a short length of the arch mouldings which it sustains, should in many cases be cast with it, so as to illustrate it as a whole, and that the art-workman or student may see the carved work in connexion wilh its natural accompaniments. Again, where certain orders, or parts of arch mouldings, are enriched with carving or sculpture, those not so enriched should be represented with them, that the grouping of the whole should be represented, and the mutual influence of the plainer and more ornate parts one upon another may be illustrated.

I have thought it necessary to premise with what is properly only a matter of detail, by way of limiting the vastness of the field which is open to us; for, so endless is the variety of our style and the richness of its resources, that a collection which would worthily illustrate it will occupy a somewhat inconveniently large space. In forming however an Architectural Museum on a scale worthy of being called national, great space is an absolute necessity; and it is of little use to make the attempt without boldly facing this primary fact.

It is known only to those who have for years been in the habit of visiting and diligently studying and sketching from ancient buildings what an inexhaustible fund of exquisite and ever-varying art we have to draw from; though it is not by any means easy to obtain the specimens most needed. It is, in fact, in many cases only through the intervention of the architects engaged in the repairs, and only when repairs are going on and scaffoldings erected, that the most valuable works in our great buildings can be reached; while in buildings of a humble class it is architects alone who know where such works of art are to be met with.

One great distinction between a national museum, for which considerable funds could be procured, and a private one like our own, is that much larger objects can be obtained. It is often most desirable to possess casts of entire doorways, or their sculptured tympana, tombs, reredoses, &c., so as to show the work as a whole, instead of in a number of small and disjointed portions. A private society like our own can very rarely do this; but in a museum supported by public funds, it would readily become practicable; indeed, the largest of such objects would not, perhaps, cost more than is sometimes expended on a single specimen of majolica.

It is not, however, our own architecture alone which must be illustrated. The contemporary art of other countries has equal demands upon us; nay, in one sense greater, inasmuch as, if our art-workmen find it difficult to visit our own architectural monuments, they will find it impossible to visit those of foreign countries.

The Gothic architecture of France is the elder sister of our own; and, if not more beautiful, possesses beauties and varied expressions of its own, which must ever secure to it the earnest love and devoted admiration of every student of Mediæval art. Our own architecture can hardly be correctly understood without a knowledge of that of France. Their origin, development, and history are so linked and entwined together, that without the knowledge of both they cannot be fairly studied or appreciated. France, too, took the first place in art—as in arms—amongst the nations of Mediæval Europe. Her art productions may, therefore, be viewed as the normal types of Gothic architecture; and as such they claim a full illustration in a museum of the architecture of those periods; and there is a boldness and nobility of treatment about them which especially commends them to the most diligent study of the architectural student and workman.

French architecture must therefore, in such a museum, be illustrated as fully and as voluminously as our own; nor can I conceive of any field of illustration so glorious or so eminently useful as this.

The Mediæval architecture of Germany and of Italy has claims only second to those of France. Indeed time would fail to enumerate in the roughest manner the glorious works which should find place in such a museum.

They must illustrate each element of architectural ornamentation and detail throughout its chronological course, and through the several countries where our architecture prevailed; giving, however, a due preponderance to the best periods, the best examples, and the countries where the art possessed the finest characteristics.

The period claiming the greatest amount of illustration, at least in Northern Europe, may be roughly said to embrace two centuries,—viz., the great thirteenth, and a moiety of the preceding and succeeding centuries; that is to say, from A.D. 1150 to 1350. Earlier and later periods must be fairly represented; but this interval contains the real vigour—the pith and marrow of Mediæval art.

Mediæval architecture demands however, for its elucidation, that certain styles which preceded it and from which it drew its first inspiration should also be duly illustrated. I refer to the Byzantine and the Italian Romanesque: each including the branches by which it was led through other countries, and especially through Germany and France, with the changes it underwent by the way.

I have taken some pains in my lectures, delivered at the Royal Academy in 1858, to show how direct was the influence of Byzantine art upon the architecture of France in the twelfth century. The foliage and the figure-carving, so well known in the earliest French Pointed works of the latter half of that century, are for the most part directly derived from Byzantine carving and drawing, with a certain degree of influence from Italy, which was herself drawing freely upon Byzantine art. It is clear therefore, that to illustrate Mediæval architecture properly we must possess ample specimens of these its parent styles.

The classification of specimens may be divided into those which are elementary and those which are in a less and in a greater degree combined into complete and applied architectural features. Thus we must illustrate in its more abstract form the history and progress of architectural foliated ornamentation; showing how it had taken, during the darker ages, that strange form which is sometimes designated as Runic (though whence derived it is difficult to say); how this was long used side by side with foliage derived from debased Classic remains; how a distinctly Byzantine tone was imported into the art, during the twelfth century, both in France and Germany; how this in process of time developed itself into a new and original style of foliage, such as we find in France, England, and Germany, in the earlier years of the thirteenth century—the noblest and the most perfect conventional and architectonic ornamentation which has, perhaps, ever been generated; how by working this gradually up towards nature, the artists at length fell back implicitly upon Nature herself: first using natural foliage of the most exquisite kind imaginable side by side with the architectonic, and at length to its exclusion; and how at length a new and inferior conventionalism supplanted it—a conventionalism of departure from, as the other had been one of approach to, nature.

In the same manner we must illustrate the accompanying progress in animal and figure sculpture: how the barbarism of the northern nations during the dark ages became gradually enlightened by an infusion of Byzantine art; how this art gradually softened down its rigid severity and gave way to the noble sculpture of the thirteenth century,—imperfect in academic correctness, but full of noble sentiment and of high aspirations after artistic perfection, unhappily not at that time fully realised, but which it is our place—would that it may be our lot—to carry forward to its legitimate results.

Then we must illustrate the history and use of these as applied to architectural features; we must show the historical progress of foliated capitals,—in itself a wide subject of historical and artistic inquiry, and of study for our own actual use and instruction: we must, in the same way, show the history of foliated enrichments in mouldings, arches, cornices, and all architectural details to which it is applied: the development and changes in surface ornaments of all kinds, and of the union with all these of representations of animal and human life. Then we must, in larger specimens, show these elementary details combined into greater architectural compositions, and united more directly with figure-sculpture. To do this we want, as I have already stated, complete casts of entire doorways, or, where impracticably large, of portions of their arches, of perhaps their entire jambs, and their sculptured tympana; casts of celebrated tombs, of pulpits, of fonts, &c. Then, again, we want the history of niches and tabernacle work—itself a most fertile subject, and demanding casts often on a magnificent scale: we want the history of crockets, finials, foliated crestings, and a thousand other architectural elements which it is impossible in such a paper as this to enumerate. The work before us is a truly glorious one, and it only requires to be taken up in a spirit worthy of its claims to make the result in the highest degree noble and beneficial. I must however add one word,—that casts alone will not do all which is wanted: they must be accompanied by photographs, and often by measured drawings.

ON THE LAYING OUT OF RAILWAY CURVES.

By Thomas Cargill, C.E.

A great deal has been written from time to time, and much valuable information afforded by various scientific men, on this important subject, but as yet, I believe, no fair comparison of the relative merits and demerits of the different methods generally employed in laying out railway curves has ever been placed before the professional public. This may partly arise from the fact that authors and inventors are naturally more inclined to laud the infallibility of their own productions than to award what is due to the claims of others. I propose in the following investigation to give a short description of the most useful methods for accomplishing the above purpose, and to point out, as far as I am able, their relative advantages and disadvantages, leaving the reader to form his own practical conclusions on the subject; it being certainly a matter of some consideration to an engineer, engaged, perhaps for the first time, in staking out some ten or twelve miles of a line, to be enabled to form a correct judgment respecting the best means to accomplish his object with accuracy and economy, without inconsiderately sacrificing one to the other.

The ranging the straight portions of a line is so simple an affair, that with ordinary care and attention an error is scarcely possible; it is in the curves that errors are liable to be made, which are often not perceived until half the curve is laid out, and even sometimes are only discovered by the curve not coming in at its proper springing point; thus necessitating a repetition of the process of putting in the curve, and, in addition to the loss of time and labour incurred, the personal annoyance and vexation one experiences in being obliged to go over the same ground twice.

Of the numerous methods at present known, some have been furnished by scientific persons laying no claims to professional practice, and consequently are of a purely theoretical nature; while others, though practically available, are only calculated to meet the requirements of such very exceptional cases that their utility is exceedingly questionable; there are a few methods, such as Mr. Gravatt's and Mr. Froude's, which have been used at different times since their introduction in about 1840, but they have failed to come into any general use. Excluding all these as, for obvious reasons, unsuitable to the present subject, the remainder may be classed under two heads: 1st, the methods by offsets which dispense with the use of an angular instrument; and 2nd, the methods which require the use of such instruments, or the methods by angles as they have been called. In laying out curves by the former methods, the necessary instruments are, chain, ranging-rods, offset-staff, or tape where the offsets exceed 10 feet in length. In the latter the offset-staff is replaced by a theodolite (plain or transit), or a portable altitude and azimuth instrument might be used if a theodolite could not be obtained, though the preference should always be given to the theodolite as the proper instrument *par excellence* for laying out curves by the methods of angles.

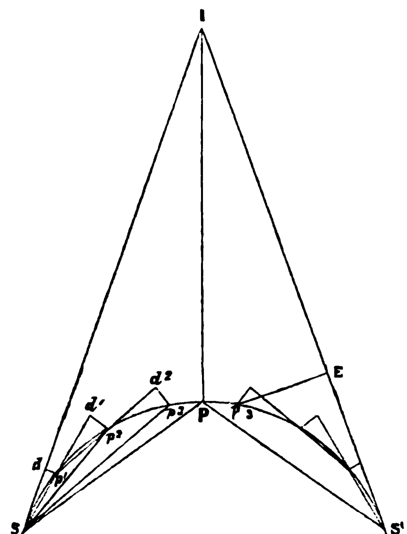
In the following investigation, I shall take Rankine's method as the best example of putting in curves by means of angles, partly because this elegant and generally useful method is becoming more and more adopted every day; and partly because the other examples of a similar kind which have come under my observation are based upon the assumption, that the springings (that is the commencement and termination of the curve), or each springing, and the intersecting point of their tangents, are visible from one another—a condition which rarely occurs in practice.

In the diagram Fig. 1, let S, S_1 be the terminations of two straight portions of a railway which are to be connected by the curve SPS_1; S, S_1 will thus be the two springings of the curve, P a point in the middle of the curve, commonly but erroneously called the secant point, and I the intersecting point of the tangents to the curve, or straight portions of the line. It may be observed, that in all the methods included under the first head, where no angular instrument is employed, the springings cannot be obtained with any great pretensions to accuracy, for they must of necessity be taken from the plan; and one cannot reasonably expect to go nearer the truth than 5 or 6 feet on the present scale of our parliamentary plans.

I shall suppose the staking out of the line to have been proceeded with as far as S, which will be the commencement of the curve or first springing, and that the stakes are driven at regular intervals of 100 feet apart, both in the straight and curved portions of the line; I shall also assume, for simplicity's sake, the point S to be at one of these stakes, although it is right to mention that, when the springings are obtained by the use of a theodolite—that is, generally, by observing the angle of intersection SIS_1 (Fig. 1), calculating the length of the tangent IS, and chaining to the point S—the chances are that it will never coincide with one of the 100 feet stakes; on the contrary, by the methods by offsets where S is assumed, it would be sufficiently accurate in the majority of cases, and far more convenient, to take one of the regular stakes as the springing, and thus save the calculation of an additional offset.

In Fig. 1, let p_1, p_2, p_3 be points in the curve 100 feet apart; and let us now examine the manner in which their positions are determined, confining our attention, for the moment, to the left hand half of the figure, which will serve to demonstrate the principles of Rankine's method and the common method by offsets. In the latter method the measured distances Sd, p_1d_1,

Fig. 1.



p_2d_2, and in the former Sp_1, p_1p_2, p_2p_3, are assumed equal to the arcs Sp_1, p_1p_2, p_2p_3. This is practically correct within certain well-known limits, and when necessary the error can be reduced, either by calculation, or by driving the stakes closer to one another—say 50 instead of a 100 feet; this however is not required except in very sharp curves.

By the method of offsets the point p_1 is obtained by chaining the distance $Sd = 100$ feet, and laying off at right angles the calculated offset dp_1; similarly the point p_2 is obtained by chaining p_1d_1 and setting off d_1p_2, and so on. By the other method, suppose the theodolite planted at S, the angle ISd_1 is laid off = angle for one chain, and the chain stretched from the point S; where it intersects the "line of direction" given by the instrument will be the required point p_1; the point p_2 is obtained by setting off the angle ISp_2 = twice the former angle, and intersecting the "line of direction" by the chain, one end being firmly held at the last obtained point p_1; and so on until the nature of the ground renders it necessary to remove the instrument to one of the stakes whose position has been previously determined, when the same process is resumed and continued to the end of the curve.

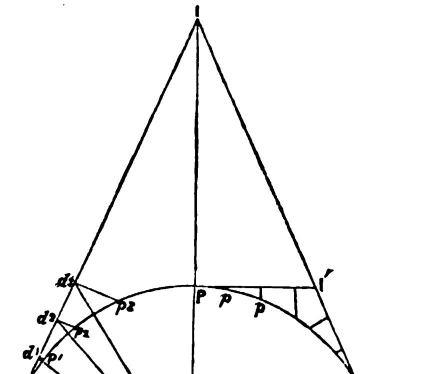
It is evident, at first sight, that, by the former method the position of any point in the curve depends absolutely and entirely on the position of the preceding ones; this however is not the case where the theodolite is used; for, take the point p_2 for instance, the "line of direction" of this point as given by the angle ISp_2 is totally independent of the position of the point p_1; and it should be observed that the "lines of direction" as I have called them are obtained with a precision peculiar to instumental agency, and to which the most practised and dexterous manipulation of the chain and offset-staff can never attain. It is true, notwithstanding this, that any error in the chaining would certainly produce an error in the position of the point p_2; but, in our present comparison, it is equally just to assume the errors incidental to chaining as common to both methods, or, what amounts to the same, to consider the chaining accurately performed, we then have the accuracy of laying off the offsets balanced against the accuracy of the theodolite; the difficulty of performing the former correctly increases with the length of the offsets employed; or supposing the measured distances constant, inversely as the radius; the reverse happens with the theodolite, for, as the angles to be laid off are thus increased, the "lines of direction" are, *à fortiori*, more likely to be accurate.

Progressive errors are common to both these methods, but the points P and S_1 act as certain and reliable checks in the latter, respecting both distance and direction; these checks are wanting in the former method, and in fact, all that can be done is to lay out the curve as accurately as possible, and take the chance of it coming in at the point S_1, which chance, especially if the curve be a long one, is very small indeed, as may be imagined, when the inventor admits that in many cases "the curve has frequently to be retraced several times before it can be got right."*

There are certain exceptional cases however, in which this method, on account of its requiring so few preliminary calculations and lines on the ground, is invaluable; for instance, where any intermediate stakes in a curve have been lost or destroyed, as frequently occurs during the progress of the works of a line; by simply producing the chords joining any two stakes, and laying off the correct distances and offsets, the missing stakes can be restored with remarkable ease and facility; also in road approaches, road diversions, &c., and all similar instances where the curve is short and great accuracy not required, this common method will be found very useful.

In order to obviate the progressive errors arising from using such short distances as one chain, greater lengths may be taken and the proper offsets measured from them, but, as the regular stakes would have to be put in afterwards, this modification of the preceding method, besides being liable to the same errors,

FIG. 2.



involves the absolute necessity of putting in the curve twice at least. The right-hand portion of Fig. 1 serves to show the demonstration of this; the errors due to progression being reduced by calculating the distance S_1E, so that the measured offset Ep_3 may serve as a check on the point p_3, one of the regular stakes to be afterwards filled in.

It may be urged as an objection to the method by angles, that a great deal of inconvenience and delay is incurred, in chaining the tangents IS and IS_1 (Fig. 1), in order to obtain the accurate position of the springings of the curve S and S_1; these points, however, may be accurately found in another manner whenever the middle point P in the curve is previously determined; for, let the instrument be set up over P and the angles IPS and IPS_1 laid off, each being equal to ninety degrees *plus* half the angle in the whole curve, which give us the "lines of direction" PS and PS_1, and all that remains is to produce them until they intersect the two straight portions of the line in S and S_1: the nature of the ground will be the best guide respecting which of these means should be employed for the above purpose.

Another example of the methods by offsets is shown in the diagram (Fig. 2), in which SPS_1 is the curve, and the remainder of the figure is self-explanatory; taking the left-hand portion of the diagram first, it will be seen that the distances are measured along the tangent line S_1, and the offsets measured perpendicularly, which, it is manifest, in long curves of small radius, would assume such lengthened proportions as to render it impossible to lay them off accurately: were our railways now constructed on the same principles respecting curves as the Great Western and a few other lines, there would be no fear of this result; but unfortunately, in the present system, curves of three-quarters and half-a-mile are of common occurrence, and sharper ones are occasionally employed; as a rule, to insure the proper degree of accuracy in the points of the curve in the example in (Fig. 2), the length of the curve should not exceed one-fourth of its radius, so that this method becomes inapplicable to curves possessing radii of the above dimensions, when their length is greater than from one-eighth to one-quarter of a mile, which last is even a very short curve. This example has an advantage over the first described in (Fig. 1), inasmuch as the progressive errors cannot go beyond half the curve, for the offsets for the remaining half are obtained from an independent datum—viz., the other tangent line S_1I; the liability to error is also further lessened, in consequence of the direction of the lines along which the distances are measured remaining constant, instead of requiring to be changed for every offset, as in the example given before: this advantage is partially lost in long and sharp curves, when, in order to keep the lengths of the offsets within proper limits, it becomes necessary to run two or more tangent lines as base lines, to measure the offsets from, as shown on the right-hand portion of Fig. 2; in fact, it amounts to this, that in order to reduce the chances of error in one direction we are compelled to incur the chances of making them in another. In the place of measuring the offsets perpendicularly to the tangents, they may be set off in a radial direction whenever the centre of the curve is visible from the necessary portions of its circumference; but this is a case which very rarely occurs in practice. When the curve is short and the radius large, these two methods approximate very closely to one another, for the difference between the offsets measured perpendicularly and those measured radially to the tangents becomes very small.

There is another example of laying out curves by the method of angles which is worthy of notice, though, in reality, a modification of the method mentioned above; the same principles and preliminary calculations are available, but the position of the points are determined by the intersection of two "lines of direction" given by two theodolites working at the same time, the intermediate chaining being dispensed with. The diagram (Fig. 3) will serve to render this clear. Let SPS_1 be the curve, and we will take a case in which, as often happens, the springings, though not visible to one another, can be seen from P the middle point of the curve. Suppose it is required to put in the stake p_2; let one theodolite be set up at S, and the other at P; by the former let the angle ISp_2 be laid off, and the "line of direction" Sp_2 obtained. The line Pp_2 is similarly obtained by the latter instrument, and the point of their intersection is the position of the stake P_2. This method has the advantage of all others in being perfectly independent of the irregularities of the ground, but it is very seldom used, as it requires the services of two engineers, and one is generally considered sufficient for the staking out of each allotted portion of a line of railway; moreover, unless a skilful assistant were employed capable of comprehending the method in lieu of an ordinary chainman, too much time would be wasted in shifting about before the point of intersection of the "lines of direction" of the two instruments could be determined; it is clear however, that in certain cases where it was required to obtain the position of a stake which could not be chained to in the ordinary manner, it might be well worth the time of the engineer to first range the "line of direction" by laying off the proper angle for that stake, and then shift his instrument to some other previously determined point in the curve, and lay off another "line of direction," their intersection

* See notes to chapter on Railway Curves in Baker's 'Elementary Treatise on Land and Engineering Surveying.' London: Weale, 1857.

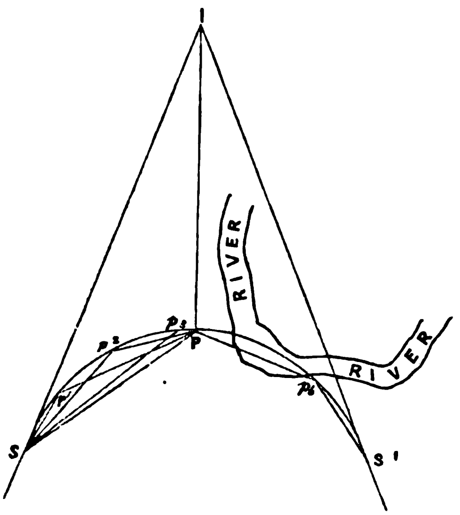
giving the required point. For instance, let it be necessary to put in the stake p_6 in the right hand portion of (Fig. 3), which comes on the bank of a river through a part of which the line goes, suppose the instrument set up at P and the "line of direction" Pp_6 ranged, then removed to the point S_1 and S_1p_6 obtained, and the position of p_6 is determined.

I have hitherto purposely abstained from giving any formula or calculations required for the different methods described, as they are mostly to be found in books on the subject; yet it may not be out of place to mention one general formula for the method of angles, which I think will be found useful from its great simplicity and facility of calculation. Let a = any length of arc, r the radius of the curve, and θ the required angle for that length of arc; then $\theta = \frac{a \times 28{\cdot}648}{r}$; θ being the angle between the chord and tangent of the arc, and thus obtained in degrees and decimals; putting a = 100 feet we have in round numbers

$$\theta = \frac{2865}{\text{radius of curve}}.^*$$

Having now investigated the methods in ordinary use among practitioners for laying out railway curves, it must be left to the reader to form his own conclusions respecting their different merits, and of the method which is most worthy of general adoption; although, at the same time, it should be borne in mind that they may all prove advantageous in exceptional cases—but,

Fig. 3.



in reality, the best provision against exceptional cases, lies in the resources of the engineers' own skill and ingenuity in the application of a few, rather than in the employment of a multiplicity of methods calculated to meet a variety of contingencies. Those given above will be found to amply suffice for every case which could occur in practice.

It is much to be regretted that sharp curves are of such frequent occurrence in our present system of railway making, and that what was formerly the exception has now almost become the rule. This may be partly attributable to the desire to avoid any great additional expense which would be incurred in constructing thsoe portions of the line with a curve of larger radius; or to escape the enormous outlay often necessary in parliamentary proceedings (the greatest blot in our railway legislation) to withstand the opposition of land proprietors hostile to the intended projects, and through whose land the line would pass.

It is the manner in which our railways are laid out which virtually puts a limit to the average speed which can be reached on them; the power necessary to produce a certain speed can be readily obtained, but where would be the utility of constructing locomotives capable of attaining with an ordinary passenger-train a speed of from 70 to 80 miles an hour, when it would be inconsistent with safety to run at a higher speed than 40 or 50 miles an hour? It is in vain to suppose that the twofold advantages of high speed and security can be obtained on any line where there is a frequent repetition of curves of less than one mile radius; yet there are doubtless, at the present moment, trains running over curves of such radii at velocities which are highly dangerous, and which our late eminent engineers—Brunel and Stephenson—would have disapproved of in the strongest terms.

* For proof and demonstration see my communication in *C. E. & A. Journal*, Number for October, 1861.

SUBTERRANEAN RAILWAY IN PARIS.

It appears that the French are about to construct a subterranean railway in their metropolis. We do not hesitate to express our doubts as to the success of the undertaking as a speculation. Paris is not like London. It does not lack room for circulation of all its vehicles in the busiest thoroughfares. It has no trade, of any importance. The "Chemin-de-fer de ceinture," which forms a belt round Paris, transports the goods which arrive from one side of France, to the railway which will convey them to the opposite provinces. There is no need of a "Pickford," or a "Chaplin and Horne," in Paris.

The following is the scheme proposed by M. de Hir:—The "Paris Railway," as he terms it, is to be of a single line only, except in the stations &c., and is estimated at 850 francs (£34) per metre; it is to follow the line of boulevards, the quays, and the principal streets. Partly in open cutting, and partly in tunnel (as in London) from 50c. to 1m. below the surface of the street, he says, that no sewer requires to be diverted, a few only must be lowered in the crown, in the higher portions of the town, where, inclination being very favourable, the water will always find its course; some drains must be diminished in height altogether from 50c. to 75c., and widened out to give the same waterway as before. This line is to cross over the two branches of the Seine and the St. Martin Canal by means of swing bridges.

The fare for conveyance from one end of Paris to the other, such as from the Bois de Bologne to Vincennes, &c., is fixed at 5 centimes (a halfpenny) per person for all classes. Forty-seven stations in the underground railway will communicate with the seven stations and goods sheds of the railways now entering Paris from the provinces.

One advantage may accrue to the present sanatory arrangements in Paris by this railway—viz., the transport of the contents of cesspools, &c., which are now carted through the streets; but the constructors must take every precaution against the danger of the whole train finding itself *enforcé*, some day, in one of the catacombs.

ARCHITECTS' CHARGES.

The subject of professional practice—more particularly in relation to architects' charges—has recently attracted the attention of the Institute of British Architects, and their Committee on Professional Practice has prepared a report on the subject, which, after being considered and altered at three special meetings, has been adopted and circulated.

The importance of some standard for reference in the matter of fees, and some authoritative statement of what the practice of the best members of the profession has usually been, renders such a report as the one now under consideration very valuable. We believe that it will be found to provide for most of the cases which ordinarily occur in practice, and that the charges here named are such as will be admitted to be fair both to the architect and the employer.

The subject has been before some of the provincial societies, and tables of fees have been drawn up by at least two of them—these are less ample than the one furnished by the Institute, and of course must be admitted to be less authoritative. We hope, however, in our next number to furnish them; and it will be then seen that they agree pretty closely with the subjoined statement.

"Professional Practice and Charges of Architects,

Being those now usually and properly made, as confirmed at the Special General Meetings of the Royal Institute of British Architects, held 13th and 27th January, 1862.

New Buildings, &c.—The usual remuneration for an architect's services, except as hereinafter mentioned, is a commission of 5 per cent. on the total cost of the works executed from his designs; besides which, all travelling and other incidental expenses incurred by the architect are paid by the employer, who is also chargeable under certain conditions, as hereafter mentioned, for time occupied in travelling. But for all works in which the art required is of a high kind, and the expenditure mainly for skilled labour and not for materials, *e. g.* in designs for the furniture and fittings of buildings, for their decoration with painting or mosaic, for their sculpture, for stained glass, and other like works, the architect's charge is not made by way of commission on the cost, nor does it depend upon the time employed in making the design, but is regulated by special circumstances, and varies according to the skill and artistic power of the architect.

A commission of 2½ per cent. is to be charged upon such works as sculpture, stained glass, and others of a similar nature, for which the architect does not give the design, but arranges with the artists or with the tradesmen, and directs the work generally.

In works under £500 in amount, 5 per cent. is not fairly to be considered as remunerative, and in such cases it is just to the employer as well as to the architect, to charge by time or by a scale, varying from 10 per cent. for works under £100, to 5 per cent. on amounts above £500.

The commision is reckoned upon the total cost of the works, valued as if executed entirely by labour and of new materials provided by the builder. The commission is to be charged upon the whole value of the work executed, with the addition of 2½ per cent. upon any omissions: this is exclusive of the charge for measuring extras and omissions. The architect is entitled during the progress of the building to payment on account at the rate of 5 per cent. on the instalments paid to the builder; or otherwise, to half the commission on the signing of the contract, and the remainder by instalments as above.

Travelling.—All travelling expenses are to be charged extra. These rules suppose the work to be executed within an easy distance of the architect's office; but if the work be executed at a considerable or inconvenient distance from it, an allowance beyond the 5 per cent. ought to be made for the *time* occupied in travelling, in addition to the actual expenses.

Extra Services.—The per-centage does not cover professional services in connection with negociations for site, arrangements respecting party walls, or right of lights, nor services incidental to arrangements consequent upon the failure of builders whilst carrying out work; but all such services are charged for in addition, the basis for charge being the time employed.

Alterations in Design.—Supposing that the employer, after having agreed to a design, and had the drawings prepared, should have material alterations made, an extra charge may be made according to the time occupied. If the architect should have drawn out the design complete, with plans, elevations, sections, and specification, ready for estimate, the charge is half the usual commission above named. If the architect should have, in addition, procured tenders in accordance with the instruction of his employer, the charge is one-half per cent. extra to the above.

Alterations of Buildings.—For works in the alteration of premises, the remuneration may be increased according to the time, skill, and trouble involved.

Duties of the Architect.—All of the following requirements for buildings are included in the ordinary charge of 5 per cent. :—

Preliminary sketches.

Working drawings and specifications sufficient for an estimate and contract.

Detailed drawings and instructions for execution.

General superintendence of works (exclusive of clerk of the works.)

Examining and passing the accounts (exclusive of measuring and making out extras and omissions).

No additional remuneration is due for making such a rough estimate as may be obtained, for instance, by cubing out the contents. If a detailed estimate be framed, additional remuneration is due from the employer. An architect is bound, under the 5 per cent. charge, to provide one set of drawings and one set of tracings, with duplicate specification ; it being understood that the architect is paid for the use only of the drawings and specification, and that they remain the property of the architect.

Estates.—The charge for taking a plan of an estate, laying it out, and arranging for building upon it, should be regulated by the time, skill, and trouble involved. For actually letting the several plots (in ordinary cases) a sum not exceeding a whole year's ground rent may be charged.

For inspecting the buildings during their progress (so far as may be necessary to ensure the conditions being fulfilled) and finally certifying for lease, the charge should be a per-centage not exceeding one-half per cent. up to £5000, and above that by special arrangement. All the above fees to be exclusive of travelling expenses, and time occupied in travelling, as before mentioned. The charge for the above does not include the commission for preparing specification, directing, superintending, and certifying the proper formation of roads, fences, and other works executed at the cost of the employer, nor for putting the plans on the leases.

Valuations.—The following definite charges are recognised for valuation of property. The charge throughout is 1 per cent. on the first £1000 and one-half per cent. on the remainder up to £10,000. Below £1000 and beyond £10,000 by special arrangement. These charges do not include travelling expenses, nor attendance before juries, arbitrators, &c.

Per Day.—The charge per day which may be made by architects depends upon their professional position, but the minimum charge is three guineas per day.

Dilapidations.—The charge for estimating dilapidations is 5 per cent. on the estimate, and in no case less than £2. 2s.

Quantities.—It is not desirable that an architect should supply to builders quantities on which to form tenders for executing his design; but in case of such being done it should be with the concurrence of the employer and the architect should be paid by him and not by the builder."

MACCORD'S DIFFERENTIAL PLANETARY GEARING.

Communicated by OLIVER BYRNE, C.E.

THE Differential Planetary Gearing to be described is the invention of Mr. C. W. MacCord, of Hackensack, New Jersey, U.S. The woodcuts represent one of its most simple and useful modifications as arranged for the multiplication of power. P is the driving pulley, on the shaft of which *s*, is keyed a transverse arm *b*, in which is the bearing of a journal *c*, on which are secured two spur-wheels $d\ d'$, gearing respectively into other two spur-wheels D D′, whose axes are coincident with that of *s*. Of these two wheels, one D′, is fixed to the framing, being drilled for the passage through it of shaft *s*. The other D, is free to rotate, and its shaft *o*, is that to which the increased power is transmitted. It is evident that, things being thus arranged, a rotation of P will produce a revolution of the wheels $d\ d'$ around the wheels D D′, and that this revolution will, by the action of the fixed wheel D′, cause the wheels $d\ d'$ to rotate upon their axis; that, as the wheels gear *internally*, the direction of this rotation will correspond to that of P, and that consequently the rotation of *d* will *tend* to cause D to rotate in the opposite direction. And since the velocity with which d' rotates is to that with which it revolves in the inverse ratio of the diameter of d' and D′; and since the directions and velocities of the motions of *d* are the same as those of d', it follows that if this ratio be equal to that subsisting between the diameters of *d* and D, the velocity of D will be the same as that of D′, which is none at all; and that, if there be any difference between these ratios, then the ratio between the antecedent motion of P, and the consequent motion of D, will be a function of that difference.

The operation may be investigated mathematically thus,—Let $d\ d'$, D D′, denote the diameters of the wheels marked with these letters respectively; let $v\ v'$ denote respectively the velocities of the rotation, and of the revolution of the wheels $d\ d'$; let V′ V denote respectively the entire velocity of D, and that which the rotation of *d* tends to impart to it; and let U′ U denote the entire velocity of D′, and that which is due to the rotation of d' only.

We shall then have the general equations,—

$$(1)\quad \pm\frac{V}{v} = \pm\frac{d}{D} \quad \text{and} \quad (3)\quad \pm V' = \pm V \pm v'$$

$$(2)\quad \pm\frac{U}{v} = \pm\frac{d'}{D'} \qquad (4)\quad \pm U' = \pm U \pm v'$$

Now subtracting (4) from (3), $(5)\ \pm(V'-U') = \pm(V-U)$

But from (1), $(6)\ \pm V = \pm\frac{vd}{D}$ and from (2), $(7)\ -\pm U = \pm\frac{vd'}{D'}$

Substituting these values in (5), $\pm(V'-U') = \pm\left(\frac{vd}{D} - \frac{vd'}{D'}\right)$

$$\text{or,}\qquad (8)\ \pm(V'-U') = \pm v\left(\frac{d}{D} - \frac{d'}{D'}\right)$$

But by hypothesis, $(9)\ U'=0$; whence from (4), $\pm U = \pm v'$

Substituting this in (7), $\mp v' = \pm\frac{vd'}{D'}$, whence $(10)\ \pm v = \mp\frac{v D'}{d'}$

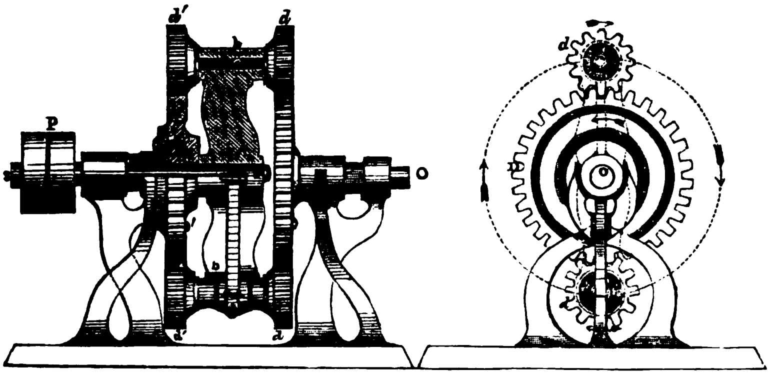
Combining (9) and (10) with (8), $\pm V' = \mp\frac{v' D'}{d'}\left(\frac{d}{D} - \frac{d'}{D'}\right)$

$$\text{or, finally,}\quad \pm V' = \pm v'\left(\frac{d D'}{d' D} - 1\right)$$

Since, when $U'=0$, we have $\pm(V'+U') = \pm(V'-U')$.

This is the general expression for the operation of those arrangements in which the rotatory motion imparted by a fixed wheel to a free one revolving around it, is transmitted to another concentric with the first, under the original limitation, that the wheel which imparts the resultant motion shall correspond with that which receives the initial motion, in the directions and velocities of its own motions, and *in its position with relation to the wheel to which it imparts motion.*

This last condition is italicised, as being in the form illustrated the feature which distinguishes the mechanism from the planetary horse-power of Bogardus, which as constructed differs from



the drawing only in this,—that D′ is *annular*, or toothed internally, which causes the ratio of the antecedent to the consequent velocity to be a function of the *sum* of the two ratios, $\frac{d}{D}\,\frac{d'}{D'}$. Though this feature does not prevent us from considering this horse-power to be the best that can be made, and though we would here acknowledge that the mode of balancing the mechanism, and equalising the motion, by using two pairs of the wheels *d d′*, is borrowed from that unique and admirable invention, yet it is necessary to make prominent the fact, that upon this distinction depends the advantages of the device we have described as a means of multiplying speed or power; for while a *differential* motion may be varied between the limits of zero and infinity, it is clear that one dependent on the *sum* of any quantities having the same sign is practically circumscribed in its variations by narrow boundaries.

THE BELL ROCK LIGHTHOUSE.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Sir,—Having been absent, and much occupied, I only accidentally opened the number of your Journal for this month this day, and was much surprised to find a letter from Mr. Alan Stevenson, claiming the whole merit of the design and construction of the Bell Rock Lighthouse for his father, the late Mr. Robert Stevenson; and that a model of the Bell Rock Lighthouse has been placed in the International Exhibition at South Kensington, stating that "it was designed and executed by the late Robert Stevenson."

Having given a detailed history of the above work, in my letter addressed to you in February 1849, and inserted in your valuable Journal of that month, and also in my work on British and Foreign Harbours, published in 1854;—and Mr. Smiles in his excellent work, 'The Lives of the Engineers,' lately published, having given a similar account of the Bell Rock Lighthouse,—where, from the historical records of the Commissioners of Northern Lighthouses, and from Mr. Robert Stevenson's own work on the Bell Rock Lighthouse, it is clearly established that the late Mr. Rennie designed and constructed the Bell Rock Lighthouse, and that Mr. Robert Stevenson was simply the "*assistant engineer*," appointed at Mr. Rennie's recommendation, to act under his (Mr. R.'s) direction, and to carry his instructions into effect,—it is unnecessary now to repeat the whole of these statements: I therefore beg leave to refer any of your readers who may be interested in this subject to those documents. I will simply however repeat the most important.

At the first meeting of the Commissioners of Northern Lighthouses (after the Act for Building the Bell Rock Lighthouse was obtained), held at Edinburgh on December 3, 1806, the following resolution was passed:—"Resolved unanimously, that the building to be erected for the purpose of a lighthouse on the Bell or Cape Rock shall be of stone, and that the same shall be erected *under the directions* of John Rennie, Esq., civil engineer, whom they hereby appoint *chief engineer for conducting the work.*"

Previous to the above resolution being passed, Mr. Rennie, who attended the meeting, entered into the fullest details, describing the particular kind and form of lighthouse, the materials of which it was to be built, and everything connected with it. At this meeting it does not appear that Mr. Stevenson was present, and no notice was taken of him.

At a subsequent meeting, held by the Commissioners at Edinburgh, on December 26, 1806, Mr. Rennie recommended Mr. Stevenson to be appointed assistant engineer, to execute the work under his directions; and a resolution was passed, "that the Commissioners agree to the appointment of Mr. Stevenson, to be *Assistant Engineer under Mr. Rennie*, but they delay taking into consideration the recompense to be made to him, both as to the amount and manner of doing it, until next meeting." Mr. Rennie also recommended that Mr. Logan should have the direction of the masonry; and Mr. Francis Watts, a skilful mechanic and millwright, bred under Mr. Rennie, should have the direction of the cranes and other mechanical details: which was agreed to.

The works were accordingly commenced and carried on, until their completion, under Mr. Rennie's direction; in fact, Mr. Rennie had the entire responsibility, superintendence, management, and direction of the whole of the works. He furnished the design, and the details were worked out and completed under him; nothing was done without his approval. He repeatedly visited the works, and made his reports to the Commissioners during their progress, until their final completion. All this is proved beyond doubt in Mr. Stevenson's book, together with the other documents in my possession. The design which has been carried into effect underwent certain alterations, differing somewhat from that originally furnished by Mr. Rennie, which generally happens during the progress of such works. These were chiefly confined to raising the tower a little higher, and altering the mouldings round the top of the tower and lantern, and some minor details. These alterations however were made under Mr. Rennie's direction.

The lighthouse, as erected, differs materially from that originally proposed by Mr. Stevenson, which was not approved of by Mr. Rennie. The base of the tower is much wider, and different in form, in order that it might be better adapted to suit the form and character of the rock upon which it is placed, so as to diminish the action of the waves upon it, and to prevent them from undermining the base of the lighthouse. The courses of stone are narrower on the outside, and larger towards the centre, differing in this respect from the Eddystone system, by which they are rendered stronger. The construction of the floors is different also, the pressure being rendered *vertical instead of lateral*, which also was an improvement upon the Eddystone system. All this is clearly explained in Mr. Rennie's Reports to the Commissioners of Northern Lights, nearly the whole of which have been printed in Mr. Stevenson's book.

As to Mr. Alan Stevenson's assertion, that Mr. Rennie never arrogated to himself the credit of the Bell Rock Lighthouse,—*this is totally contrary to the fact.* I have heard Mr. Rennie claim it over and over again, and complain bitterly of Mr. Stevenson's presumption in claiming it for himself; so much so that, according to Mr. Smiles' statement above referred to, and which is *perfectly correct*, "when he learnt that Mr. Stevenson was about to write a book on the subject, but without communicating with him thereon, 'I have no wish,' he says, in a letter to a friend, 'to prevent his writing a book, if he details the truth fairly and impartially. I am satisfied, I do not wish to arrogate to myself any more than is justly my due, and I do not want to degrade him.'"

Mr. Stevenson, however, took care not to publish his book until after my father's death; so that he had no opportunity of answering it, which no doubt he would have done, and have placed the facts still more clearly before the public. But even Mr. Stevenson's book establishes sufficient to prove that the Bell Rock Lighthouse was designed, and carried into effect, under Mr. Rennie's superintendence.

As to Mr. Alan's statement, or rather quotation, from one of Mr. Rennie's letters to his father, "that it would immortalise him in the annals of fame;"—this *was a mere joke*, and which I have frequently heard Mr. Rennie apply to his assistants, who were placed under his direction in a similar manner as Mr. Stevenson was.

As to Mr. Alan Stevenson's statement, that the amount of responsibility may be judged from the greater sum paid to Mr. Stevenson than to Mr. Rennie;—this goes for nothing, for it too frequently happens, that those who are least entitled to it get best paid.

As to Mr. A. Stevenson's statement about Mr. Charles Cunningham;—I knew him well, and have heard him give a very different version of the story of the lighthouse to that stated by Mr. Alan Stevenson.

I also knew very well the late Mr. John Paterson, the resident engineer of the Leith Docks, as well as the late Mr. David Logan and Francis Watts, who were the executive foremen assistants, constantly employed either at the building on the rock or in the workshops, or those attached to the lighthouse; and I have heard these gentlemen over and over again laugh at the very idea of the Bell Rock Lighthouse having been designed and executed by the late Mr. Stevenson; it is in vain, therefore, for Mr. Alan Stevenson to set up such a claim for his father, for it is wholly unsupported by any written or verbal evidence; and it is established beyond all doubt that, with every respect to the late Mr. Robert Stevenson, he was neither more or less, as his appointment expresses, than ***assistant engineer, under Mr. Rennie's superintendence, to carry into effect Mr. Rennie's directions;*** and that the Bell Rock Lighthouse was designed, and carried into effect, by the late Mr. Rennie.—I am, yours &c.,

JOHN RENNIE.

London, May 29, 1862.

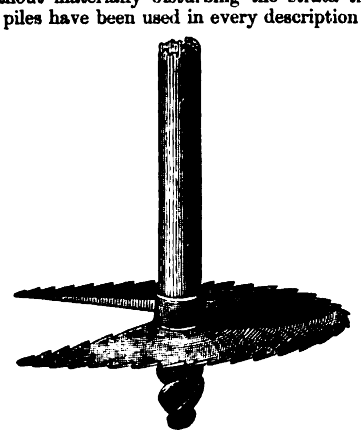
REVIEWS.

Mitchell's Screw Piles and Moorings, with Johnson's Patented Improvements. By FREDERICK JOHNSON, C.E. London, 1862.

This little pamphlet sets forth the various applications and advantages of screw-piles for lighthouses, piers, bridge, and other foundations, and more recently for moorings, and also explains the improvement introduced by Mr. Johnson, the present licensee of Mitchell's patents. Although many of our readers will be already acquainted with the original pattern, if not with the recent ingenious modification of it, we extract the following short description.

"The original screw pile consisted of a round bar, or cylinder of iron, with a broad projecting screw at its lower extremity, serving the double purpose of forcing the pile into the ground, and of affording an extended base for resisting either downward pressure, or an upward strain, but the improvements upon this screw consist in making the periphery, or a portion of the periphery, of its flange similar to a circular saw, as shown in the figure.

By a very simple arrangement of machinery, the screw works its way downwards, without materially disturbing the strata through which it passes. Screw piles have been used in every description of ground, hard



rock alone excepted. They have been applied with great advantage in chalk, and even been made to penetrate to a depth of 12 feet in the coral rocks of the Florida Reefs, on the coast of the United States of America.

The proper size and form of the screw must, in every case, be determined by the nature of the ground and other attendant circumstances; and it is obvious that great advantage results from its being in the power of the engineer to increase the area of the flange, or bearing surface, without altering the dimensions of the pile; particularly in situations where it is desirable to interfere as little as possible with the action of waves or currents.

Such cases are very frequently met with, both in the erection of lighthouses, piers, &c. at sea, and of bridges over rivers with rapid streams, or subject to sudden floods. In the former instances the soil, or sand, is often so loose and unstable as to be incapable of supporting any massive structure; and in the latter the expense of coffer dams, or other contrivances for building solid piers, would often be so great as to preclude their erection, even if otherwise desirable.

The introduction of screw piles has enabled engineers to execute works in the most unpromising and inconvenient situations. The open framework usually adopted, whilst it opposes no serious resistance to the waves, is capable of being formed into so rigid a structure, that scarcely any vibration is perceptible, even in the heaviest weather. At the same time no scour is produced, nor is there any accumulation of sand, or other debris,—the ordinary course of the currents remaining unchanged.

The difficulty of driving ordinary piles into sand is well known, indeed when the sand is in a compact state it is almost impossible to force them, by any means, down beyond a very few feet; the recoil being so great, that the timber or iron is shivered or snapped off under the blows of the monkey, and the attempt is usually attended with annoyance and loss.

By the use of iron, the ravages of the *Teredo navalis* and other sea worms, so much dreaded for timber structures on almost every coast, may be entirely disregarded; and experience has shown that no apprehension need be entertained of the prejudicial action of salt water upon the screw piles; neither the wrought nor the cast-iron work of the Maplin Lighthouse, which was fixed twenty-three years ago, at the mouth of the Thames, being in the slightest degree injured, and the Courtown Pier, Ireland (built fourteen years since), being in an equally good state of preservation. In some cases, however, as in the Portland Breakwater, wooden piles fitted with iron screw shoes may be advantageously employed."

Screw-piles have been so extensively used, and their serviceable qualities have become so well known, that we need do no more than select from the numerous instances of their successful application adduced by Mr. Johnson, one or two of the more important.

"The largest and most important lighthouse yet erected on the British or Irish coasts is that of the Gunfleet, off Harwich, constructed and erected for the Honourable Corporation of the Trinity House, by Messrs. Saunders and Mitchell, and the work was commenced in the year 1852, and completed in 1855, with the exception of the lantern and interior fittings. The Gunfleet Sand is one of the most dangerous on the east coast of England, and the site of the lighthouse is covered with water at all times of the tide. It is at this point very much exposed, and is subject to very heavy seas, which break upon it with tremendous violence during easterly gales.

The building is of wrought-iron, of great strength, and is perfectly rigid. The piles are hollow, seven in number, the lower length of each weighing about 7 tons, and being 45 feet long. These had to be taken more than fifteen miles out to sea, and were all screwed down 40 feet into the bank, in positions and directions previously determined, with the greatest accuracy, as the rigid bracing and superstructure had been already prepared.

The ground had been previously proved by boring to a depth of more than 50 feet, by means of an experimental screw pile, and was found to consist entirely of an extremely hard and compact sand, with occasionally (in the upper stratum) a few fragments of coal, from the numerous wrecks which occur every season on this dangerous shoal.

"The Madras Pier, designed by Messrs. Saunders and Mitchell, was commenced in the latter part of the year 1859 by Mr. F. Johnson, their successor, and is now nearly completed. This pier is 1080 feet in length, and its width 40 ft. 6 in. It terminates in a cross-head 160 feet long by 40 ft. 6 in wide. The piles are of solid wrought-iron, the screws of which are inserted to a depth varying from 11 ft. to 19 ft. 6 in. in the ground. This pier extends about 40 feet beyond the water line of surf. When it is considered that several attempts have been made to erect piers at Madras, all of which proved impracticable, it will be readily understood the situation is one of great exposure. The dangerous nature of the surf on this coast is well known. During the monsoon season it rises to such a height above the sea level as to entirely prevent all communication between the shore and outlying vessels even by native boats, and yet during the course of construction of this pier not the slightest vibration has been perceptible, a convincing proof of the great advantages of screw-pile structures over any other,—a great base or supporting surface being obtained without the necessity of exposing a large body to the action of either wind or wave.

The Portland Breakwater, now being constructed in the English Channel, was commenced under the direction of the late Mr. Rendel, and is perhaps the most important in which screw piles have hitherto been employed. When completed it will consist of two lines of breakwater, 6000 feet and 1500 feet long respectively, approaching each other at an obtuse angle, and having a passage or entrance 400 feet wide between them; the whole being constructed in a depth of water averaging more than 54 feet at low-water spring tides, excepting for a short distance close to the shore, and forming a harbour of refuge of about three square miles in extent. The breakwater is constructed of stone, which is quarried in the neighbouring hill, and carried out to sea upon a temporary timber staging erected upon screw piles. This staging is 120 feet wide, and the piles are 30 feet apart; each being built up of double balks of creosoted timber, nearly 90 feet long, trussed with iron, and having a screw shoe at its lower extremity. When the character of the work and its exposed situation are considered, the value of the screw piles in this and similar structures will at once be evident—in fact without them the difficulties of the work would have been almost insurmountable."

Mr. Johnson thus advocates the use of the screw for moorings.

"The description already given of the principle of the screw pile will have served sufficiently to indicate that of the screw mooring. It is evident, that if a broad plate or disk can be deeply buried in the ground, it must afford a firm attachment for the buoy-chain. Before this screw can be withdrawn by any upward tension, a mass of earth must be disturbed having the form of an inverted frustrum of a cone, upon this again presses the weight of the superincumbent column of water; and when it is considered that screw moorings are frequently inserted to the depth of 15 or 20 feet into the ground, in from 30 to 60 feet water, it will be evident that enormous force must be required to dislodge them. Their holding power is indeed so great, that in several instances chains made of iron 3¼ inches diameter have been broken, without bringing up the screw.

Besides their security, the advantages of screw moorings in other respects over those formerly in use, are very considerable. They are very readily fixed in any depth of water. In most cases all ground chain is dispensed with, the buoy chain going down direct to the screw. This not only saves a very heavy expense, but does away with the inconvenience, always arising in narrow harbours, from anchors getting foul of these chains, which are usually stretched across the harbour, in a manner which greatly interferes with the operation of dredging. In confined situations the moorings are particularly valuable, from the small scope which may be given to the buoy-chain, on account of the great holding power of the screw, often a matter of very great importance."

THE LOAN COLLECTION OF OBJECTS OF ART AT THE SOUTH KENSINGTON MUSEUM.

The South Kensington Museum is just now temporarily enriched by an exhibition of the choicest objects of art, placed there by their proprietors, and gathered from all the best collections in Britain.

This loan collection, as it is called, has been opened principally for the benefit of visitors to the Exhibition, and is probably the richest and most select exhibition that has ever been brought together under one roof, not excepting that portion of the Manchester Exhibition which was devoted to works of the sort.

It would be impossible in any space we can devote to describe in detail the contents of the Museum, and it is here mentioned principally for the benefit of those of our readers who may be able to visit it for themselves.

A vast amount of ancient gold and silver plate is here collected, including all the superb pieces belonging to the different colleges in Oxford and Cambridge. The maces of Oxford, Glasgow, Bath, Maidstone, and a host of other pieces of plate belonging to city and other companies, corporations, and the like. Magnificent specimens of genuine antique Etruscan and Egyptian jewellery are to be seen here; also the best of Her Majesty's collection of antique gems, together with still more valuable gems from private collections. Lord Palmerston and some other exhibitors display a quantity of antique Irish jewellery; and Lord Londesborough and others have sent arms and accoutrements of the choicest quality.

All the varieties of porcelain and China, Raffaelle, Wedgwood, Sèvres, and other costly wares are here displayed; and of one sort, the 'Faience' of Henry II. of France, which is all but priceless in the eyes of amateurs, all the specimens which England contains are here to be found.

Bronzes, church vestments, enamels, embroidery, iron-work, and specimens of all that is rich and rare, including Mr. Webb's superb collection of Mediæval ivory carvings, and many specimens of Flemish ivories, are also to be found; and in short the lovers of art workmanship will find in this collection an opportunity such as will probably not again occur.

VOLUNTARY ARCHITECTURAL EXAMINATIONS AT THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

We are now in a position to lay before our readers the leading features of the scheme for voluntary examinations which has been adopted by the Royal Institute of British Architects, and circulated among their members. We have from time to time reported the position of this undertaking and the progress that has been made in it; and although the scheme has been a long while in preparation it will, we think, appear upon examination of it that the time consumed has not been lost, and that the careful and thorough consideration which all its details have received has rendered it far fitter for adoption and far more likely to be successful than if it had been hastily and imperfectly prepared.

Three separate documents have been issued, of which the first contains a statement of the course of examination and the regulations to be observed, and contains copies of the forms of application and recommendation proposed to be employed. We give the larger and more important portion of this paper entire, as it will concisely and exactly inform those interested what it is intended shall be the subjects of examination, and what the regulations. The portion of this paper which is not here given contains the regulations (apparently complicated, but really practical, and analogous to what are followed elsewhere) intended to secure thorough impartiality by rendering it impossible that the names of the candidates should become known; and contains also the forms above referred to.

The second paper consists of a sort of specimen examination paper, prepared with the intention of enabling intending candidates and others to judge of the character of the examination proposed; this, with the exception of some observations appended to it, is too voluminous for our columns, but it will be read with interest by those who may possess themselves of it.

The third paper is the list of books. This, as originally drawn up, has already appeared in our columns, but it is now revised and somewhat augmented, and we propose in an early number to re-present it to our readers.

It only remains to observe that, as we are given to understand, the first examination will take place in January of next year, and that those who desire to possess the papers may obtain copies on application to the Honorary Secretaries of the Institute, at No. 9, Conduit Street, W.

"The examination shall be opento all British subjects, and shall be arranged in two classes, so as to offer to a candidate the opportunity of acquiring an acknowledgment of proficiency, and further an acknowledgment of distinction. No candidate under thirty years of age shall be permitted to present himself for an acknowledgment of distinction without having previously passed the examination in the class of proficiency.

The examination shall in no respect be conducted vivâ voce. It shall take place in the last week of the month of January, as often as there shall be five candidates seeking an acknowledgment of proficiency; and it shall occupy not more than three days for the candidates in that class, with not more than three additional days for the candidates seeking an acknowledgment of distinction.

The first of such days' examination shall be in drawing and design; the second in mathematics, and physics, with professional practice; the third in materials, and construction, with history and literature; while the fourth, fifth, and sixth days shall be assigned to the same subjects in similar order; languages being included on the fifth day. If fewer than six days be devoted to any examination, the examiners are at liberty to vary the distribution of time prescribed. The hours of attendance shall be from ten till five, except on the sixth day, when they shall be from ten till two: and on each day there shall be an interval of one hour during which no work shall be allowed, and the Institute shall provide some simple refreshment.

Upon the days of examination the candidates shall have access to such books of tables as may be provided by the honorary secretaries under the advice of the examiners.

A candidate who has passed in the class of proficiency shall not be required to attend on the days appropriated to the class of proficiency in any subsequent examination at which he may present himself for the class of distinction.

The examiners shall be not less than three in number, and they shall be elected, as well as two moderators, by the Fellows of the Institute at the first general meeting in January. The moderators always, and the examiners as far as possible, shall be members of the profession. No examiner or moderator shall be concerned in the examination of any candidate connected with him by any tie of relationship, tuition, or business. No examiner shall attend at the Institute during the hours of examination.

After the third examination, the council shall request the examiners to report any change that they may deem desirable in the system, and shall take the sense of the Institute theron.

The papers of questions and requirements of work shall be framed by the examiners as much as possible with direct reference to architecture, and in conformity with the applications of candidates, regulated by the subjects in the following programme.

The number of marks to be allotted by the examiners to their questions shall be 10,000; of which 6000 shall be in the class of proficiency, and 4000 in the class of distinction in the following programme, and also shall be as there noted,—Drawing and design, proficiency 1500, distinction 600; Mathematics, prof. 750, dist. 600; Physics, prof. 500, dist. 400; Languages, dist. 300; Professional Practice, prof. 500, dist. 500; Materials, prof. 750, dist. 400; Construction, prof. 750, dist. 500; History and Literature, prof. 1250, dist. 700.

Of these marks 3000 in the class of proficiency shall entitle a candidate to pass in the said class; and 2000 in the class of distinction shall entitle a candidate to pass in the said class; being in each case one-half of the entire number for the class; but the candidate shall not be held to deserve the acknowledgment of proficiency unless he obtains at least half of the number of marks allotted to divisions of Drawing and Design, Materials, and Construction respectively, in addition to at least a fifth of the number of marks allotted to each of the other divisions in that class.*

Class of Proficiency.

Preliminary Work.

A measured sketch of some existing building or portion of a building; a perspective sketch of some existing building or portion of a building; a drawing of some ornament from the round or relief; and a perspective view with working plan, section, and elevation, of a design by the candidate for some building, together with its whole specification and a portion of its working details at full size.

Work to be done in the presence of the Moderators.	Marks.
Drawing and design.—A design of some building or portion of a building, in the style named by the candidate, the subject being given by the examiners	1500
Mathematics.—Arithmetic, including the square root; algebra, including simple equations; Euclid, books 1 and 2; mensuration	750
Physics.—The elements of mechanical philosophy; also heat, light and ventilation	500
Professional Practice.—the principles of estimating; the laws relating to accident, agency, contracts and dilapidations ...	500
Materials.—The general natures and properties of building materials, including their decay, preservation, quality, and strength	750
Construction.—The detail drawings and specification for such branches of the work suggested in the above-named design (including drainage) as the examiners may indicate	750
History and Literature.—An outline of the characteristics of the principal styles of Architecture in Europe; the particular characteristics and history of any one style named by the candidate ...	1250
	6000

Class of Distinction.

Preliminary Work.

Besides a perspective sketch or a measured drawing of an existing building, or portion of a building, or other subject of architectural design (this is indispensable), one specimen in each of three at least of the following branches is necessary for the admittance of the candidate: 1. Sketches or measured drawings of existing work in wood, plaster, stone, marble, mosaic, glass, iron, brass, precious metals, textile fabrics, or embroidery; 2. Detail drawings at full size of any design by the candidate, for ornamental work in any of the materials just enumerated; 3. Drawings of the human figure from the round or from memory; 4. Subjects of landscape gardening; 5. Architectural subjects in colours; 6. Subjects of decoration, in colour or otherwise; 7. Specimens of workmanship in modelling; 8. Specimens of workmanship in carving.

Work to be done in the presence of the Moderators.	
Drawing and Design.—Such designs, drawings, and specimens of skill, in the style or styles named by the candidate, as may be thought needful to test his skill with regard to such preliminary work as may have been attached to his declaration: the subjects to be given by the examiners	600
Mathematics.—Algebra, including quadratic equations; Euclid, books 3, 4 and 6; plane trigonometry; conic sections and the higher mathematics. The candidate to name the extent of the examination that he thinks himself capable of passing beyond plane trigonometry	600
Mathematics and Physics applied to Practical Purposes.—Mechanics; statics; dynamics; hydrostatics; hydraulics; land-surveying; acoustics; chemistry; electricity; galvanism; geology; and theory of colour. The candidate to name the portions chosen by him†	400
Languages.—Translation from Greek or Latin, and translation from or composition in one or more living foreign languages; architectural nomenclature in any living foreign language. The candidate to name the languages	300
Professional Practice.—Laws of property relating to buildings, including fixtures and rights of adjoining owners; arbitration ...	500
Materials.—Detail of the nature and properties of building materials, including materials which are not in ordinary use ...	400
Construction.—Complex construction in scaffolding, shoring, securing dangerous structures, pulling down work, alterations of buildings, foundations, walls, partitions, floors, roofs, arches and vaults; formulæ for calculating the strength of materials ...	500
History and Literature.—The structures, architects, writers on practice and theory, and works illustrating styles or structures, in any style or styles named by the candidate	700
	4000

It shall not be necessary for a candidate, in order to obtain the number of 2000 marks required for passing the examination in this class, to obtain marks in all these subjects, or a particular number of marks in any one of them; and he therefore shall be at liberty to endeavour to obtain a high number of marks in those subjects upon which he may think he can best show his competency.

Fees.

In the first year each application for an acknowledgment of proficiency must be accompanied by a fee of one guinea; and each application for an acknowledgment of distinction must be accompanied by a further fee of one guinea. The fee shall be raised one guinea in each class, at each successive examination, until the revision of this scheme."

The following observations accompany the "Sketch of Form of Examination Papers," prepared by the Institute, and will serve to show the intentions of that body:—

"The Institute, aware that architects in practice cannot command the leisure sufficient to prepare for such an examination as is here contemplated, will not consider such persons as called upon in any way to present themselves as candidates; and the Institute, not intending that any compromise of the examination should be offered (except the modification as to number of marks in the first two years), announces that no architect above thirty years of age will be encouraged to offer himself as a candidate. It also suggests that very young men, although they may have availed themselves fully of the advantages of an academical education, ought not to present themselves for this examination until they have acquired that amount of architectural knowledge which practical experience alone can afford. The Institute therefore will not encourage any person to offer himself as a candidate in the class of proficiency under twenty-one years of age, or in the class of distinction under twenty-five years of age.

These papers are framed to indicate the standard to which the examination shall ultimately rise, rather than to suggest the adoption of questions so difficult as the most advanced herein contained; and therefore the first papers must present less difficulties. As candidates in order to pass in the class of proficiency must obtain a certain proportion of marks in each division of that class, the examiners shall provide a number of questions in each division sufficient to allow each candidate the advantage of an opportunity of selection, and therefore shall indicate to the candidates what proportion of the number of each set of questions must be answered.

It is strongly recommended that a greater number of questions be set on each paper than can fairly be expected to be answered in the time allotted. This should be done to give each candidate the advantage of selecting those on which he can best show his ability; but the candidate should be informed that he is expected to answer a certain portion only, or he may be deterred by the apparent weight of the paper. It has often happened (and nothing can be so disheartening to a candidate) when very few questions are set, that the majority of them may relate to the only points of which he is not master, and thus a candidate of great ability may obtain a low rank simply from the paucity of questions. Unusual questions, and some of considerable difficulty, as well as those of obvious and ordinary character, may be set, to give candidates of greater talent an opportunity of exhibiting their ability and industry. But these questions should on no account be suffered to degenerate into what are commonly called 'catch-questions,' or be such as would rather exhibit the cunning of the examiner than manifest the ability of the examined. The marks should also be so set, that the omission to answer any unusual question should not tell against any candidate. These errors have caused more dissatisfaction, and thrown more discredit on competitive examinations, than any other causes whatever, and should most carefully be avoided. Answers to one or two questions in a language, or solving one or two equations, can be no sufficient test of a candidate's competency as a linguist or a mathematician, and would not conscientiously warrant a notice of distinction from any examiner. Every examination to be satisfactory must not only be absolutely impartial and perfectly fair, but to

* The Council is empowered to fix for the first Examination a smaller number of days and a less proportion than that above arranged of marks necessary to pass; and to raise for the second examination the proportion of such marks to an average between that of the first and that provided in the regulations, which shall be used for the third.

† The extent to which the candidate is expected to be prepared in any subject of abstract science shall be governed generally by direct application to building operations and materials.

be of any worth or to carry any weight with the world it must be complete. Too severe an examination is tyrannous, while one too slight is obviously worthless.

Of course it is difficult to steer evenly between these errors. Few examinations have been established without being charged with one or the other at the outset. The subject is now, however, better understood than it was, and the reports from the various professions where it has been instituted are so favourable,—the system has been found to answer so well with legal and medical men; with the soldier, the sailor, and the diplomatist; with, in fact, every rank where the education of a gentleman is expected, as well as the ability of a professional man,—that there seems little doubt that this examination, if carried out with judgment and good feeling, must advance the British architect in popular respect, and in social status."

MACHINERY IN THE INTERNATIONAL EXHIBITION, 1862.

(Continued from page 159.)

Among the manufacturing machines and tools, those exhibited by William Muir and Co. (1668), approach the standard of perfection; in this department they stand unrivalled in the Exhibition. The powerful self-acting radial drilling-machine of this firm, with vertical elevating slide radial-arm, movable through an arc of 190°, drills holes up to 10 inches diameter, it is particularly adapted for drilling ends of boiler plates, large cylinders, and all work of a massive character, as it will take in an object 9 feet high; all holes within range of the machine can be drilled without removing the object; this tool notwithstanding its great range is steady and effective. Muir's small planing machine, worked by hand or power, with crank movement and elliptical wheels for producing uniform motion in cutting, and treble speed in returning, is very complete. Muir's centre duplex lathe, centre double-geared lathes, 8-inch foot lathe, vertical double-geared drilling machine, self-acting universal shaping machine, self-acting slotting and shaping machine, grindstone apparatus, screw stock and tackle, now being exhibited, are the most effective and complete manufacturing machines and tools now in use. The type composing and distributing machines of W. H. Mitchel (1662), receive and deserve much attention; these machines have been successfully used in America, as well as in some of the leading printing houses of England and Scotland. They may be applied to every description of book or newspaper work, and effect a large reduction in the cost of composition, in the wear and tear of type, and in the quantity of type required for a given amount of work.

The boot and shoe making machine (1680), of Parker and Sons, saves much labour; this simple and ingenious invention, from the facility and ease with which it can be worked, cannot fail to recommend itself. Its construction renders it portable and easily managed. P. Fairbairn and Co. (1594), present a numerous collection of manufacturing machines, which appear to us clumsy in their construction, geared inconveniently, and calculated to destroy much of the motive power. The spanners of Ferrabee and Co. (1597), are small tools, but worthy of a large share of attention. In the wood-working department, James Powis (1688) holds a high place, his machine for cutting double and single tenons is made expressly for doing the heavy framing of railway carriages and waggons. It is self-acting, and has a quiet return motion to bring back the work after having passed through the cutters. It operates upon four waggon soles at one time, and requires only a minute or so to complete the operation. It is the only machine exhibited in the building suitable for this heavy class of work. Mr. Powis exhibits eleven other machines—all excellent in their way—namely, a six-horse power horizontal engine, with most of the recent improvements, combining compactness and extreme portability in case of removal;—combined timber and deal frame for 24-inch logs, or two deals 24 inches by 7 inches, this machine is a small mill in itself;—contractor and builder's combined machine, for planing, moulding and edging all four sides at one operation, any size under 12 inches wide by 6 inches thick;—double deal frame to cut two deals 14 by 4 inches, advantageous where the mills are by the side of tidal rivers, being so constructed that no expensive or deep foundations are required;—combined moulding, thicknessing, and squaring up machine, for carriage framing and door styles;—band sawing machine, with adjustment for regulating the tension of saws and prevent their breaking;—self-acting circular saw bench, made with or without bogies, capable of breaking up logs 20 inches diameter, or cutting deals;—combined mortising, tenoning, and boring machine, for hard or soft wood; this tool is capable of doing the work of eight men. Mr. Powis states that 3000 of them are now in use. Mr. Powis' machine, which he terms "Multum in parvo," will saw, plough, groove, rebate, thickness, bore, cross-cut, and strike mouldings.

Although America compares favourably with other nations with regard to manufactures and mechanical inventions, yet, on account of the war, the arts and manufactures of the United States may be said to be unrepresented. It was through the enterprise and creditable ambition of a few private individuals, who were determined to show, at their own risk and on their own responsibility, that inventive skill is actively employed in America. The collection in the south-eastern angle of the building contains many articles of utility and novelty, chiefly collected by Mr. Holmes, and his son-in-law, Mr. Taylor, the engineer. One exception must be made—sewing machines are well represented, they are successfully exhibited, and form a great attraction. The rapidity and neatness with which these machines execute a variety of needlework must astonish those who only know the use of the common needle.

Among the mechanical contrivances may be noticed, near the south east entrance, the cork cutting machinery of Mr. Conroy of Boston; the cork is first cut into parallelopipedons and then into smaller figures of the same kind, according to the length of cork required. These smaller pieces are brought into contact with a knife mounted on a circular horizontal disc. The disc is put in motion by a large wheel similar to a cutler's wheel, and a band running over a drum in immediate connection with it; or the motion may be derived from steam power. This disc by means of gearing traverses a platform from right to left, then returning; by this means a cork is no sooner cut on one side than a cork is cut on the other. The square body to be rounded is placed in a groove, the gearing seizes it in the manner of a piece of wood in a turning lathe, by its extremities, advances it to the edge of the circular knife, and in an instant the rough block of cork becomes a shaped article. The ease with which this machine does its work is surprising. An active cork-cutter working by hand can turn out on an average eight gross of corks a day: by this machine fourteen gross of corks can be made in an hour. The corks can be cut perfectly cylindrical, or bevilled to any required angle by slightly elevating the horizontal disc. We also noticed among the American contrivances in this court, a bolt which has all the excellence of a rivet, with this advantage over a rivet—that when required it may be moved from its place without much trouble. It is well adapted for the frame-work of locomotives and railway carriages. The bolt passes through an iron frame or through wood-work, and is secured behind by a nut. But as a nut is liable to be unturned in the extremity of the thread of the screw-bolt by vibration, and as many railway accidents have happened from the fact of bolts having parted for the want of their retaining nuts, in the present case the nut is kept in its place by having a spring inserted into it, which adapts itself to the ratchet work of a hollow washer. Messrs. Lawrence and White, of Melrose, N. Y., are the inventors.

The curious in pianos should examine those in the American court. The internal arrangements of these instruments are novel; the strings are not all in parallel lines like those in the usual pianos—on the contrary, the bass strings are placed at acute angles above the tenor and treble strings, and obtain the full advantage of the sounding-board. The motions of the hammers are not impeded by this arrangement. These instruments vie in power, tone, and cabinet work with any in the Exhibition. The American life-boat of Scholl, as shown by a rough model, developes a novel principle in its way. The internal fittings are below the centres of gravity and flotation, they are hung in the manner of a binnacle compass; that is, the persons within are always maintained in a horizontal position, while the hull, which has no outer deck, is turned round and round rapidly. The steering apparatus and arrangements for a screw propeller are inside the boat, which when properly constructed would, we have little doubt, pass through a heavy surf with safety. We step aside to notice a machine in the Sheffield court for testing the tensile, compressive, and torsional resistances of iron and steel. It was made by Greenwood and Batley, of Leeds, for the proprietors of the Cyclops works, Sheffield, and is by far the most complete instrument of the kind that has fallen under our notice. It tests beyond fifty tons, not upon aliquot parts of a square inch of cross sectional area, but upon the whole square inch.

Chemistry an aid to Archæology.—Lately, under the walls of the ancient château of Verteuil, two stone tombs have been discovered, each containing a human skeleton in a perfect state of preservation. These tombs, of a rude style of workmanship, contained no inscriptions whatever; thus the archæologists were completely at a loss as to the precise date of their origin. A distinguished chemist, M. Gouerbe, however, by the analysis of the bones found therein, completely resolved the problem. The analysis of the humerus showed, among other results, that these bones contained 10·47 per cent. of organic matter. But we know that living bones contain 33 per cent.; then, during the unknown period of sepulture 22·5 per cent. of organic matter had disappeared. If we knew the quantity of organic matter decomposed each century, by dividing the total loss 22·5 by the quantity lost each century, we could arrive at the period of inhumation. Now this centennial quantity is easy to be ascertained by the analysis of bones found in tombs of known date, and M. Gouerbe, from the fact that all azotic matter is destroyed at the end of 1100 years, as appears by analyses on various tombs, proves that *in enclosed sepulchres* 3 *per cent. of organic matter* is decomposed every 100 years. Dividing 22·5 by 3, we have 7 centuries and a half for the period of inhumation of the bodies, giving A.D. 1112 as the date of sepulture. A curious instance of the accuracy of M. Gouerbe's theory is that M. Drouin, Member of the Bordeaux Academy, had independently fixed A.D. 1110 as the date of the tombs.

Bread and Lead.—Very lately a curious case, perhaps without parallel, occurred at Chartres and the environs, of poisoning with lead. Eight communes of the department of Eure-et-Loir were attacked with violent colics, which were attributed by the peasants to the wheat having been altered or decomposed by hail. It was not long before these colics became epidemic, and many inhabitants perished thereby. Docteur Girouard the younger (of Chartres), persuaded in his own mind that lead was the cause, examined all the food consumed by the people of that district, in conjunction with several other medical men to whom he had mentioned his ideas, and soon discovered lead in the bread. He at once went to the miller who ground the flour for the afflicted communes, and discovered that the miller had for some reasons of his own plugged the holes in the millstones with lead, a considerable portion of which was constantly being mixed with the flour. Docteur Girouard had the satisfaction of seeing his opinion confirmed by the total cessation of the epidemic as soon as the lead was removed from the millstones.

New Description of Telescope.—At a meeting of the Academy of Sciences in Paris, last month, M. Leverrier presented a notice of telescopes of a new description, on the part of M. Foucault. For the last few years M. Foucault has been endeavouring to construct reflecting telescopes with the specula formed of silvered glass, but the invention will only be of decided importance from the time that he can produce a glass speculum superior in power to the largest achromatic lenses now in use. The first partial success was obtained in constructing mirrors of 10, 20, and 40 centimetres diameter. Now, a large one has been constructed 80 centimetres (2·62 ft.) diameter, with a focal distance of 4m. 50c. (14·77 ft.); it has been fitted into a Newtonian telescope, and, for the last three months has given perfect satisfaction. M. Leverrier considers it a really valuable acquisition to the observatory. This enormous disc of glass of great thickness, and of convex form on the reverse side, was cast in the St. Gobain glass works, under the direction of M. Sautter, the director of the works for the lenticular lenses for lighthouses. After being cleaned up for polishing, it was taken to the workshops of M. Secrétan, and put into the hands of the opticians, to work it into proper curve by hand-labour alone. It was apparent at first sight that for such exceptional dimensions extraordinary methods should be resorted to. In eight days the polishing, first with emery, and then with crocus or red oxide of iron, brought it to the proper curve, all by hand; it was tested step by step with the spherometer; at the end of a week a surface was formed of an even grain as nearly spherical as possible, the back having been left slightly convex for the better rigidity of the reflector. The telescope, meanwhile, having been completed, it was temporarily mounted on a wooden stand, which can be carried out from the observatory rooms and placed on any convenient spot. It can be placed on an equatorial stand at any time, but M. Leverrier prefers transporting to the South of France some of these large instruments which, to use his own words, "*l'atmosphere impure de Paris rend très-souvent inutiles.*"

CLASSIFIED LIST OF PATENTS SEALED IN JUNE, 1862.

3086 Hemingway, J.—Ornamentation of textile fabrics—December 4
3040 Hacker, H. G.—Manufacture of chenille—December 4
3067 Lawes, T.—Manufacture of quilts and coverlets—December 7

3110 Leeming, J.—Looms for weaving—December 11

2249 Lord, E.—Preparing cotton and other fibres—December 28
3075 Mellowdew, T.—Dyeing and printing fabrics—December 7
3199 Pereau, E. E.—Cleaning woollen fabrics (com.)—December 20

903 Loft, J. T.—Machines for printing in colours—April 2, 1862
3203 Le Souef, D. C.—Printing cylinders (com.)—December 20
765 Jaques, J. A.—Elastic surface rollers—March 18, 1862

327 Mackenzie, A.—Sewing machines—February 7, 1862
868 Coltman, T.—Sewing machines—February 12, 1862
3190 Evans, P. C.—Sewing machines—December 20

3048 Knowelden, J.—Pumps—December 5
3065 Schramm, H. G.—Rotary engines and pumps (com.)—December 6

3088 Brooman, R. A.—Uses of gases and elastic fluids to obtain motive power (com.)—December 9

3167 Sheppard, S.—Cocks—December 18
3 Johnson, J. H.—Hose joints (com.)—January 1, 1862

3090 Alexander, H.—Apparatus for making gas-burners—December 10

555 Sim, J.—Gas-meters—March 1, 1862
17 Gulknecht, J. S.—Meters—January 1, 1862
3052 Cochrane, J.—Wet gas-meters—December 5

3060 Napier, J. D.—Brakes—December 6
3117 Longridge W. S.—Wheels—December 12
3133 Quantin, P.—Sleepers—December 13
182 Higgin, J.—Brakes—January 24, 1862

3205 Morris, T., and Weare, R.—Submarine telegraphs—December 21
3109 Potter, J.—Joining telegraph wires—December 11

903 Pooley, H.—Weighing-machines and bridges—March 31, 1862
3137 Appalby, H.—Machinos for boring broom heads, &c.—December 13
3193 Walkland, G.—Machines for winding lace on cards—December 20
3212 Kemp, W.—Brushing mills—December 21
3258 Payne, J. B.—pinning machines—December 30
914 Johnson, J. H.—Spinning machines (com.)—April 1, 1862

3211 Selby, F.—Boilers—December 21
3234 Shepherd, J.—Apparatus for cleansing steam-boilers—December 26

1173 Scoville, G.—Pistons for steam-engines—April 22, 1862
3207 Grimaldi, F.—Rotary steam-boilers—December 21
70 De Normandy, A. R. M.—Fixing tubes in plates—January 10, 1862
3263 Green, T., and Green, W.—Chain wheels—December 31
102 Hughes, E. W.—Malleable cylinders—January 14, 1862
3239 Silver, T.—Steam governors—December 27

3024 Ralston, G.—Coating for ships' bottoms (com.)—December 2
3129 Friend, J. W.—Apparatus for measuring speed and distances—December 13
3194 Tipple, W.—Paddle-wheels—December 20

3068 Clark, G.—Iron armour-plates for vessels—December 7

3251 Henry, M.—Fire-arms (com.)—December 28
3072 Hutchinson, W. N.—Ordnance and projectiles—December 7
3245 McIntyre, J.—Bomb-shells—December 27
309 Newton, A. V.—Fire-arms (com.)—February 5, 1862
841 Winans, W. L.—Mounting ordnance—March 27, 1862
183 Corngorth, J.—Gun-barrels—January 24, 1862

3069 Jolley, R.—Gases, &c.—December 7
3076 Gerland, B. W.—Sulphate of copper—December 7
3241 Moreau, P. A.—Fatty and resinous substances (com.)—December 27
163 Martin, L.—Mineral oils.—January 22, 1862

3196 Clark, W.—Lucifer matches (com.)—December 20
3217 Rosindell, J.—Apparatus for separating solid from liquid substances—Dec. 24

3082 Fordred, J.—Improvement in treating linseed oil—December 9
3118 Tonnar, A.—Brewing—December 12

3299 Jones, J.—Lead and other soft metals—December 26

129 Romaine, R.—Steam cultivator—January 17, 1862

3242 Bright, T.—Chaff machines—December 27

3113 Lightfoot, W.—Bridle—December 12
794 Marsh, T.—Hames for horses—March 22, 1862

3044 Brooman, R. A.—Photographic albums (com.)—December 4
3115 Wiley, W. E.—Pencil cases, &c.—Deeember 12
39 Newton, A. V.—Manufacture of cigars (com.)—January 6, 1862

3200 Wailes, R.—Apparatus for cleaning windows, &c.—December 20
3230 Standing, T.—Cinder-sifters—December 26
810 White, T.—Nut and lobster-crackers—March 24, 1862

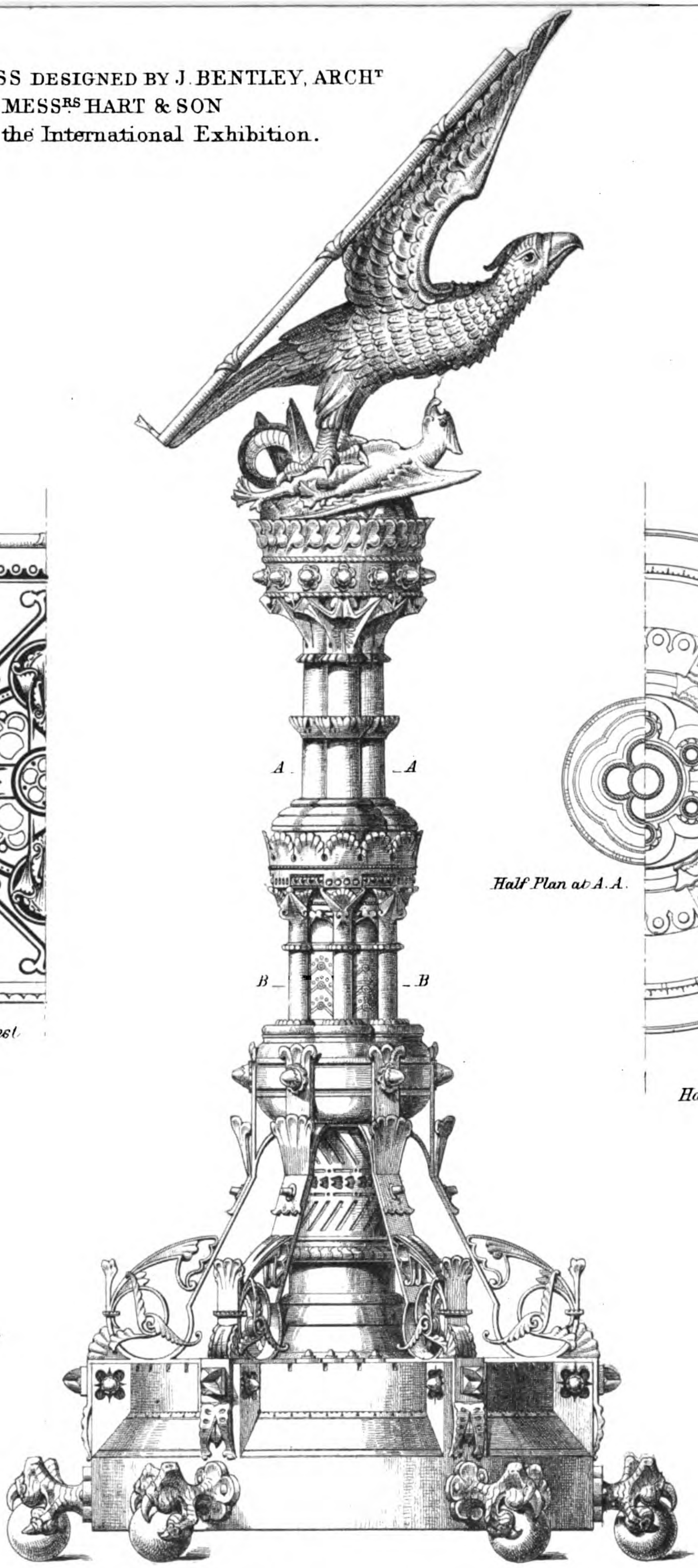
3185 Treuille, A., and Traxler, F.—Cards and tickets (com.)—December 19
3268 Haslam, J.—Blind-racks.—December 31
148 Mappin, W. S.—Locks—January 20, 1862
26 Belloche, F. S.—Parasols—January 3, 1862
3200 Harvey, J. F.—Umbrellas and Parasols—December 24
3087 Clark, W.—Gloves (com.)—December 9
3099 Vogl, D.—Garments—December 10
3216 Smith, C.—Stays—December 24
3218 Smith, C.—Stays—December 24
3215 Bodmer, L. R.—Knapsacks (com.)—December 24
403 Renison, T.—Water-closets—January 15, 1862
3094 Daguzam, V. L.—Paving roads—December 10

3098 Redier, J. A. J.—Watches—December 10

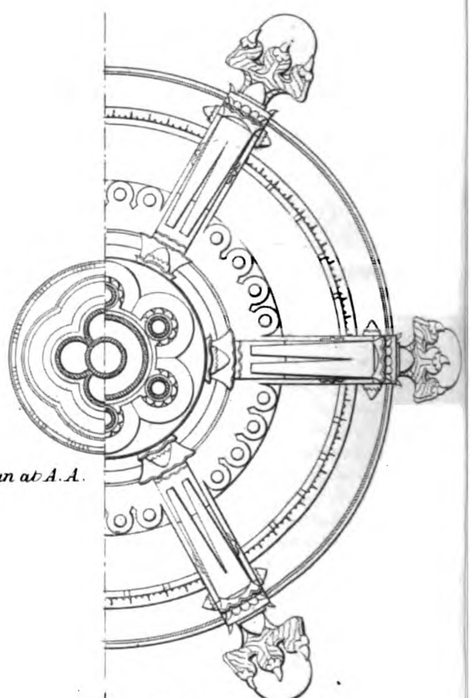
1308 Tyler, J.—Clarionets—May 3, 1862

LECTERN IN BRASS DESIGNED BY J. BENTLEY, ARCHT FOR MESSRS. HART & SON
Exhibited at the International Exhibition.

Half Plan of Book rest

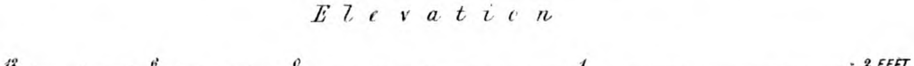


Elevation



Half Plan at A.A.

Half Plan at B.B.



LECTERN, INTERNATIONAL EXHIBITION 1862.

(With an Engraving.)

The Lectern we illustrate in the accompanying plate is the production of Messrs. Hart and Son, of Cockspur-street, London, designed and manufactured expressly for the International Exhibition. The workmanship does them great credit, and is likely to add to the reputation of this already eminent firm. Their labours were rewarded with a medal, "for great beauty and variety of design, and perfection of workmanship."

The lectern is divided into three stages in height, terminating with an allegory—the Gospel overcoming Infidelity, represented by an eagle trampling on a dragon, which supports the book rest; under this is a foliated crown, the band of which is ornamented by twelve crystals set in pateræ; then comes a quatrefoil column with cap, base, and annulet; under this again are six small shafts with caps and bases, surrounding the main or centre one, resting on a blocking. The base is circular on plan, surrounded by six scroll straps, connecting it with the blocking on the centre shaft. The whole rests on eagles' claws, one coming under each strap and fixed to the base by rivets. On the book rest is a cross, surrounded by the evangelistic signs in black incise, on the underside is a foliated decoration. The whole was designed by Mr. Bentley, architect, London.

CONVENTIONALISM IN ORNAMENT.

By John P. Seddon, M.R.I.B.A.

"Conventionalism" I take to mean, primarily, what is artificial, in contradistinction to what is natural, and "conventionalism in ornament" the artificial treatment requisite to maintain consistency with regard to its material, purpose, and position. The word will, however, bear other meanings, for when applied to what is already artificial, its object can only be to express that its artificiality is intensified: it is so in relation to architecture; thus, in the Dictionary of Architecture it is defined to be "that general acceptation of some arrangement or disposition in art, or objects of art, at variance with the *strict* canons of taste or laws of propriety, but admitted by common assent, either from habit or to suit some special purpose otherwise unattainable." Now this definition is correct doubtless so far as regards its application to architecture, because that art is altogether artificial itself, and therefore the application of the term conventional to it would refer to some extreme mannerism, some exaggeration defiant of the laws of propriety,—such as the constant repetition of the forms of carpentry rendered in stone, which characterises the buildings of India, and even the whole of the Classic styles. Almost all the so-called ornaments of the modern Italian buildings, broken and misplaced pediments and the like, are indeed conventionalities, "at variance with the strict canons of taste." Conventionalism, in the sense of mannerism, may also be fitly used as a term of reproach in reference to arts which do not rightly admit of such artificial treatment at all, and which, when not drinking deeply of the spring of truth in nature, stagnate altogether. Such was the case with painting while under the Byzantine influence, before Cimabue, Giotto, and the early Christian painters of Italy, infused life into its veins; and long, even in spite of their efforts, did many of the conventionalities of that period continue, as for instance the elongated, sleepy-looking eyelids of their saint of which malicious report averred that one of our esteemed Mediæval revivalists was so enamoured, that he hung weights to his own children's eyelids in order to make them grow into the said approved form. And again, at a later period, when the art had thrown aside all these clinging cerements of its Byzantine sepulchre, it succumbed to the false conventionalism introduced by the school of Raphael, when, to the dicta of the fancied rules of high art, priests and prophets stalked about in blankets, and played the parts of theatre supernumeraries, to bolster up one of the absurdest of conventionalities—the theory of composition.

Conventionalism, however, in the meaning I have attributed to it in ornament, is by no means to be disapproved of; it is one of its essential characteristics; and its absence, not its presence, therein, would be a violation of the strict canon of taste and laws of propriety.

Yet, as ornament stands as it were midway between architecture and its handmaids sculpture and painting—partaking of the character of each, being more decorative in its nature than architecture, more artificial than sculpture and painting—the degree of this conventionality proper to it is far less than that requisite in the former, and far more than that which is desirable in the latter. It is not indeed easy to define its exact bounds, as they vary under different circumstances; yet, its aberrations on either the one side or the other are perfectly distinguishable, though with singular pertinacity almost all modern ornament transgresses in either the one direction or the other, consistently refusing to remain within the right bounds; whereas the ornament of every age, period, and clime, up to the period I have elsewhere named the Dark Ages, flowed on steadily, without any apparent wish to deviate from its proper course in this respect.

My present object is to endeavour to point out the proper degree of conventionalism that should obtain in ornament; to mark out, as well as it is in my power to do, its boundaries; to give warning of the rocks that, like Scylla and Charybdis, lie on either side, in the shape of too close an affinity to, and of too great a neglect of, the type taken from nature.

I shall assume then, firstly, the axiom that *the type of all ornament must be natural or imitative of other work of man*; for since, born in this world, man has no other ideas than those he has gleaned herein, some natural production, either animal, vegetable, or mineral, must be the type of that wherewith he, as an imitator without any pretensions to being a creator, seeks to ornament his work; and if ambitiously he would portray scenes of heaven, hell, or localities of pure imagination, his angels will but prove to be a combination of humanity and wings; his devils will differ only from those in being ugly and black, with possibly the addition of tail, with horns and hoofs; while his most weird-like monsters can be but a jumble of fish, flesh, and fowl, florescent it may be of limb, and arborescent in their extremities. In the highest, because the most spiritual and purpose-ful, art the world has seen, that of Mediæval Christianity, if we were to isolate some of the conventional representations by which it was sought to signify matters and things beyond the power of art to imitate or conceive, from the context which justified the attempt, they would seem puerile enough. The nimbus round the heads of the figures of our Lord may conventionally indicate, but it in no way actually represents, the glory of his holiness. The illustration given in Didron's 'Christian Iconography' of our Lord in an auriole supported by angels (from a carving in wood of the fourteenth century), sufficiently and legibly stands as a sign of the heaven to which He is ascending, and is a fair conventional rendering of the firmament, with its sun, moon, and stars—unpretending, yet in no way ridiculous in its place; and it may be compared with advantage to the modern puerile and almost, blasphemous attempts to represent the actuality, by clouds resembling pancakes, and suns like exaggerated starfish, which irreverently provoke smiles in the chapels of Westminster Abbey.

Ornament may be classed as either *the representation of some type found in nature*, or *of the work of man*; and these may both be treated with more or less of *conventionality*.

As far as I have been able to examine, it would seem that in the rudest state of barbarism, among human beings scarcely raised above the level of the brutes, before they even gain sense sufficient to cause them to build themselves huts to live in, they make clubs to batter out each others' brains; and these they delight to ornament so that the deed may be done in a gentlemanly and refined manner, according to their notions; and the type they select to imitate is the markings of the bark of the trees around them. The next step in civilisation is to build huts, and the next, in ornamenting them, is to whittle the posts in a similar manner. Again, if you look to the prevailing ornaments on the buildings of India and the East, a very slight analysis will show that the types are few, and derived by imitating in stone the features of previous wooden buildings; or, as Mr. Simpson recently pointed out, by carving as rosettes and beads in stone the jewels and strings of pearls which as offerings had been bedded in the plaster of earlier temples. So that out of the work of men before them, these Indian builders elaborated a type of conventional ornament, and not directly from nature itself.

So also did at a later date those authors of all architectural evil, the Romans, who, dangling from a peg a conglomeration of military boots, helmets, cuirasses, and weapons, made such a type of conventional ornament; which piles of absurdities being termed trophies, were the precedents whence sprung all the abominations of the ornament of the Renaissance period, till the very name of *a trophy* has in the never-failing course of justice been turned into ridicule by the far more sensible, if not more beautiful, pyramids of candles and kettles, pickles and toys, which encumber the avenues of the World's Fair-booth of to-day.

But early at any rate, how early we need not pause to inquire, men saw also in the fair forms of the leaves and plants around them lovely shapes which it pleased them to reproduce, and in those of the birds, beasts, and fish which owned their supremacy, and in their own likenesses, worthy themes to carve and paint from; and their common-sense, or instinct even, told them that if they would reproduce these as ornaments they must at the same time obey the requirements of the materials in which they had to work them; that it being hopeless, as well as useless and wrong to try to make their work to be mistaken for the things themselves which they were copying, it needed some orderly arrangement, and in fact a conventional treatment, to adapt the types to their purpose; and it was left, not even to the Romans, though few were the artistic vices in which they did not indulge; not even to the Italians of the Renaissance School, though they parodied all the merits, and intensified all the demerits of Roman art; but to Grinling Gibbons and his crew, under Sir C. Wren, to tread roughshod over all the instincts of our nature in this respect, to dispense with conventionality, and vainly strive to do in stone and wood that which nature only has attempted to do in gossamer and guaze, forgetting the purpose and position their work should fulfil and was destined to occupy; and so around and within the massive structure of St. Paul's hang their swags of fruit and flowers, mere tape-tied flimsy vanities, ignoring the fact that they are, and should appear to be, a part of its stonework, and rendering painfully obvious the barrenness of any proper decoration, the place of which neither they nor the cherubs that seemed nailed up everywhere like bats on a barn-door, can worthily fill. Yet these, with all their faults, can boast of consummate execution and great freedom and grace, that, were they otherwise employed, might command our admiration and respect. It is to the present day that thanks (if thanks be the due) we are indebted for the notion that the pellmell piling up of all the contents of the poulterers' and fishmongers' shops strung up with neither order nor arrangement, and with conventionality defied, is ornament! It is in the International Exhibition of 1862 that, if we seek them we may find (nay, we must find, even though we would avoid them) huge buffets and sideboards, flanked by female giants in oak or walnut, which are neither useful nor ornamental, and down whose panels, despite dogs' heads and whatnot supposed to restrain them, slides a perfect cataract of ptarmigan and grouse, wild fowl and fish, lobsters and crabs, with other crustaceæ and mollusks, all done indeed, as it is said, to the life, but as ornament absolute monstrosities, outdone only by the Robinson Crusoe and Shakespeare sideboards in which this species of the ridiculous nearly attains the sublime. Against the other elaborate carvings in wood, which are placed under glass cases in the English and French furniture courts, there is no such objection to be made: they are simply what they profess to be—mere representations of cocks fighting, groups of animals dead or alive, wonderful in their way for elaborate execution, but not pretending to be ornament, for which they are totally unfitted.

You see, therefore, that ornament, which I have broadly divided into the two classes—viz., (1) that founded upon natural types and (2) that founded upon the work of man—is liable to error, either by lack or by excess of conventional treatment, and that each class has its own peculiar vices. Modern ornament is mostly of the first description; and I think I could not give you a better typal example of it than those gates in the nave of the Exhibition, whose thin metal foliage looks like the unpruned, ragged, well-smoked side of a hedge in a London square, or like natural leafage rubbed over with black lead; the unfitness of which for the purpose I am sure all will confess, if they will compare it for a moment with the far more rightly treated work on the screen for Hereford Cathedral (in the transept) by Mr. Skidmore, of Coventry.

Almost all Oriental art is of the latter class, the entirely conventional, and may be seen in very glorious perfection in the Courts of India, China, Japan, and Turkey. It is almost always right in principle, graceful in form, but it is difficult to discover any specific types for its foliage and flowers; its principal excellence seems to be its unerring harmony of colour, which makes our best European attempts appear faulty experiments in comparison in this respect.* It is strange that these qualities should be found together with besotted superstition, and cruel and bestial criminality, as recent events that have passed into history have proved. But the arts in those climes seem to have stagnated at this point of perfection for centuries, and they show neither progress nor healthy study of and delight in nature, the foliage being altogether nondescript, and the figures introduced rather being monstrous than grotesque, and telling little or no story—at least such is the case with Indian work generally; whereas, in Japan, where manners we are told are more genial and civilised, there seems to be altogether a better or higher class of art practised, even if in less perfection of the same mechanical sort. Among their bronzes in the exhibition are to be found much grotesque work of a pleasant character, almost resembling the Mediæval; and their japanned goods present some splendidly treated birds and plants, in which the spirit and beauty of nature is preserved, with a proper degree of conventionalism. Of the glorious Mediæval grotesque itself, the present Art Loan Collection, and also, I am glad to say, that in the permanent collection in the South Kensington Museum, present many splendid specimens, which deserve the deepest study.

The best Classic and Mediæval ornament seems to hold the proper middle course between over-conventionalism and over-naturalism; and to Greek art we may refer for, I think, perhaps the most excellent work of the class the world has produced. The Greeks seem to have had little invention, but the most exquisite feeling for grace and proportion. Their types of ornament are few, and seem to be derived from the earlier Egyptian or Oriental styles, but their constant repetition and little variety is somewhat monotonous and lifeless. The Romans, who stole all they had of art from the Greeks and then vulgarised it, took up the type of the acanthus leaf and worked it to death; but its merits are yet so great, that we should acknowledge them more gratefully were we not absolutely wearied of it by its fulsome repetition in modern days. It was in the Romanesque style that life and vigour was first infused into it, and its leaves bend under the bells of the capital, and intertwine and writhe as leaves should do, yet always like leaves of stone; whereas, in the Corinthian capital, they are so treated that they look as if they neither could nor dared to deviate one hair's breadth from the ordered arrangement and precise attitude in which they were first put; so that even that most melancholy of modern makeshifts, the casting the separate leaves in cement, and sticking them around the smoothed bells of the capitals, hardly seems to do them violence (although of course no capital of any other reasonable style would submit to be so treated without the utter degradation of the whole); and we can bear to see them in Belgravia, veiled in wire-baskets from the access of sparrows and the inspection of men, without a pang.

The Romanesque and the Byzantine ornaments were both developments from the Classic acanthus work; and I might dwell upon the host of interesting examples we still possess of either class, but to give an historical survey of all that has been done in the way of ornament is not my present purpose; so I must leave the ever-varying capitals of St. Mark's at Venice, and of the numerous Romanesque churches in Northern Italy and on the banks of the Rhine, and the very similar works in France, such as that at Poictiers, and the cotemporary Anglo-Norman work; merely by the way calling attention to the vigour and grotesque fancy with which they all abound, and the superior freedom from restraint in their foliage in comparison with that of their Classic prototypes. But this freedom and vigour was retained, while far greater precision and care in execution prevailed, as soon as the Gothic element began to modify the arts of Western Europe. Men were then no longer content with the worn-out Classic types of ornament, which gave but little scope for their energy and love of variety, and they began to see that nature teemed with forms quite as suitable for their purpose as the hackneyed acanthus. A complete Flora in stone soon attested the success of their studies. Upon this I desire to dwell somewhat.

(To be concluded in our next.)

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* I wish to call attention particularly to the absence of raw colours in their work, whereas the eye is elsewhere continually injured, as not a little in the decorations of the building, by rude, crude, cheap ultramarine, upon which nasty pigment it were much to be wished a heavy tax might be laid, if not an altogether prohibitory duty.

GAS ENGINEERING AT THE EXHIBITION.

Many important practical improvements have been made in the manufacture and distribution of coal gas during the eleven years that have elapsed since the great Exhibition of 1851. These improvements relate however more to the economical production of gas than to any actual improvement in the quality, though the public have to a considerable extent derived benefit, not only in a reduction of the price charged, but in being supplied with gas of increased illuminating power. One important effect of the experience gained during the past eleven years has been the resolving of doubts respecting the substitution of some other material than coal for the production of illumination. Many have been the plans proposed, some of which bid fair for a time to supplant coal gas, but they have one by one lost favour; and it is now more fully established than at any period within the last twenty years, that coal gas affords the cheapest and the cleanliest mode of obtaining artificial light. Nor ought we to omit to mention, as an important event in the history of gas-lighting, the application of Boghead coal, which material had been discovered only a short time before 1851, and the importance of which, in the manufacture of gas, was then unknown. That substance—a richly bitumenised coal found near Edinburgh—produces gas of three times higher illuminating power than Newcastle coal; and it has supplied the means of readily improving the quality of the poorer kinds of coal-gas. It is now largely used for that purpose in most gas works.

The improved processes of manufacture consist in the application of more economical plans of distilling coal, by the use of earthenware retorts; in the use of oxide of iron for the purification of gas in towns; and in the additional value that has been given to the waste products by new chemical discoveries.

The advantage of employing earthenware retorts as a substitute for iron was discovered by Mr. Grafton as early as 1820, but it was a long time before gas companies could be convinced of their superiority. These retorts require a peculiar mode of working to produce gas of an equal degree of illuminating power, and, as made and set when first introduced, they were attended with great leakage of gas. To prevent that loss it was found necessary to employ "exhausters," to reduce the pressure of gas in the retorts, and with that addition and improved modes of construction and setting, the inconveniences of clay retorts were removed, and their durable qualities were found to make an important difference in the cost of retorts. Of earthenware retorts, of fire bricks, and of different modes of setting, to form "beds" of retorts in which the fuel for heating them is applied in the most economical manner, there are many illustrations in various parts of the Exhibition building. In the eastern annexe there is a model of a setting of seven double clay retorts (283), exhibited by Mr. A. Potter of Newcastle-on-Tyne, which presents some peculiarities; and in an open court of the same annexe there is a full-sized setting of six of Mr. G. Walcott's clay retorts (387), in which the ordinary mode of setting is reversed; the spaces between the flues, which are made of hollow bricks, forming the retorts wherein the coal is distilled. In Class X. there are exhibited fine specimens of clay retorts and fire bricks by Messrs. J. Cliff and Son, of Wortley, near Leeds (2259); by Messrs. J. Cowen and Co. of Newcastle-on-Tyne (2265); by Messrs. Fishe Brothers and Co., of Stourbridge (2281), and by other manufacturers: and Messrs. Ramsay and Sons of Newcastle, and some makers of clay retorts from Stourbridge, contribute largely in the eastern annexe.

The improved process of purification by the oxide of iron has been the cause of much litigation, as there were several claimants to the invention of the process. Mr. Hills, who has succeeded in establishing his claim, has, it is understood, made as much as £6000 per annum, by granting licenses to use the process, but the term of his patent has now nearly expired. The principal advantage of that method of purifying gas consists in its avoidance of the strong disagreeable smell that is produced when lime is employed to deprive foul coal gas of its sulphuretted hydrogen. The sulphur is liberated by the oxide, or combines with it in the form of proto-sulphide, without any smell, and one great advantage of the process is that after exposure to the air the oxide of iron becomes revivified, and may be used over and over again. The use of lime is still necessary to remove carbonic acid, which is one of the greatest impurities of coal gas. The chief benefit therefore that is derived from the new method of purification is the removal of a nuisance, which when lime alone is used is very great, and renders the establishment of gas works in a populous locality next to impossible. The method of applying the oxide of iron process differs little from that of purifying gas by means of dry lime, and there is no exemplification of either plan of purification in the Exhibition; but there are several specimens of improved valves and passages for regulating the flow of gas to and from the purifying chambers. The four-way valves of Messrs. Cockey and Son of Frome, that are among the best and cheapest contrivances of the kind, are exhibited in Class X. (2261), and near to them are the valves of Messrs. C. Walker and Sons (2357); whilst among the machinery in motion, in the western annexe, will be found valves for gas by Messrs. Donkin and Co. (1840), and by Mr. J. Beck (1796).

It has long been an object of importance with the manufacturers of coal gas to turn the various products to the most valuable account. The value of the coke alone is generally equal to three-fourth parts of the cost of the coal carbonised, and could it be produced from the gas retorts in the dense metallic-looking condition fitting it to be consumed in the furnaces of locomotive engines, its value would exceed that of the coal distilled. Many attempts have consequently been made to give increased solidity to gas coke, by employing larger retorts, and by conducting the process more slowly. Such attempts have, however, generally failed, for the gas generated at a comparatively slow heat possesses much less illuminating power. Among the many contrivances proposed and tried during the last few years was one for making metallic coke in large ovens, the gas produced being considered merely as a product of the manufacture, to be subsequently rendered illuminating by impregnation with hydrocarbons. The most successful plan of this kind is that of Messrs. Pauwel's and Dubrochet, who have taken out several patents for it, and it has been successfully applied on an extensive scale in Paris. In England, however, there has not been much improvement in the quality of the coke, but there have been great advances made in the application of the other products of gas-making, especially of the tar. That material, which formerly accumulated in gas works in quantities that were difficult to be got rid of on any terms, has, by improvements in the chemical arts been converted into a great variety of articles, and promises to become a valuable addition to the income of gas companies. In the Great Exhibition of 1851 there was a single paraffin candle shown as a curious product from peat; in the present Exhibition there are tons weight of that beautiful substance, in crystallised masses or manufactured into candles, all extracted from the "waste" tar of gas works. Some of the most beautiful dyes are extracted from the same material, and among the chemical products in the eastern *annexe* will be found numerous samples of dyes and colouring matters obtained from coal tar. In a recent lecture delivered by Dr. Lyon Playfair, at the Royal Institution, he displayed a great variety of silks and woollens dyed the most beautiful colours with the products of coal tar, and for the purpose of presenting in a striking form the result of chemical pro esses, he placed on the lecture-table a block of coal weighing 100 lb., and ranged round it were the various colouring matters produced from the distillation of a similar mass, and the quantities of wool died with equal quantities. The facility of obtaining dyes of almost every colour from coal tar is so great, that Dr. Playfair anticipates that this country will, in a few years, become the exporting country for dyes, even to those parts of the world whence we have hitherto been accustomed to import them.

To facilitate the introduction of gas lighting in villages and in private establishments, remote from gas mains, several forms of apparatus have been contrived for manufacturing gas on a small scale, and of these there are three exhibited. Messrs. Porter and Co. of Lincoln, and of John-street, Adelphi, exhibit in Class X. a complete apparatus of this kind, which, within a small compass, comprises all the things requisite for distilling the coal, for purifying the gas, and for distributing it to different parts of a building. The patentees assert that the apparatus is cleanly and devoid of nuisance in its working, and that it produces gas at a price, varying with the size of the apparatus and the cost of coal, of from 1*s.* 9*d.* to 4*s.* per 1000 feet. The charge for a complete gas-work, capable of supplying fifteen lights a day, is only £50, and the price for larger sizes is less in proportion. Mr. Bower, of St. Neots, and Mr. Edmundson, of Dublin, also exhibit in the same class apparatus of a similar description, and the Irish invention professes to have the additional advantage of cooking a dinner with the fire employed in heating the retort.

Some of these diminutive gas works are portable, and they might be placed on board ship to light the decks, or on a railway truck to supply gas for illuminating a train of carriages.

The apparatus in the Exhibition connected with the distribution of gas—particularly gas meters and gas fittings—is abundant. In a small court in the south-east transept there are placed specimens of meters by nearly all the principal makers; and others are dispersed in various parts of the building. Mr. G. Glover, for example, has a separate stall (2291) in Class X., and in the same class the meters made by Messrs. Laidlaw and Sons, of Glasgow, are exhibited; while in a far-distant corner of the northern gallery there is placed a specimen of the meters made by Mr. Sugg (6350). Wet and dry meters compete with each other in nearly equal numbers, and those who are interested in the construction of this ingenious kind of self-acting apparatus will not fail to be gratified by an inspection of Mr. Richards's case (6342), containing a collection of many kinds of meters in various stages of manufacture. In several instances the instruments of other makers are fitted with glass fronts, to show the action of the wheels or diaphragms. The last invention by the late Mr. Clegg, the original inventor of the gas-meter, is exhibited by Messrs. Bischoff, Brown and Co. (6283), and, like all the apparatus of his invention, it displays great ingenuity. Gaseliers, chandeliers, and gas burners of every description of ornamentation, are amply represented in different parts of the building, particularly in the meter court already noticed, and among the hardware manufactures. Messrs. Hardman and Co. have a court of their own in the south-east transept, filled with Mediæval metal work, including a variety of gaseliers. Messrs. Hart and Son (6307), Messrs. Hulett and Co. (6317), Messrs. Messenger of Birmingham (6327), Messrs. W. Winfield and Son, also of Birmingham (6257), and the Skidmore Art Manufactures Company of Coventry, are conspicuous in the display of numerous elegant and brilliant devices for the burning of gas. It is curious to observe the variety of ways in which one of the most important recent inventions is applied by modern artificers to the semblance of objects of past times, so as to adapt, if possible, the practical improvements of the present age to the imitation of devices of an age in which gas-lighting was undreamed of. We do not notice, however, that in any instance has innovation proceeded so far as to make a jet of gas issue from a fictitious wax candle at an altar table; though the apparent miracle of an ever-burning non-consuming candle might have been turned to good account in monkish times.

On taking a rapid retrospective glance at the improvements in gas lighting since the last Exhibition, they appear to be rather of a solid practical character than to present anything brilliant or striking. They have tended hitherto rather to improve the position of gas companies than to benefit the consumers of gas, though the latter have partially experienced the advantage of a diminished price with improved quality of light. The business of gas lighting has been advanced from a speculative undertaking to a well-regulated commercial enterprise, and very high profits are no longer considered necessary to recompense shareholders for the risk of engaging in such works. In all recent gas Acts of Parliament, clauses have been introduced limiting the profits to 10 per cent. at the most, and the rapidly improving circumstances of nearly all gas companies are bringing them near to the highest paying point, after which all further addition to profits must be devoted to reductions of charge. The increasing facility of manufacture, and the increasing value of the "waste products" of gas works, will thus tend in a few years to produce a still further reduction in the price; and, it is to be hoped, a further improvement in the quality of gas.

PASSAGE, ON THE LEVEL, OF A TORRENT ACROSS THE CANAL DU MIDI.

Among the very interesting and instructive collection of models and drawings of French engineering works now in the International Exhibition, may be seen a model 1-25th full size and two drawings, representing a work certainly unique in its character,—no other than the passage, on the level, of a torrent across a canal. The torrent in question is the Libron, which crosses the last level but one of the Canal du Midi (called the level de l'Ecluse Ronde) at a distance of 1300 metres from the Mediterranean. Often dry, and commonly containing but a scanty supply of water, the Libron suddenly assumes in wet weather the character of a violent torrent, bringing with it masses of sand and gravel detached from the friable mountains and rocks among which it takes its rise.

At the point where it crosses the canal the bottom of the bed of this torrent is even with the higher level of the water, which only exceeds the mean height of the sea by 90 centimetres or about 3 feet. This circumstance rendered it impossible to construct such a work as would in ordinary cases be employed to keep an artificial watercourse clear of the natural streams with which it meets.

The inadequacy of the fall made it impossible to take the Libron under the canal by a syphon aqueduct, which would have been liable to get constantly choked with sand. And the carrying the canal by an aqueduct above the highest floods of the Libron was also in a sense impracticable, since it would have involved raising the canal many metres above the level of the plain for a distance of more than 20 kilometres (12 or 13 miles.)

During the first years of the execution of the canal, the Libron had no determinate bed. After rains its waters spread over the plain and discharged themselves at many points into the level de l'Ecluse Ronde, filling it with sand and gravel to such an extent as to render dredging necessary to restore the navigation interrupted by these deposits.

The first step taken was to confine the waters to a single bed, and carry the stream across the canal through a species of lock or basin having transverse and wing walls, the course of the canal through the lock being commonly open, but closed during the rains by strong dams; which were fixed by means of grooves in the masonry, and removed after the turbid waters had spent themselves. This arrangement confined the silting up of the bed of the canal to one spot; but the barges were stopped not only during the continuance of the floods, but also during the placing and removal of the dams, and the re-excavation of the basin.

Subsequently these interruptions of the navigation were shortened by placing in the basin a pontoon having its deck level with the bed of the stream, and having at its sides wooden bulwarks of sufficient height to convert it into a species of aqueduct deep enough to carry the flood waters. In ordinary weather this pontoon was moored on one side, out of the way. In seasons of flood it was placed across the basin, so as to form a distinct channel for the torrent, and while in this position it of course stopped the passage of the boats.

At length, after the stoppages of the year 1853 (which extended over no less than a hundred and five days), it was resolved instead of replacing the pontoon, which had given way under the weight of gravel and sand deposited on it, to try to devise an expedient for keeping the navigation uninterrupted. This end was attained by means of the present work, of which the following is a description.

At the meeting of the Libron and the canal two new beds or branches symmetrically placed were dug for the stream, starting at 50 metres above the canal, and reuniting at the same distance below it. These two branches, each of which is of equal section with the old bed, are separated by a basin exactly similar to a lock, and affording room for one boat.

In these two branches are placed, on each side of the canal, and in a direction parallel with it, an equal number of archways dividing each arm into bays, which can be closed against the stream by floodgates working in timber framing. By means of these floodgates the torrent can be stopped, and caused to flow through whichever channel is desired.

To keep the turbid waters from mingling with the waters of the canal, movable aqueducts or troughs of timber are provided, two in each bay, of the same width as the bays, and of a length equal to half the width of the canal. These troughs are suspended from trucks, which run on rails carried on vaults of masonry, which are built across the canal.

During floods the torrent passes alternately through each of the two branches, as they are opened and closed by the sluices. In the branch where the floodgates are open, the troughs are brought together, so as to cover the entire surface of the basin corresponding to each bay. While in this position they stop the passage of the boats. On the other hand, in the branch of which the floodgates are closed, the troughs are withdrawn into the recesses contained between the abutments of the vaults thrown over the canal and the arches, leaving an open passage for the boats. These recesses are made deeper than the bed of the torrent in order to take the troughs, and are covered with movable flooring to prevent the silting up which would otherwise impede the movement of the troughs.

It will readily be understood that from whichever side a boat approaches (during floods) the torrent is turned through the further channel, until the boat passes into the lock in the middle, where it is made fast. The troughs of the branch which the boat has to pass through are then run together, the flooring lowered, the sluices drawn up, and the torrent flows for some moments through both branches at once. As soon as the stream has set well on the side by which the boat entered, it is stopped in the other branch by closing first the up-stream and then the down-stream sluice. What water remains is run off into the canal by a valve provided in the partition of the troughs. The flooring in the recesses is then raised again, and the troughs are run back, leaving the passage open for the boat to continue its journey.

THE OXFORD NEW MUSEUM.

In our last number we gave a series of sketches from beautiful capitals and corbels in the Oxford New Museum, intending them to exhibit a peculiar development of art-handicraft in the present time, which is well worthy the attention of architects on account of its novelty in modern times, its significant revival of an old power long lost in the mere mechanism of the common workman who follows the template and the sketch with most stupid and dreary persistency; or, amongst other advantages, as presenting a new opening for the development of intelligence in a class of men which may be of infinite service to the cause of art. It is of the greater importance that this matter should be well understood, insomuch that we have, in the very astute class alluded to, numbers of men and youths who would not be behindhand in forcing an opening for themselves to credit and competency if the value of their work were distinctly put before them, and acknowledged to be one of the most important developments of the art-education now going on throughout the kingdom.

That this has sprung up originally, of its own strength, only fostered by the encouragement given to it by a gifted architect, now deceased, and liberally employed by him in decorating the Oxford New Museum, is a fact of some importance. It is indeed significant that the men who wrought these things owe little or nothing to the costly Government scheme which encourages "design," and is recognised in the "Department of Science and Art." It would appear as if here, where some education would seem most useful and desirable, and might be readily afforded through study of the innumerable models got together from all parts of Europe by the "Department" in question, none has been given; so that again, as ever before, the original spirit of the thing has brought forth an able and valuable school of artisans, unnursed, and, it may be, unspoiled, by the mechanical routine of a drill system that has forgotten no small portion of its purpose in the extension of its means.

Officially aided or not, there is evidence ample enough in the works in question to show the existence of a fine feeling for art and delicate love of nature, such as may not injudiciously be guided to a good result, or left to find its own way to some end such as its healthy purpose may declare in time. If we cannot teach such men, we may at least advise those who might do much to extend the movement it indicates, and direct it into a right path. At present these decorators and their class are evidently bent upon reproducing a sculptor's notion of architectural decoration, to the neglect of that held by all architects who have studied the history and characteristics of their art, and acknowledge its limitations and peculiarities.

We wrote last month that the carvings before us are interesting, not only on account of their beauty, but from the fact that in them we have the native productions of the highly-skilled artizan, who, working almost independent of the architect, has produced fron his own love of nature, works which will, in some respects, bear comparison with the finest Mediæval carvings similarly derived, and in no way are inferior, excepting in the conventionalising character, which results from a severely restrained course of study, bound to the development of architectonic sculpture, rather than that which we are accustomed to style sculpture *per se*. In order to trace how it is probable that this peculiar direction of the carver's ability has been derived, it may be well to relate something of the history, purposes, arrangements, and character of the remarkable building they have so admirably decorated.

We must premise that to those acquainted with the history of sculptural art, so employed, this inquiry is the more significant, as they will recollect that the naturalistic character indicated by the drawings themselves, and our words above repeated, was a distinct mark of the decadence of the art, and found its most unfavourable climax in mere imitation by Grinling Gibbons, or the fripperies of the school of carving in France at that and the near subsequent time. Students, thus informed, know the finest periods of architectonic carving are those of the severest development, being in fact coeval with the bloom of the Early English style, culminating in the so-called Early Decorated. Examples of this perfect art, in somewhat archaic forms it is true, are or were to be found in the now mutilated wall arcade at Worcester Cathedral; some exist in Westminster Abbey, and, wherever the hand of the "spoiler" has spared them, in most of our glorious cathedrals and abbeys, now, alas! so thoroughly "restored." Examples of the transition from the severely restricted chastity of this order of art are common enough. One of the best of these is the far-famed Percy shrine at Beverley. We do not intend to compare the Oxford carvings with such work as this, while we acknowledge the merits of the Percy shrine, seeing that they are infinitely more genuine in their honest elaboration.

To return to the building. The ground plan of this edifice is quadrangular, three sides of an inner court are enclosed by buildings, comprising offices, lecture theatres, professors' rooms, and minor museums. The fourth side is at present not so far carried out, but remains two corridors enclosed by arcades on its inner face. At some future time, the building will be extended so as to receive upon the fourth side a similar range of rooms to those now existing on the other three. The space inclosed by these chambers is a court; this, for economy and convenience, has been roofed over with glass, and contains the museum. In the original specification of what was desired for the building, this glazed central court was decided upon, and therefore its adoption is neither to the credit nor discredit of the architect, whose difficulty was indeed how to give an architectural effect to it. In addition to the quadrangle, there are masses of building placed on the north and south sides of the plan at their eastern and western extremities respectively. By this means much diversity of appearance has been obtained, and a number of favourable points of view. These structures are respectively dedicated to the Anatomical and the Chemical Sciences. Both are furnished with open yards, where plenty of air is obtainable, each being inclosed by the offices proper to the sections, which thus are separated from the main building—a needful precaution, and a considerable advantage.

The laboratory, which occupies the southern angle of the chemical annexe, has been designed after the model of the Abbot's Kitchen at Glastonbury; it is connected with the main building by about 50 feet of a lower corridor, and, together with the beautiful pyramid of its high-pitched roof, and the four chimney shafts one at each corner of the square basement, is ingeniously designed to allow the roof to take an octagonal form, by the bretsummers of the furnace hoods cutting off the angles of the main four square walls. The Anatomical buildings at the obliquely opposite angle of the main body being set back give considerable variety to that side also. The front, which is on the west side, advances in plan slightly beyond the corridor above referred to; the junction of the last is marked by an elegant turret and lofty pinnacle, which contains one of the stairways giving access to the upper galleries of the main edifice.

The main front, thus described, is in two floors, with dormer windows in the roof. It extends, six windows in either floor, on each side of a central entrance tower, where the wall-face, projecting slightly in advance of the façade, is carried up to the level of the high-pitched roof-ridge covering the mass of the front, and terminates in a pyramidal slate roof, surmounted by well-designed ironwork. At the base of this tower is the porch, in a bold recess; over it are two broad lights, of distinctly pronounced character, having mullions, jambs, and heads carved most exquisitely.

The general character of this building is Lombardo-Gothic, a character marked in the lofty pitch of the roof, the coupled form of the lights, their diverse grouping, which last is effected with great ability, the character of the quaint dormer windows, and above all by the style of the tower. The whole of the window mullions, jambs, hood mouldings, and heads they inclose, have been admirably carved by the artisans whose work we have already introduced to our readers Most of these carvings are beautiful and original. Each of the extremities of the front, where the return is, has a pair of lights in it, well combined with a circular window above them.

The disposition of the interior of this building was made in the most sensible manner. Each professor sent in an estimate of the space and nature of the accommodation required for his department. Under one roof, Astronomy, Geometry, Experimental Physics, Chemistry, Mineralogy, Geology, Zoology, Anatomy, Physiology, Medicine, have a home. These may be regarded as a model of convenient arrangement, the Museum being even more successful in that respect than in the architectural character of the edifice itself. Surrounding the interior of the building, and looking upon the glass-roofed court, are two arcades, one above another; these are corridors of communication with the different departments just referred to. The glass roof springs from above the upper arcade, so that the arcades of both floors are open to the covered court. The arcade on the ground-floor is entered from the centre of each side of the court. In each of the arcades are seven piers, forming eight openings, and carrying eight discharging arches, within which are two lesser arches, resting their outer sides on the piers, and at their junction with each other on a shaft with a capital and base. The arrangement on the upper story is similar, excepting only that the piers and shafts are of less height, though the piers are of the same number. On this account, in the same horizontal space between each pier four arches are supported by three shafts in the upper arcade, instead of, as below, two arches supported at their union by one shaft. There are, on the ground-floor, thirty-three piers and thirty shafts—on the upper floor thirty-three piers and ninety-five shafts. Thus one hundred and twenty-five shafts surround the court; and, if we include the capitals and bases of the piers, there are one hundred and ninety-one capitals and bases. The shafts have been carefully selected, under the direction of the Professor of Geology, from quarries which furnish examples of many of the most important works of the British islands. On the lower arcade are placed, on the west side, the granitic series; on the east, the metamorphic; on the north, the calcareous rocks, chiefly from Ireland; on the south, the marbles of England. In the upper floor, as far as may be, a similar disposition has been made. The capitals and bases represent various groups of plants and animals, illustrating different climates and various epochs. They are mainly arranged according to their natural orders.

On massive corbels, projecting from the fronts of the piers, are placed statues. Aristotle and Bacon are in the portal. In the mathematical department is placed Leibnitz; in the astronomical, Newton, Galileo; in that of physics, Oersted; in the chemical, Davy; in that of zoology and botany, Linnæus; in that of medicine, Hippocrates, Harvey; in that of applied mechanics, Watt. To these may be added, Descartes, Hipparchus, Kepler, Archimedes, Roger Bacon, Robert Boyle, Franklin, Young, Lavoisier, Stahl, Hutton, Werner, Ray, Jussieu, Humboldt, Hunter, Haller, Sydenham, and George Stephenson.

The next step brings us to the disposition of the capitals and other carvings. Illustrative of natural facts and characteristics, these works of art have quite other points of value than those ordinarily expected from decorative carvings. In a building of the character of that under consideration the imitative spirit was not undesirable, however much it is to be jealously watched in other and differently devoted edifices. It will be understood that these carvings are illustrative as well as decorative, and have therefore a function apart from that of architecture.

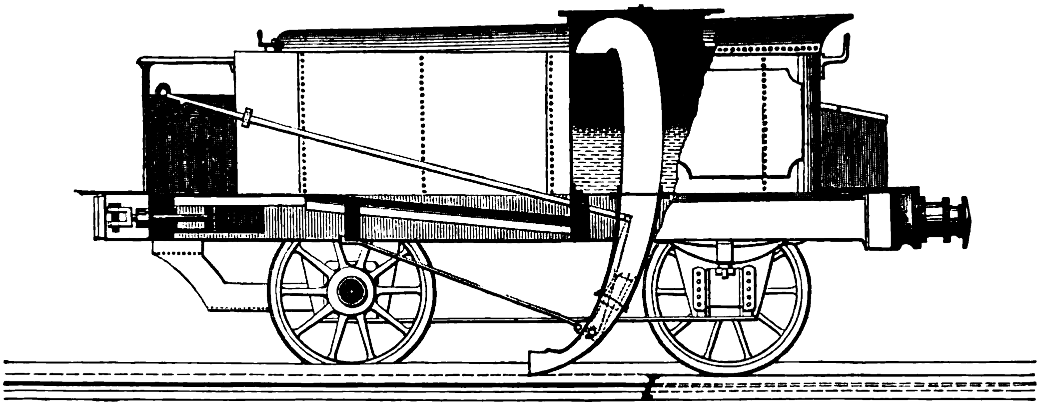
Upon each shaft is disposed carvings of its appropriate botanical accompaniments. Thus, upon the grey granite of Aberdeen, Mr. James O'Shea carved a cap of *Alisma plantago* (No. 1, Plate 15), with corbels on each side of *Sagittaria sagitifolia* and *Alisma ranunculoides*. Upon the porphyritic grey granite appear the palms. The *Aloe*, shown in our engraving (No. 4), that so beautifully turns the chamfer of the pier-angle, comes over the red granite, in this instance got from the Isle of Mull. It was wrought by Mr. Edward Whelan. The *Hart's-tongue fern* (No. 6) was carved by Mr. James O'Shea: it surmounts Devon limestone. In this way, and upon this system, we have the second-named carver's work in the *Typhaceæ* above mountain limestone. *Calla Ethiopiea* comes wth the green serpentine. The *Gramineæ* accompany mountain limestone, and have amongst their slender stems sparrows, buntings, and quails. Then comprise *Bromus*; wheat, oats, Indian-corn, sugar-cane, rice, and canary-grass. The *Zeminaceæ*, Mr. John O'Shea has wrought very finely, comprising *Cycas revoluta*, *Dioes edules*, *Zamia horrida*, *Encephelartos*, &c. These are above the elvan and trap rocks. By the same is *Taxus baccata* upon porphyry. Upon another example of serpentine comes *Stone pine* and *Abietinæ*. The *Orchideæ* come upon gypsum.

The manner in which the original design for the Oxford Museum has been carried out does honour to all concerned. Its energetic prosecution is due in no small degree to the Dean of Christ Church, and Dr. Acland. The architect was Mr. Woodward, whose recent death has left a vacancy in art not soon to be filled up. Mr. Pollen has had a hand in some of the decorations. Mr. Bramwell, clerk of the works, and since the completion of the structure resident assistant architect, has had not a little influence upon the general success. The carvers we have named are best named in conjunction with their works. With them, and with other decorators, the work, architectually speaking, now rests. One fortunate element of success has been vouchsafed to this building, one of more importance than is generally conceived; this is, that no part of it has been hurried. Haste, the bane of our modern restorations—which is doing so much towards the art-destruction of many a noble ancient cathedral! wherein the works are pushed on madly, partly because the wretched system of contracts compels the undertaker to do his task at all speed, in order to get anything like profit out of it; partly because subscribers desire to see a whole edifice, which took two hundred years to erect, scraped to the bone, and produced to them "as good as new," in twelve months;—this miserable folly, we say—this haste, is not inflicted upon this one of the best examples of modern Gothic work in the kingdom.

INTERNATIONAL EXHIBITION 1862.

Class 5.—*Railway Locomotion.*

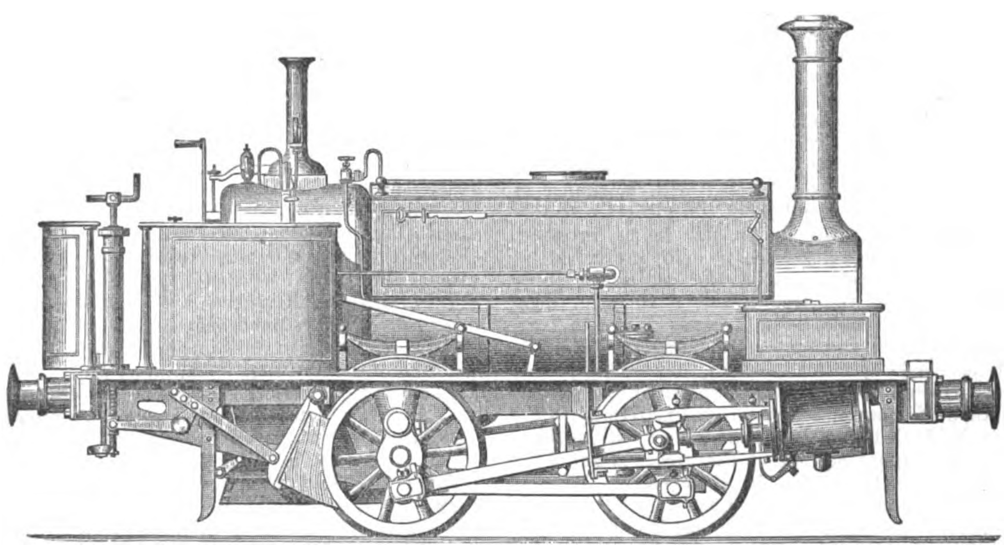
The locomotive engines and other objects connected with locomotion on railways are less numerous in the Exhibition of 1862 than they were in 1851, but they are generally better finished, and they are displayed to much greater advantage than in the gloomy space allotted to them on the previous occasion. At that time the "battle of the guages" was waging, and the Great Western and the London and North Western Railway Companies competed with each other in exhibiting the most powerful locomotive engines adapted to their respective lines. It was then shown that, notwithstanding the greater width of guage, a greater amount of power was gained by the elongated boiler on the London and North Western line than by the heavier engine on the Great Western, the driving-wheels in the competing engines being each 8 feet in diameter; and there was one engine, also made by the London and North Western Company, the driving-wheels of which were 8 ft. 6 in. None of the engines now exhibited exceed their predecessors in power, and there is no specimen of the broad guage locomotives. The engine built by Mr. Ramsbottom, the locomotive superintendent at Crewe (No. 1269), is the first of its class, and a similar one to it has run the express train from Liverpool for a distance of 130 miles without stopping, at an average speed of 54 miles per hour. This actual work done may be considered nearly equal to the estimated performance by the Great Western engine in 1851 of "taking a passenger train of 120 tons at an average speed of 60 miles an hour upon easy gradients." In Mr. Ramsbottom's engine the driving-wheels are 8 feet diameter; it is fitted with duplex safety-valves and lubricators, and is adapted for burning coal. To have accomplished a distance of 130 miles without stopping for water would have required a greatly enlarged tender unless it had been fitted with Mr. Ramsbottom's apparatus for taking up water whilst running, which is one of the most recent important improvements for facilitating rapid locomotion on railways. The tender of the locomotive exhibited has this apparatus attached, and at the back of it there is exhibited (1270) a working model, on a railway 80 feet long, showing how the tank can be thus supplied. Between the rails a water-trough is laid, which in practice is about five inches deep, and the one laid on the Chester and Holyhead railway near Conway is 441 yards long on a level. At each end the trough is tapered off in depth. A tube rises through the tender rather higher than the surface of the water when filled, and it is extended under the tank, and curved, having an open mouth to serve as a scoop to take up the water as it is propelled rapidly through the trough. The principle of the action of this apparatus, as explained by Mr. Ramsbottom, consists in taking advantage of the height to which water rises in a tube when a given velocity is imparted to it on entering the bottom of the tube. The theoretical height is that from which a heavy body must fall to acquire the velocity of the water, hence since a velocity of 32 feet per second is acquired by falling 16 feet, the same velocity, or 22 miles an hour, would raise the water 16 feet. In the working tender the water is lifted 7½ feet from the level in the trough to the top of the delivery tube. The width of the scoop is eighteen inches, its depth in the water is two inches, and, in passing through the 441 yards of trough with a velocity of 33 miles an hour, the quantity of water delivered into the tender is 1200 gallons. That is the *maximum* quantity, for at greater speeds the more rapid entrance of the water is counterbalanced by the reduction in the time of action, so that there is very little difference in the quantities raised, whether the scoop passes through the water with a velocity of 22 miles or of 50 miles an hour. This self-acting plan of feeding the tender with water surpasses in ingenuity, though it is of less practical value, Mr. Dicker's automatic apparatus for transferring mail bags when the trains are at full speed, which was the chief novelty in railway apparatus exhibited in 1851. The annexed engraving represents a tender fitted with Mr. Ramsbottom's scoop, that portion of the tank being shown in section. It will be observed that the tube is jointed, so that the scoop may be raised a few inches above the ground when not in action, in which position it is retained by a balance weight.



Tender fitted with Ramsbottom's Apparatus for taking up Water whilst Running.

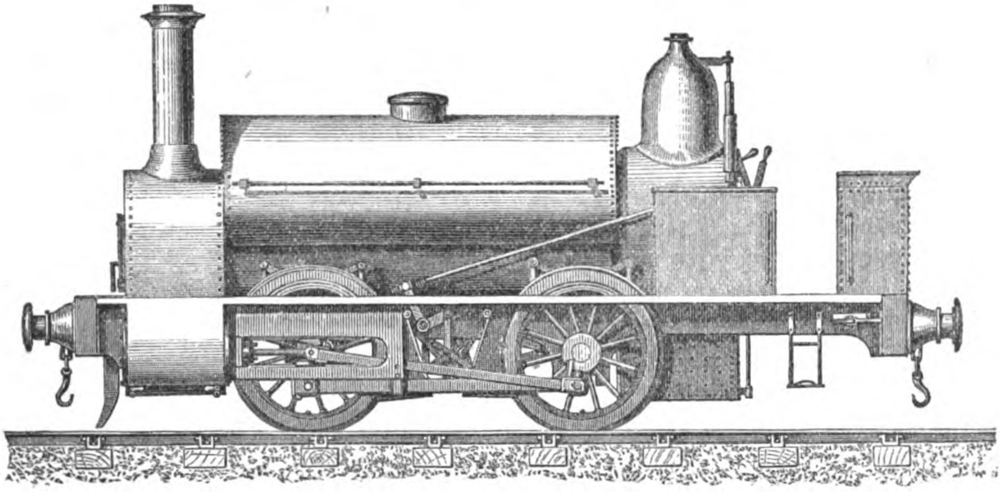
Passing from first-class passenger engines, we come to that useful class of small locomotives intended for collieries, or for contractors' work, and may be designated railway traction engines. The requisites in such engines are, power slowly exerted on small wheels, to obtain greater adhesiveness to the rails, and the capability of turning sharp curves and ascending steep gradients. There are two very good specimens of this class of engines exhibited; one of them by Messrs. Manning, Wardle and Co., of Hunslet, near Leeds (1274); the other by the Lilleshall Company, of Shiffnall, Shropshire, of both of which we give illustrations. The small tank engine of Messrs. Manning and Co. weighs, when in full trim, only 10¾ tons; it has four wheels, coupled together, 2 ft. 9 in. in diameter; and its cylinders, placed outside, are 9 inches diameter, with 14 inch stroke. The advantage of outside cylinders in a four-wheel engine is, that they allow the driving axle to be placed farther back than could be done with inside cranks, and thus reduce the overhanging weight. The object of having only four wheels placed near together is to enable the engine to turn more readily round curves; and it is so constructed that it can go round any curve that an ordinary railway-waggon will pass. Experience has proved that these engines are of great use in collieries and in the construction of railways, and their light weight enables them to pass over temporary rails on which heavier engines could not be safely used.

The tank-engine of the Lilleshall Company is in its main features similar to that of Messrs. Manning and Co.; and in the subjoined engraving it seems somewhat simpler in construction, owing to the omission of the break apparatus, and to the lower position of the springs. In the description which the Company give of their engine, it is stated that "the engine has outside cylinders, four wrought-iron wheels coupled, hardened, and steel link motion expressly arranged for keeping the boiler unusually low in the frame, steel piston-rod, slide bars, copper fire-box and steam pipes, brass tubes, patent brass fittings. It is also fitted with the Lilleshall Company's patent compensating buffers, which adapt themselves to take an equal strain round sharp curves. The whole is built extra strong to resist the wear and tear of heavy gradients, sharp curves, and the frequent inequalities of colliery roads."



Manning, Wardle & Co.'s Locomotive Mineral Tank Engine.

The contrivances exhibited for the prevention of accidents on railways, in the form of improved "breaks," buffers, or signals, are less numerous than they were in 1851. Notwithstanding the many plans there shown of stopping the motion of a train, the old method of blocking the wheels and of relying on the resistance caused by the friction of the tires with the rails for retarding the impulse, has continued to be adopted. The inspecting officers of the railway department have often reported on the accidents produced by the breaking of the wheels, and they have directed attention to the importance of not weakening the tires by rivet-holes. This is the more essential so long as the present system of retarding trains by the friction of the tires against the rails is continued; and it becomes important that the tires should be made perfect, and be shrunk or otherwise fixed on without rivets. There are several exhibitors of wheels and tires of this kind, among others, Messrs. Dixon and Clayton, of Bradford (1270); Mr. Owen, of Rotherham (1285); and Messrs. Spencer and Sons, of Newcastle-on-Tyne (1301).



THE LILLESHALL COMPANY'S LOCOMOTIVE ENGINE, FOR COLLIERIES, CONTRACTORS, &C.

IRON RAILWAY BRIDGE FOR INDIA.

THERE is now in course of construction at Manchester a large wrought-iron lattice-girder railway and carriage-way bridge combined, which is to cross the river Jumna, near Delhi. The contractors, Messrs. Ormerod, Grierson & Co., of the St. George's Iron Works, Hulme, have just completed for it the first of a series of twelve spans. The bridge is for the East India Railway Company, and is from the designs of Mr. A. M. Rendel, C.E. It is constructed to answer the double purpose of a railway and an ordinary road; a single line of railway being along the top, and the roadway beneath it. Each girder is 216 feet long; the clear span is 205 feet between the piers, of which there will be eleven. The twelve spans will therefore form a structure having a total length of over half-a-mile. Confining attention to one span, as representing the main features of the whole bridge, it may be described as consisting of two lattice girders united to each other by means of strong transverse girders. Between the upper side of the lower roadway and the under side of the railway there is a clear height of 16 ft., and the total depth of the bridge at its centre is 18 ft., and its breadth 18 ft. It has a slight rise towards the middle, being constructed with a camber of 5 inches. The top and bottom members of the girders resemble a sort of continuous trough, the upper pair being inverted. The bottoms of these troughs commence with one thickness of ½-inch plates, but increase towards the centre to three thicknesses. The sides of the trough are 1 ft. 9 in. deep and 2 ft. 3 in. apart, each side being composed of two half-inch plates riveted together; and instead of being joined to the bottom plates in the usual way with angle-iron, they are flanched or bent to a curve of 4 inches radius, thus forming their own attachment. This method of construction has added materially to the appearance of the bridge without detracting from its strength.

The breadth of the upper section of the girder is 3 ft. 5 in., while the lower increases from 3 ft. 5 in. at the ends to 4 feet at the centre. The transverse girders for supporting the metals of the railway are firmly fixed below the upper section of the main girders; they are 4 ft. 6 in. apart, and there are 46 in each span. Those for the roadway are 6 feet apart, and there are 35 in each span. The lattices are placed at an angle of 45 degrees, and the tension bars are riveted to the outside of the top and bottom troughs. At the ends of the girders the bars are flat, 1 inch thick and 5 inches broad, but they are substituted by channel iron of a lighter section as they approach the centre. The compression-bars are formed of two angle-irons riveted to the inner sides of the trough, and cross-braced by light channel bars. The whole is surmounted by a light and elegant hand-rail, formed with wrought-iron standards of a curvilinear outline, connected together by iron tubes.

In a structure of such magnitude it was of course requisite to provide for the variation from expansion and contraction, and this object appears to be effectually secured. The extremity of each girder is firmly fixed to a casting, the under side of which is concave, and rests so as to move freely upon a corresponding casting, with a convex upper surface made to fit accurately the concavity above. This casting has a flat planed under surface resting upon five iron rollers, arranged in a strong wrought-iron frame, which has perfect freedom of motion over a bed-plate secured to the masonry. By this arrangement the span is at liberty to undergo deflection, and yet to press with equal weight upon all the rollers. The rollers are placed at one end only of each span.

A peculiarity in this structure is that none of the rivet-holes are punched. Multiple drilling-machines, five in number, were constructed specially; the largest receives upon its table a plate 13 feet long and 4 feet broad, and in the course of seven minutes drills four rows of holes, making together 160. The pressure upon the drills is maintained by two hydraulic rams acting upon the under side of the table. We are informed that the Messrs. Cochrane, of the Woodside Iron Works, Dudley, were the first who applied this machinery to bridge building; and to them Messrs. Ormerod, Grierson & Co. acknowledge themselves indebted for much valuable information relating to it. The holes made in this manner are more accurate than when punched, and the fibre of the iron remains uninjured.

The first span has been completely riveted up in the works, and loaded with 432 tons of pig-iron, or two tons to the lineal foot. The girder deflected with its own weight 1 inch, and 3 inches more under the load applied. The iron was supplied by the Shelton Bar Iron Company, near Stoke, and was required to bear a tensile strain of 21 tons to the inch of section. The breaking strain is estimated at from 2500 to 3000 tons equally distributed. The bridge, notwithstanding its great size and strength, has a light and airy appearance. The open lattice-work relieves it from the dull and heavy aspect inseparable from tubular structures; and when a dozen such spans as that now completed stretch across the Jumna, we can scarcely think otherwise than that the Railway Company will regard the bridge sent from Manchester as highly creditable to the skill of their engineer as its designer, and to the firm who were entrusted with its construction.

ITALIAN ARCHITECTURAL DRAWINGS IN THE ROYAL LIBRARY AT WINDSOR.*

By Arthur Ashpitel, M.R.I.B.A.

A short time before the fatal illness which deprived the architectural and artistic world of one who had devoted the best part of his study and energy to cultivate and foster their pursuits, that great personage had occasion to direct some very important alterations in the Royal Library at Windsor. During his researches there he discovered some old Italian architectural MSS. having the name of Muzio Oddi, of Urbino. He was much interested by the bold, original, and in some degree quaint nature of some of the drawings, and the extent of the knowledge and pursuits of the author. There were rough designs for large churches and palaces, mixed with sketches for details of the smallest matters; and with them were plans of battles and sieges, projects for fortifications of vast extent, and with them minute details, comprehending even the method of raising a drawbridge. The writing is in old Italian, and very difficult both to decipher and to translate. As other volumes now from time to time came to light, evidently by various architects, and all inscribed in the same language; and as many long days' reading in the libraries of Italy, while in search of materials for the restoration of the remains of old Rome, had made me, in some degree, familiar both with the character and phrases of the MSS. of the time I was requested to examine them. I was able to identify and explain the greater part of the subjects. The research was of course suspended and delayed by the melancholy death of His Royal Highness, but ultimately this was the result:—No less than thirty-two bound volumes, mostly of very large size, were discovered, besides six large portfolios of drawings, which probably were intended at one time to have been bound. The earliest date I could discover written in them was 1563, and the latest 1773, but many of the drawings are probably older. Some of these volumes contain the arms of the Albani family, and as they are surmounted by the cardinal's hat, it is probable they came from the library of some ecclesiastical dignitary of that family. Some have the arms of the celebrated Consul Smith (as he is generally called), a gentleman who occupied a distinguished diplomatic situation in Italy for a long time, and who is favourably known among artists as a collector of very refined taste, and better known among the lovers of old books as the editor of the curious fac-simile of a very early and celebrated edition of Boccaccio. Some of them contain reports directed to Pope Clement XI., who was one of the Albani. Whether he bequeathed them to his family, or in what way they came to England, is matter of conjecture. The tradition is that Consul Smith had an unlimited commission from George III. to purchase for the royal library. Suffice it to say, they commence before the period of the completion of the chancel, as we should call it, but, more strictly speaking, the *tribune* of St. Peter's, and proceed, giving examples of some of the finest modern edifices in Rome, to the decadence of the art of architecture in Italy, a range of more than 200 years.

Among the objects of which we have copious detail drawings are those of the completion of St. Peter's and building the sacristy; the alterations of the basilican churches of the Lateran, St. Sebastian, and St. Maria in Trastevere, which were required by a change of ceremonies at the period of the papal benedictions of the pope; a great number of new churches, among which San Ignazio, Spirito Santo, San Pietro in Montorio, works connected with Santa Maria dei Angeli, and many others; among the villas are the Giulia, Medici, Albani, Riarii, Madama, Panfili, and the banqueting-house of Cardinal Farnese; among the public buildings, the Curia Nuova, the Propaganda, and many of the buildings on the Quirinal; of the theatres, Alibert, Tordenone, that at Parma so well known; the noble flight of stairs or salità of the Trinita ai Monti, and the fine façade of the fountain of Trevi. Among the objects of antiquity are drawings of the columbaria about Rome, and of all the temples and basilicas in the state they were in at the time. Valuable as those are which represent objects still in existence, there are many which have a twofold value to the Roman antiquary, because they have since wholly or in part disappeared. Among them are the temple of Minerva Medici, that in the Forum of Nerva, the Settizonium of Septimius Severus, the villas of Hadrian and of Pliny, and a great number of relics formerly in the Appian Way. There are also rich treasures in beautiful copies of friezes, arabesques, stuccos, and mosaics, taken from the remains of antiquity, many of which have faded since exposed to the light, and some, perhaps, have perished. But the architects have not confined themselves simply to building operations; they have condescended to design the minute adjuncts to decorations required. We find among those volumes, drawings for altars, tents, tombs, funeral decorations, chimney-pieces, fountains, and even lamps and thuribles. Nor have they been content with the artistic portion of their profession; we find among those volumes evidences of high scientific knowledge; we have drawings of harbours, with the method of repairing breaches of the sea and constructing breakwaters—on a less scale, it is true, but as ably planned as that at Plymouth, and a more wonderful work, if we consider they could not compel the services of that gigantic helot steam in those days. There are also designs for prisons and houses of correction, quite on the principle of our system of inspection, plans for complete drainage of towns, and a number of others, which show that architecture and engineering were at that time synonymous arts. Not only so, but military engineering exhibits itself largely in these volumes. There are plans of the sieges of Tortosa, Monferrat, Fuentes, Antibes; a number of military plans for various parts of the country; projects for fortifying the city of Lucca, which were carried out and now exist; curious designs for towers of defence, mounting one large gun, like our Martello towers; designs for large granaries; powder manufactories, with drawings of the machinery; designs for drawbridges; in short, specimens of almost all the useful and ornamental arts of the day may be found in those volumes. The names attached to the drawings, which in most cases, and perhaps in all, are autographs, are indeed deserving of deep respect, second only to those of the great men of the age which immediately preceded them, as Da Vinci, Raffaelle, and Michael Angelo. We find the names or works of Julio Romano, Domenichino, Bramante, San Gallo, Pirro Ligorio, Bartoli, Borromini, Oddi, the Fontanas, &c. And one precious volume is filled with original sketches chiefly from Venice, by the famous Canaletti.

When we consider the versatility of talent displayed by the Italian architects, who did not disdain small things in art because they were capable of great things, nor the useful because they were masters of the ornamental, it is not to be wondered at they held the high rank in society they did. The pope, the emperor, the grand duke, all welcomed the architect as not only a lofty but a useful spirit in the state, and he trod in courts the equal of the leading minds of the day in other intellectual pursuits—the diplomatist, the jurist, or the great inquirers into the physical or metaphysical worlds. Whether the system urged upon us by some, in the present day, of despising science and learning, and narrowing the mind to one branch alone, or rather to a sub-branch of a branch of architecture, tends to raise the profession in the eyes of the public, or whether it has not already tended to its depreciation in some degree, it is not our purpose now to inquire.

By gracious permission of the Queen we have before us four volumes out of the collection at Windsor, on which I beg to venture a few remarks. They are not specimens of the most finished and most highly-coloured drawings there, but exhibit rather the architect in his studio, dashing off with a common pen the rising ideas in his mind, and the greater part had probably never been meant to meet the public eye. The most of them, however, are evidently to scale, and the localities and the subjects, and the purpose-like manner in which they are executed, will I am sure be worthy our attention.

The first to which I shall direct your attention has a melancholy interest attached to it, for it was the first discovered by the late Prince Consort. The name of its author is not one of those familiar to every ear, though in foreign biographies it holds a respected place. It may be convenient, however, to state a few facts as to his character before proceeding to the examination of the contents of the two volumes, which I will endeavour to do as briefly as possible. Muzio Oddi, whose name stands conspicuous on the title-page, was born at Urbino, in 1569. His father was an officer in the troops of Francisco di Medici. At an early period he gave promise of spirit and talent, and was placed under the tuition of the celebrated Baroccio, from whom he learned drawing. This painter was also a native of Urbino, and one of the few that opposed the so-called eclectic school of the day, preferring rather that of Correggio, Raffaelle, and their predecessors. He soon discovered in the lad a talent for mathematics and the constructive arts, and advised him to give them his particular attention. His biographers say that Oddi made rapid progress in these studies,

* Read at the Royal Institute of British Architects.

when, like our late lamented fellow-member, the celebrated Cavaliere Canina, he entered the army and became *chef d'artillerie*. He seems to have distinguished himself so much, and to have won the approbation of the grand duke to such a degree, as to be admitted member of his privy council; when suddenly a storm broke over his head. He was charged by the grand duke with having betrayed the secrets of the privy council, and that to his wife, the grand duchess, and he was immediately consigned to the dungeons of Pesaro. The charge seems strange, and there are hints that, after all, Italian jealousy was at the bottom of the accusation. However this may be, it seems clear that the unhappy young man was subjected to a strict and cruel confinement for nine long years. He was deprived of the use of pen, ink, and paper; but his biographers say he got over these defects by making pens out of pieces of reed, and ink from charcoal and the soot of the chimney, and that he fabricated a sort of size from the relics of his food, with which he prepared the commonest sorts of paper so that they could take the ink. Specimens of these drawings are still preserved at Urbino, and shown as curiosities; and I have very little doubt that some of the rougher sketches now on the table before us were done in the same manner. In these pursuits, and in the study of mathematics the time passed away, and he was at length liberated; but on condition of his leaving his native place for ever. He proceeded at once to Milan, where he was elected to the professorial chair of mathematics, and probably practised also as an architect; for we have in the volume before us some designs which appear to have been carried out in the cathedral there. From thence we read that he was invited to Lucca, to fortify that city; it was in the year 1626, when a struggle was going on for the vacant dukedom of Mantua, and Italy was ravaged alternately by the arms of France and Spain. The drawings of those fortifications are before us; and we are told that they gave such satisfaction to the authorities that he was presented with a medal of honour. From the drawings of sieges and other military operations, it is probable he was present at some of the battles which ended with the sack of Mantau. He seems, however, to have resided at Lucca; for his biographers state he was invited from thence by Cardinal Trivulzio to return to Milan. This invitation he declined, preferring to proceed to Loretto, where he seems to have designed the sacristy for the famous church there, and to have executed works at Ancona. Shortly afterwards he appears to have had permission to return to his native town, Urbino, where he died at the age of seventy years.

His writings are still extant; and they are purely mathematical. One is a description and the direction for use of an instrument which he calls the polymetral compass, a delineation of which it is supposed is in one of the volumes before us. On the title to the book is neatly written, "Original drawings from the hand of Muzio Oddi, of Urbino." It commences with a large number of sketches in a sort of ink and in red chalk. Some of these are very neatly finished, others are of the roughest description—in fact, nothing but scratches, and as if done by a very imperfect light. They are on mere scraps of paper, and the probability is, a good portion of them were done in the solitude of his dungeon, and with the imperfect materials I have described. Among them is a drawing of a curious instrument, composed of two limbs connected together with a graduated circular arc, which seems to be fixed, and carrying another one graduated in like manner, which seems to be movable. It is furnished with a plummet, and seems intended for taking angles or levels, and may be the polymetral compass alluded to by his biographers. We have no clue to the period, but might infer it was made after his liberation. A rough sketch (p. 21) is given of a tablet to the memory of his father. The inscription is—"D.O.M. To Captain Lactantius Oddi, who, when alive, was strenuous and upright under every fortune. Mutius and Matteo placed this as an act of piety to their father." Many of the drawings which now follow are more neatly executed; and many have dimensions figured on them which would lead one to suppose they had actually been executed. They are not only for churches, campaniles, and other large constructions, but even for organ-cases, brackets, and other ornaments; and one seems a design for a picture-frame. A large number of them are for doorways, entrance-gates, and large windows, and, I think we must agree, display much ingenuity and boldness of handling.

The second volume commences with plans which seem to have been parts of conventual buildings. Among these is a very curious sketch of the inside of a dome looking upwards, and showing a construction of scaffolding cords, &c., probably intended as appears by a section at page 22, to enable the builders to fix the tambour at the top. At page 19 we have an elaborate plan of a large palace, fortified at each angle with a bastion, with embrasures for twelve guns each. It in some degree resembles Caprarola in arrangement; but the latter is a polygon on plan, while this is square. This is followed by the plans of the *enceinte* of a large town, strongly fortified by the sections, or, to use the expression of the old engineer, "profiles" of the ramparts; unfortunately there is no description by which it may be identified. We have three plans, &c. for conventual buildings, one of which is indorsed "A monastery for the nuns of Ancona," and shows our author continued his avocations as an architect even while occupied in military pursuits. We then have the plan of a large amphitheatre, on the back of which are some curious moral reflections on beauty and love. One of these is headed by a reflection, expressed, no doubt, many thousand times before and since his time—"*Amore tiranno.*" Whether the remembrance of the grand duchess gave birth to this expression, we know not. We then have the design for a large window, which, from the inscription, we may suppose to have been put up at Milan in the Duomo; under this it appears an altar was intended to stand, which, he says, was to be conformable to the altar of St. Joseph. The whole is of marble, and seems of very large size. It would be tedious minutely to describe every item before us. Suffice it to say, we have designs for a chapel, on the back of one of which is written, "Plans of the Chapel of the Pope in the Church of Minerva," probably Santa Maria sopra Minerva at Rome; and others for the sacristy at Loretto.

We now get the designs for fortifying the town of Lucca. Some are marked the "Idea of George Settale of Milan"; while his own is modestly inscribed, "The idea of another without a name" (*innominato.*) With these are detail drawings of bastions, one with rounded, and the other with square orillons; there are also stairs apparently leading to casemates, or magazines, or other places of safety. We then have a plan of the city and citadel of Casale, on which is sketched in red chalk the approaches of the enemy, and some rough outworks, which seem to infer that he was present and took part in the operations. The mixture of military and civil architecture which follows shows that Oddi still combined the pursuit of arts and arms. But it would weary you to describe them all. I would, however, call your attention to a very ingenious contrivance for raising and lowering a drawbridge, where the increased weight, due to the increased leverage as the bridge descends, is compensated by a very clever contrivance, much on the principle of the fusee of a watch. To judge of his abilities in a military point of view by the knowledge of the present day would be absurd. The increased powers of ordnance, particularly of the mortar and shell, have entirely altered siege operations from the time of Muzio Oddi. He seems to have used both the flat bastion (such as those with which San Michele fortified Verona), and the bastion with a larger capital and sharper angles, of Vauban and Coehorn; but he seems to have taken especial pains with his orillons. In his time cities were often taken by storm as soon as any breach could be effected, and very often merely by escalade, by *coup-de-main*. In this case it was very important to be able to get guns to sweep the face of the curtain, and equally important those guns should not be exposed to a cross-fire. San Michele put one under another in the orillons; but of course, like all casemated guns, they were annoyed by their own smoke. Oddi placed his side by side. If, however, we judge of his abilities from the honours paid him, and the testimony of his biographers, he must have been a great military architect.

The next volume to which I shall beg to call your attention is one wholly devoted to the Church of St. John Lateran, at Rome. This noble building has a façade nearly 40 feet wider and 30 feet higher than our St. Paul's; and is nearly 80 feet wider between the clear of the walls of the nave. The old Basilica was destroyed by fire about the year 1350; and was restored by a long succession of popes, and completed, as to its interior, by Clement II., about the close of the seventeenth century. The volume contains a number of plans and sections of the building, boldly and almost roughly executed in pen and ink. These show the present state of the church. It formerly consisted of five aisles, divided simply by immense Corinthian columns, from the capitals of which arches sprung in the old Basilican style. As modern requirements demanded a great number of altars, large piers were constructed, with niches, &c., fitted for that purpose. A great many of the old columns which had escaped the fire are said to have been built into these piers. It has, therefore, entirely lost its ancient Basilican character. The whole edifice is enriched with the finest marbles, mosaics, gildings: it is full of noble statues and fine monuments; and is, in fact, second in richness only to that of St. Peter. The book before us is well worthy of inspection, not only to those who have seen the building, but to those who have not. The latter half of the volume is occupied by a most curious subject, It contains drawings for all the ceremonies of a council of the church. This, of course, would not be an œcumenical or general council; the last of which, as is well known, was that of Trent, nearly three centuries and a half ago. It is, probably, a smaller council, or conclave. The principal feature in decoration is an immense tabernacle, called a catafalco, which stands over the high altar, and is very richly decorated. It seems to have been surrounded by bas-reliefs showing the procession and the other ceremonies, the bishops and other dignitaries: some are walking, some sitting at a table, some kneeling at an altar; while behind a sort of screen stand skeletons, which seem watching and mocking their pomp and state. There are plans of the arrangements of the seats, and even of the hangings to adorn the church, and drawings of the accessories down to the chalices and candlesticks. The benches and chairs are also drawn. One is said to be "for the Pope made:" it tells "of red brocade and damask velvet, with two footstools to match." Another more curiously is marked "Seat of straw with two cushions of silk." All have figured dimensions. This volume is probably by Carlo Fontana, as the arms of Clement XI. appear in several places. This prelate came to the papacy in 1700, both Borromini and Bernini then being dead.

The last volume to which I venture to invite your attention (at least the greater part of it) is superior in artistic execution, and the subjects are of greater interest than those I have already alluded to; although there are others at Windsor possessing still greater claims to your admiration. The volume commences with some extremely well executed sketches of Roman remains, very carefully outlined and shaded with bistre. They consist of the arches of Constantine, Septimius Severus, the Goldsmiths, of Lucius Verus; the Porta Maggiore, the Arch of Titus; the remains in the Roman Forum of that of Nerva; the baths of Paulus Emilius, the Theatre of Marcellus; the temples of Fortuna Virilis, Antoninus, &c.; the Septizonium, the Pyramid of Caius Cestius, &c. They are very faithfully rendered, and possess the unusual interest of giving some examples which are now destroyed or removed. Thus, the Temple of Pallas, in the Forum Transitorium, was taken down by Paul V., and the columns now form part of the magnificent fountain called the Aqua Paola. The Arch of Lucius Verus has disappeared. The Septizonium of Septimius Severus has also perished, and nothing is left of it but a heap of old bricks. At first, I thought the drawings were the originals of those given in Gamucci's "Rome;" but, though they resemble them somewhat in character, all differ more or less; while the larger part differ *in toto*. One curious circumstance arose during the research, and that led to the inference that they are older than this book, which was printed in 1565. The Arch of Septimius Severus, in the latter work, shows an excavation round the lower part, by which the pedestals are exposed to view as they are at present; while in the Windsor MS. they are drawn as still covered up with the earth.

An examination of Rossi, Sadeler, Du Perac, Defrairius, Gamucci,—in fact, of all the authors on the subject to which access could be had in the very limited time I had to prepare this paper,—proved these drawings were no part of their works. I therefore took the volume up to the British Museum, the kindness, attention, and courtesy of whose officers, on repeated occasions, I am proud to acknowledge. Mr. Carpenter, Mr. Rye, and Mr. Bond gave a very long and patient investigation of the subject. The former gentleman said immediately that he thought they strongly resembled the drawings of the Jacopo Tatti, whom we know better as the great Sansovino of Venice. Unfortunately the museum possesses but one drawing from this architect's hands. On comparing it with those before us, there certainly was a very great similarity. The colouring was hardly so warm as these, but that might have been quite an accidental circumstance. The latter gentleman, who I ventured to name, and who, in judgment of the identity and period of handwriting, may be considered "*facile princeps*," also thought the inscriptions on both extremely like. With but one drawing from which to judge, however, it would be much too hasty to pronounce a decided opinion. We all thought, however, we might go so far as to say there is great probability that these drawings are the work of Sansovino; and, if that be correct, of course they are of the greatest interest and value.

The remaining drawings in the volume are by different hands, some being very well executed, and some evidently copies of good drawings by inferior hands. In one or two of them, the blunders in the perspective are such as none but an inexperienced person could make. On one drawing there is the name of Vignola; but it is not likely it is his. On another is the more likely inscription, in Latin, "From the books of Julian Giamberti, called San Gallo;" and the drawing may thus be said either to be by that celebrated architect, or to have been collected by him. The subjects are all Roman antiquities. No. 17 is the so-called Portico of Octavia, in the Peschiera, which is drawn as nearly entire, and the restoration of which differs very little from that of Canina. It is now in a very dilapidated state. Several others may be recognized, as the Arch at Verona, and those of Titus and Constantine, the Baths of Paulus Emilius, &c.; but it is exceedingly tantalising to see several very curious buildings to which we have no clue, and which we suppose must have disappeared. At the end of the volume are a number of plans which seem to suit some of the drawings; and if so, the inscriptions "One mile out of Rome," "Two miles from Rome," &c., would lead us to think they are parts of the villas, tombs, or temples which some time lined all the roads from Rome, and now are mere heaps of ruin; and, having served as quarries for ages to every one who wanted building materials, are now mere heaps of rubbish. The beautiful statues, the sculptured friezes, the marble columns, that adorned those buildings, have long ago been burned into lime to fertilise the land; such of the other materials as could be moved have formed wretched farmhouses or inclosures to keep the sheep and goats from the nightly incursions of the wolf. Nothing now remains but such masses of brickwork as are too hard, too rock-like, to be worth the labour to plunder, and which stand up among the vast plains of the Campagna as ghostly relics of past grandeur.

This paper was begun with saddened feelings, and seems to conclude in the same spirit. It is natural it should be so. It might be thought fitting to make further allusion to the great personage who has departed, I cannot but feel that such a course would necessarily revive painful feelings, and that it would be out of place for me to attempt to pronounce anything like panegyric. One thing may be permitted, however, which offers in some degree a more cheering retrospect, and that is, that one of the last things the Prince asked for from the library related to these MSS.; and one of his latest wishes was that an opportunity of exhibiting them should be afforded to a body he always held in regard,—the Royal Institute of British Architects.

THE ECONOMIC CONSTRUCTION OF GIRDERS.*

(*Continued from page* 196.)

GIRDERS OF GREAT SPANS.

The most striking peculiarity of a girder of very great span is that a large portion of its strength is absorbed in supporting its own weight: and were the span extended to a certain point (varying however according to the economic merit of its particular construction and the quality of the material made use of), the girder would just break down from its own weight, and when this point is reached, by no amount of additional material could this ultimate span be extended while the nature of the structure remained unimproved.

Another peculiarity, the importance of which has never, so far as we are aware, been sufficiently enforced on the attention of engineers, is the immense saving of material and expense that is secured in a great girder by adopting a mode of construction which on the small scale would show only a very moderate percentage of economic merit over another. This is one of the points we shall endeavour, in our next paper, to place in a clear

* Some errors in our last paper were unavoidably left uncorrected. The more important are, page 193, col. 2, line 40, for *e*1 read *e* : 1. Page 194, col. 1, line 26, for 1" read *one inch*; line 36, for $\frac{1}{8}$ read $\frac{1}{8}$; line 38, the central formula should have come first; col. 2, line 23, for *net* read *ultimate*.

light before the reader, and the results will justify our high estimate of the importance of such investigations as those in some of our previous papers devoted to the discovery of the most economic designs and arrangements of girders.

THE FACTORS OF SAFETY.

The first question that demands our attention is the proportion which the absolute strength of the structure should bear to the greatest possible stress that may be brought upon it in actual work; or in other words, the proportion that should exist between the ultimate and working stresses. Great diversity of opinion has been shown upon this point by engineers, but we need not encumber our pages with criticising the ill-judged extremes that have been by some adopted. With regard to the factor of safety for dead weight or still loading, we may almost assume it as a settled matter that in wrought-iron structures the absolute strength should be about, but not less than, *three* times that which would just withstand the stresses; or in other words, that the factor of safety should be about 3, not less, and not much more.

It is as to the strength to be provided to withstand a moving load—such as a railway train—that such diversity of opinion exists. The reasons for augmenting the factor for the movable loading above that for the still loading are,—1st, the direct shocks or blows from the wheels on passing over irregularities in the roadway; 2nd, the suddenness with which the load is imposed; and 3rd, the reaction when the engine rapidly mounts any sudden rise in the road near the centre of the bridge. Now it will be at once perceived that each of these prejudicial actions becomes rapidly less significant as the span increases, and for long spans may become in a primary form inappreciable, leaving only a vibration throughout the structure which will heighten to some degree the destructive power of the still as well as of the movable loading. The *first* of the above-mentioned prejudicial actions of a rapidly moving load—viz., that from direct blows of the wheels, may become somewhat serious in very short and light spans, since in such the load on the falling wheel may constitute an important percentage of the whole mass of loading and structure taken together; but in a long span with the load supported on a great many wheels, and the structure itself of great weight, the effect of only one or two wheels dealing their blows at the same instant becomes, when considered with regard to the whole structure, almost inappreciable. The *second* prejudicial action is likewise deserving of attention in very short spans, since in these the engine may come so suddenly upon the centre of the bridge as to act in some degree the part of an instantaneously imposed load, acquiring a certain downward momentum from the flexure of the bridge; as however the load is again removed with equal rapidity too much importance should not be given to this effect, and for the case of any span of importance it may be said to vanish. The *third* or last detrimental action is also almost confined to very short spans; in long spans it is only a very small fraction of the load that could have its effect thus increased at the same instant.*

We will now examine the modes of apportioning the ultimate strength or breaking weight of a structure as proposed by Professor Rankine and Dr. Fairbairn. The latter gentleman, in a paper read before the British Association in 1861 (see vol. for 1861 of this Journal, page 329), speaks as follows:—"For the present I would advise that in all beams and girders, tubular or plain, the permanent load, or weight of the girder and its platform, should not in any case exceed one-fourth of the breaking weight; and that the remaining three-fourths should be reserved to resist the rolling load, in the proportion of 6 to 1." Now the results by this rule are given in columns 3 and 4 of Table I., column 4 giving the *general factor*, or that estimated over the whole loading W, fixed and movable without distinction; and it will be perceived that we have its values arranged in two series, the first a decreasing one, giving a minimum of security when the dead weight becomes double the movable loading; and at this point a new and increasing series begins, which we apprehend could never have been contemplated by Mr. Fairbairn. In the Conway bridge as executed the dead weight is about three times the greatest movable, and by this table we find the general factor according to Mr. Fairbairn's rule to be = 3 for such a case; but had the structure been lighter, say equal to twice the movable loading, Mr. Fairbairn's rule would have given a factor = 2·75, being less instead of greater than for the heavier structure—this of course he could not have intended.

Professor Rankine gives the following factors:—for the fixed load, factor of safety = 3; for the movable load, factor of safety = 4 to 6. In the table we have given the results for the general factor arising from the adoption of values of the latter = 6 and 4·5. It may be pointed out that these factors lead to the same results as though we increased the movable loading to 2 tons and 1·5 tons per foot run respectively, and treated it along with the dead weight.

On comparing the general factors obtained by these methods, particularly for the case of the fixed loading being double the movable, it will be perceived how widely they differ.

TABLE I.

Actual working loadings per foot run of span for a double girder, the movable loading being = one ton per foot run.		Strength required by Dr. Fairbairn's rule.		Strength required by Professor Rankine's method.			
				Factors = 3 and 6.		Factors = 3 and 4·5.	
Dead Weight W_1	Total Weight W	Breaking Weight per foot run.	General Factor or Breaking Weight ÷ W.	Breaking Weight per foot run.	General Factor or Breaking Weight ÷ W.	Breaking Weight per foot run.	General Factor or Breaking Weight ÷ W.
0·00	1·00	6·00	6·00	6 00	6·00	4·50	4·50
0·25	1·25	6·25	5·00	6·75	5·40	5·25	4·20
0·50	1·50	6·75	4·33	7·50	5·00	6·00	4·00
0·75	1·75	7·00	3·86	8·25	4·71	6·75	3·86
1·00	2·00	7·50	3·50	9·00	4·50	7·50	3·75
1·50	2·50	7·75	3·00	10·50	4·20	9·00	3·60
2·00	3·00	8·00	2·67	12·00	4·00	10·50	3·50
2·50	3·50	10·00	2·86	13·50	3·86	12·00	3·43
3·00	4·00	12·00	3·00	15·00	3·75	13·50	3·38
3·50	4·50	14·00	3·11	16·50	3·67	15·00	3·33
4·00	5·00	16·00	3·20	18·00	3·60	16·50	3·30
5·00	6·00	20·00	3·33	21·00	3·50	19·50	3·25
6 00	7·00	24·00	3·43	24·00	3·43	22·50	3·21
∞	∞	∞	4·00	∞	3·00	∞	3·00

We must object to the results given by Professor Rankine's method, for the reason that the general factor does not diminish at first with sufficient rapidity to represent the rapid diminution in the destructive effects of a train on changing from the shortest and lightest spans to somewhat longer and heavier ones; and for the very long and heavy spans the factor diminishes too markedly. This is the opinion we would be led to on viewing the subject independently of the stresses induced in the booms by the transverse lateral action of the wind, which it has hitherto been the custom to ignore; but when these stresses are allowed for, we apprehend that the general factor may with sufficient accuracy for a general rule be taken constant after reaching a certain value, such as 3·5. This assumes that after a certain point any reduction that might be made in the factor on account of the smaller proportion of the movable compared with the fixed loading in longer spans, will be counteracted by the demand for additional strength on account of the detrimental action of the wind upon the booms. We may assume the width of structure as constant, the stress on the booms from the wind will therefore increase somewhat more rapidly than the square of the span; in long spans, furthermore, that increase in the effect of a blast which arises from the suddenness of its application may become augmented, and there is also an increased chance of the wind impulses corresponding with the oscillations of the structure. The destructive effects of the wind in extreme spans may possibly therefore become so great as to demand a higher allowance than the above assumption affords.* As a general rule however, we feel some confidence in recommending a uniform general factor of safety to be applied without distinc-

* We must call attention to the fact that the transverse girders to support the roadway are peculiarly liable to all the evils that may arise from the mobility of the loading. It comes with excessive suddenness upon them, and is nearly their whole loading; a blow from a pair of engine driving-wheels is a blow from nearly their whole loading: at the same time their mass is small, a high value should therefore be given to the factor of safety for these girders.

* The relation of the values of W_1 (the fixed) and W_2 (the movable loading) has of course some influence upon the stresses in the braces, particularly upon the central ones, but for constructive reasons these braces are at any rate made with a great excess of strength, so that practically an increase in W_2 compared with W_1 would only necessitate the strengthening of the central diagonal ties to fit them to act more forcibly as struts under an irregular loading; the amount of extra material required would be so minute that we cannot regard it as affecting the above general rule.

tion to fixed and movable loading* for wrought-iron railway-bridges of great spans, according to column 4 in Table II.

TABLE II.

Fixed loading per foot run (the movable loading being = 1 ton. W_1	General Factors of Safety according to		
	Dr. Fairbairn.	Professor Rankine. (Special factors = 3 and 4½).	Mr. Bow.
0·00	6·00	4·50	6·00
0·05	5·76	4·43	5·71
0·10	5·55	4·36	5·45
0·15	5·35	4·30	5·22
0·20	5·17	4·25	5·00
0·25	5·00	4·20	4·80
0·30	4·85	4·15	4·61
0·40	4·57	4·07	4·29
0·50	4·33	4·00	4·00
0·60	4·12	3·94	3·75
0·70	3·94	3·88	3·53
0·80	3·78	3·83	3·50
0·90	3·64	3·79	3·50
1·00	3·50	3·75	3·50
1·25	3·22	3·67	3·50
1·50	3·00	3·60	3·50
1·75	2·82	3·55	3·50
2·00	2·67	3·50	3·50
2·25	2·77	3·46	3·50
2·50	2·86	3·43	3·50
3·00	3·00	3·38	3·50
3·50	3·27	3·33	3·50
4·00	3·33	3·30	3·50
∞	4·00	3·00	3·50

The general factors for moderate spans are estimated by assuming 6 tons per foot run of span as the minimum value to be put upon the breaking weight. The decreasing series of values resulting from this is made to terminate at 3·5 as the lowest allowable factor, this term is reached when the fixed loading amounts to 0·714 tons per foot run, or 71·4 per cent. of the movable.

For really great spans then we have the uniform general factor of safety = 3½, and for such spans we now proceed to investigate the weights of the girders.

THE WEIGHT OF A GIRDER OF GREAT SPAN.

Let S = the span for calculation, being when correctly measured the distance in feet between the centres of pressure on the supports.

Let W_1 = the gross weight of the length S of the complete structure due to one double girder; that is, the total dead weight borne by the girder or girders which have to carry a movable load = S tons in railway bridges. $W_1 = W - W_2$.

Let W_2 = the movable load = S tons.

Let W = the whole load supported by a double girder = $W_1 + W_2$

Let G = weight of the girder suited to carry the load W, but G does not include parts not directly required to fit it for supporting the load. $G = W_1 - F$.

Let F = all the fixed loading exclusive of the girder G; that is, F = the weight of cross-girders, planking, horizontal and transverse bracing, hand-railing, permanent way, &c. $F = W_1 - G$.

Prop. I. In any particular form and construction of girder of given span and depth and value of the factor of safety, we may, within practical limits, assume that G varies as W.

Prop. II. When W is constant but S variable, and the factor and the relation of the depth of girder to the span are constant, we may assume within limits which secure the struts against material weakening, that G varies as S. Therefore

Prop. III. In any special form and construction of girder in which S ÷ the depth D is constant, and in which the factor and the allowances of metal to the corresponding struts may be made the same, G varies as W. S.

$$\text{Let therefore } G = WSk \quad \ldots \quad \ldots \quad (1)$$

$$k = G \div WS \quad \ldots \quad \ldots \quad (2)$$

k being a constant depending upon the value of the factor of safety directly, and inversely upon the economic merit of the structure; we may distinguish the value of k corresponding with any particular value of the factor by writing that value against it thus, $k_{3\cdot5}$; on this principle k_1 will indicate that the value is taken for the case of a breaking weight.

In formula (1) for W substitute its equivalent W_2+G+F, and we have $G = Sk\,(W_2+G+F)$, whence we obtain

$$G = \frac{Sk(W_2+F)}{1-Sk} \quad \ldots \quad \ldots \quad (3)$$

Before we can make direct use of this important formula we must describe the principles on which F is to be calculated or estimated for different structures; this however we must defer till our next paper.

We at once see from the formula that G the weight of the girder becomes infinite when $Sk=1$, or $S=\frac{1}{k}$, and therefore points out the ultimate span for the particular construction corresponding with k. Then since k varies directly with the factor of safety, we see that the ultimate span for a breaking weight $\left(=\frac{1}{k_1}\right)$ will be 3½ times larger than that which can be reached without overstepping the stresses we have been led to consider judicious (that is, the ultimate span under proper stresses $=1 \div k_{3\cdot5}$).

In our paper for next month we purpose arriving at expressions for F, and thereafter deriving values of k from various structures, and will conclude with a table of the weights of girders of various spans, and constructed on different systems; showing the immense saving that may and *ought* to be effected in large structures by attention to the principles we have developed. In the meantime we append an article of some importance and of general application, which we shall require to make use of on resuming the subject of the Economic Construction of Girders of Great Spans.

Edinburgh. R. H. B.

ON THE VALUE TO BE TAKEN FOR THE DEPTH OF A GIRDER WHEN APPLYING THE COMMON FORMULA FOR ITS STRENGTH.

IN any girder in which the moments of the web may be neglected on account either of its thinness or openwork character, the stress produced by a uniformly distributed loading (=W) is in either of the booms equal to WS÷8D, wherein D is the depth or distance apart of the booms treated as mere horizontal lines, and S the acting span. Now in applying this formula in practice it becomes necessary to assign a value to D *less* than the extreme depth of the structure, since the booms are not simple lines, but must have some vertical dimension; and it is only the extreme layer which acts with the full force of C or eT,* and with the full leverage of the extreme distance above or below the neutral axis.

Let M_1 be the sum of the moments of all the fibres of the bottom boom measured round the neutral axis; and M_2=the sum of the moments of the various parts of the top boom. Now we require to find a point in the cross section of each boom so situated that were *all* the section of the boom acting there with the full force of C or eT, the moment (that is the full sectional area of the boom multiplied by the distance of the point from the neutral axis and by C or eT) will be equal to M_2 or M_1. Let A_1† be the sectional area of the bottom boom, A_2 that of the top boom, D_1 the distance of this point in the lower boom below the neutral axis, and D_2 the distance of the point in the upper boom above that axis.

Then $A_1D_1eT=M_1$, and $A_2D_2C=M_2$,

$$D_1 = \frac{M_1}{A_1eT} \text{ and } D_2 = \frac{M_2}{A_2C} \quad \ldots \quad \ldots \quad (1)$$

$$D = D_1 + D_2.$$

The ordinary practice of assigning a value to D equal to the distance between the centres of the sections of the booms is so

* In cases such as the Conway-bridge, where we have a large flat surface exposed to the wind along with extreme narrowness of structure to resist it, additional strength must be provided.

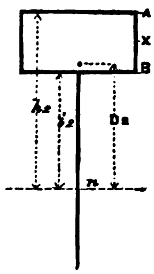
* The symbols here employed are the same as in the papers on "The Economic Construction of Girders."

† The areas and moments of the portions of the web of a plate girder could be readily introduced into the discussion, but such a mode of treatment would annul any advantage from employing the above simple formula for the strength.

very far wrong, and liable to lead to such grave errors, that we feel it incumbent upon us to enter into some detail, in order to show by examples the great difference between the correct results and those obtained by the usual modes of carrying out the calculation.

For this purpose we may restrict our attention to the parts and their moments on one side of the neutral axis; let it be that of the upper boom.

1st. When the upper boom consists of one or more rectangular cells. Let A be the area of the upper plates, B of the lower, and X of the vertical plates. Let h be the distance of the centre of A plates, and i = the distance of centre of B plates, from the neutral axis n in the diagram.



Then by formula (3), page 194 *ante*, we have the moments

$$C=\left(Ah+B\frac{i^2}{h}+X\tfrac{1}{3}\left(h+i+\frac{i^2}{h}\right)\right)$$

and therefore to obtain D_2 we divide this by the area into C, *i.e.*, by C(A+B+X), ∴

$$D_2=\frac{Ah+B\frac{i^2}{h}+X\frac{1}{3}\left(h+i+\frac{i^2}{h}\right)}{A+B+X} \quad \ldots \ (2)$$

Example.—Let the areas of A, B, and X be taken all equal, and the formula becomes

$$D_2=\frac{4h+i+4\frac{i^2}{h}}{9}$$

by which we get, on assuming different ratios between h and i, the results given in Table I.

TABLE I.

Proportion of h : i.			Values of D_2.		Percentages of Error.
h	:	i	Correct.	Usual.	
2	:	1	1·222	1·5	22·7
3	:	2	2·148	2·5	16·4
4	:	3	3·111	3·5	12·5
5	:	4	4·089	4·5	10·5
10	:	9	9·044	9·5	5·0

It will be perceived from the table that when i is not greatly less than h, the value of D_2 should be very little greater than i.

We have calculated by formula (2) the correct value of D for the Conway tubes, using the moments given in the foot-note at page 194 *ante*, and find it equal 22·067, the extreme depth outside being 25′ 5″, and the inside depth 21′ 7½″; i, or depth between centres of plates B and C, $=i_1+i_2=21{\cdot}688$.

Now this smallness of the value of D will account in a great measure for the extreme heaviness and weakness of the Conway (and Britannia) tubes, the proportion of span to depth being so great as $\frac{405}{22{\cdot}067}=18{\cdot}35:1$, or if we follow the less exact but usual course of taking the clear span, we have $\frac{S}{D}=18{\cdot}13$.

The correct value of D for the large experimental tube in Experiment IV. is =4·07; the depth between the centres of the extreme top and bottom plates is=4·53, and between the centres of the bottom and lower top-plates is =4·015. And the value of $\frac{S}{D}$ is $=\frac{75}{4{\cdot}07}=18{\cdot}43$.

As many readers may feel surprised at the true value of the depth D coinciding so nearly with the value of i, we may perhaps make it clearer by considering the plates A and B of the diagram alone; and let us suppose these of equal areas and at distances from the neutral axis equal respectively to 10 and 9 feet. The true moments are—

Plate A, area=A, leverage=10, compression=C, ∴ moment =10AC
Plate B, area=A, leverage=9. compression=$\frac{9}{10}$C, ∴ moment = 8·1AC

Sum of moments .. .. 18·1AC

Dividing by the whole area =2A, multiplied by the full compression C, we have $D_2=\frac{18{\cdot}1\ AC}{2\ AC}=9{\cdot}05$ feet, or only six-tenths of an inch above the centre of the plate B.

To make this still more clear let us compare the above arrangement of girder having the plates at 9 and 10 feet from the neutral axis, with a girder in which both plates are only 9 feet from the axis. Plate A in the latter acts with the same force C as in the former, but its leverage is reduced from 10 to 9 feet, so that its moment is reduced from 10AC to 9AC

Plate B on the other hand acts in the latter with the same leverage of 9 feet as in the former, but the force of its action is increased from $\frac{9}{10}$C to C, and therefore its moment is increased from 8·1 AC to 9AC

Or the total moment ... ... = 18 AC

being only $\frac{1}{181}$ part less or weaker than the girder so much greater in extreme depth.

From these facts some valuable hints may be taken as to the judicious designing of the booms of girders.

2nd. We shall conclude for the present with another general example.

Let the top boom be supposed to be a solid rectangle as in some timber bridges and roofs. For this our formula $D_2=M_2\div$ area C becomes simply

$$D_2=\frac{1}{3}\left(h+i+\frac{i^2}{h}\right) \quad \ldots \quad \ldots \quad (3)$$

Assigning to h and i different relative values, we get the results in Table II.

TABLE. II.

Ratio of h to i.			Values of D_2		Percentages of Error when D is taken	
					As usual.	$=i$
h	:	i	Correct.	Usual.	In excess.	On safe side.
2	:	1	1·167	1·5	28·6	14·3
3	:	2	2·111	2·5	18·4	5·3
4	:	3	3·083	3·5	13·5	2·7
5	:	4	4·067	4·5	10·7	1·64
6	:	5	5·056	5·5	8·8	1·3
7	:	6	6·048	6·5	7·5	0·8
8	:	7	7·042	7·5	6·5	0·65
9	:	8	8·037	8·5	5·7	0·50
10	:	9	9·033	9·5	5·2	0·4

Edinburgh. R. H. B.

ON THE FORMATION OF A NATIONAL MUSEUM OF ARCHITECTURE VIEWED IN CONNEXION WITH ITS BEARINGS UPON MEDIÆVAL ART.*

By GEORGE GILBERT SCOTT. R.A.

UNDER the head of actual Architecture, I must mention one other class of objects which would demand house-room within the museum. I refer to those melancholy but invaluable relics of ancient art which exist in our ruined abbeys, and to those in other buildings which are in danger of being destroyed by inevitable decay.

It is the absolute duty of an art department, whether or not they had contemplated an architectural museum, to rescue these exquisite and invaluable works from oblivion by obtaining casts, photographs, and measured drawings from them while they yet exist. Every winter abrades their ancient carved surfaces, and brings down, perhaps, large portions of their sculptured foliage. Those who have been for many years in the habit of sketching from old buildings see at every visit the progress of destruction which is ever going on, and which is ever accelerating its destructive inroads. A few years more of delay, and these precious works of art will have perished. In the name then of art, of reason, and of patriotism, let us delay no longer, but at once obtain perfect representations of what we have left, by means of plaster, of photography, and of drawing; and enshrine them as the most precious relics, to be for ever preserved in the archives of our national art! I will add here, however, one word

* Concluded from page 207.

of caution,—let a hardening process be always applied to the ancient carved work before attempting to make casts of it, or we may destroy the original while obtaining the copy.

What I have said of architecture proper applies equally to the second head,—sculpture forming a part of architecture. I will, therefore, view this as included in the foregoing remarks; only adding that a collection of the Mediæval sculpture of the thirteenth and fourteenth centuries of France, Germany, and Italy, would be an invaluable acquisition to a national museum —indeed, would be an absolutely necessary portion of it.

Architectural Woodwork.—This, being much scarcer than stonework, especially that of the best dates, must be collected with great care. Let me, however, be always understood to mean casts, rather than the actual work; though when this has, unhappily, been severed from its proper position, it will promote its conservation to place it in such a museum. Of woodwork of the fifteenth century and later there is a large supply of casts in the hands of the Government, which were prepared to assist the carvers employed in the Houses of Parliament. This however is by no means the best period. We want woodwork of the thirteenth and fourteenth centuries. This is in England somewhat scarce; and, wherever it exists, casts should be made from it. Among foreign countries, Germany, perhaps, contains the largest store of ancient woodwork. The stalls at Cologne, not only in the cathedral, but in many of the churches; the wonderful doors of St. Mary's, of the Capitol, the stalls, &c., and at many churches throughout the length and breadth of the country, should find the representatives in such a museum. The elementary classes of woodwork, and the progressive illustration of their history, would assume a course quite parallel to what I have shadowed out in speaking of stonework; and it is needless to recapitulate them. The objects however themselves, and the art expended upon them, differ considerably from the previous class; and the objects are comparatively so scarce that there is much more difficulty in obtaining them; and it is only by the help of those who are in the constant habit of searching out objects of study in the most out-of-the-way places that they can be found out. Every year, too, they are getting more and more scarce. Even the few early remains of woodwork in our old cathedrals are diminishing, from the carelessness and want of knowledge of their guardians. Let no time, then, be lost in searching out and obtaining perfect representations of those which remain, whether at home or abroad.

We now come to the fourth class,—*Architectural Metalwork.* If woodwork of the best ages is so scarce, how much more so is metalwork; and how indescribably important is it that we should use our utmost exertions to collect and to preserve representations of it where it would be improper or impracticable to obtain the reality of what yet remains to us!

Here the Department of Art, as regards the smaller and more movable classes or objects, is doing very great things for us: indeed, we cannot be too grateful for the splendid collection of specimens of this and kindred branches of art which is being formed within these walls; nor can we be too assiduous in availing ourselves of the facilities for study which are thus afforded us. These however can scarcely, for the most part, be classed under the head of Architectural Metalwork, though they bear very directly upon it. What I refer to is chiefly of a larger description, such as screen-work, hinges, brass fonts and lecterns, retabulæ, coronæ, doors, gates, &c., and the other forms of metalwork brought more immediately into contact with architecture. These, like other architectural objects, are chiefly to be represented by casts and drawings; and these should be from time to time made from all the best specimens which remain in this country, and all which we can gain access to abroad. We long ago contemplated obtaining a cast from the truly magnificent brass font and its cover at Hildesheim, but our funds forbade it. There are a great number of such fonts nearly equally worthy of being represented in our museum, as well as innumerable other objects of all kinds and descriptions. Among others I will mention, though a late example, the exquisite brass genealogical tree which clothes the tomb of Mary of Burgundy, at Bruges; and this leads me to call attention to the numerous brass effigies and entire monuments which exist, and many of which would be well worthy to be represented in such a collection. I will also call attention to the most magnificent of all classes of metalwork,—the gorgeous shrines of the twelfth and thirteenth centuries. There are some invaluable specimens of the same exquisite workmanship in the museum of the Department, and it is possible that a few more may by chance be obtained. The greatest and most glorious specimens, however, of this wondrous art must ever remain where they now are, and where for the most part they have always been; and can there be only rarely visited and studied. What I wish to press upon the attention of the Department of Art is the necessity of obtaining perfect full-sized representations of these most sumptuous works. Among many which exist, I will call especial attention to those of the Three Kings at Cologne; of Notre Dame at Aix-la-Chapelle; and of St. Elizabeth at Marburg. These are absolute *miracles* of art; and I would earnestly press the necessity of perfect, full-sized, and perfectly detailed drawings being made from them; accompanied by some more tangible representations of some of their parts.

But I must go on to my next head,—*Coloured Architectural Decorations.* Here again we have heartily to thank the Department for much which they have done, and to entreat them to go on as they have begun. They have already collected many drawings of such decorations, with some of the originals. Mr. Octavius Hudson, of whose zeal, knowledge, and skill I cannot speak too highly, has adopted the excellent practice of having casts made for the details of ancient buildings on which he is engaged, and making upon them fac-simile copies of the remains of colouring which he finds. This if followed out would supply invaluable illustrations of decorative art; and I would urge the collection of full-size drawings of all other branches of decoration, wherever they can be procured. Such remnants of old art are continually being destroyed: how easy would it be to perpetuate them by fac-simile drawings! And thus of all the other classes of art I have enumerated. Let us have coloured tracings of stained glass, not only of famous works, but of the fragmentary remains in village churches. Let us have (as in fact, we already have to a considerable extent) rubbings of brasses and incised stones; coloured rubbings of ornamental pavements; and perfect representations of all other branches of decorative art. I exhibit a fac-simile copy of a part of the ancient retabulum in Westminster Abbey, as an illustration of the kind of drawing I am recommending. Time will not allow me to go further than to say that a museum thus constituted would be worthy of being called "National;" and would not only be the greatest benefit which could be conferred upon our art, but would be no more than the carrying out to its natural results of what the department have already commenced.

It may be feared by some that such a collection would encourage slavish copying. My own experience has led to a contrary opinion. I have observed with pleasure that so far from this being the case, the increased study of ancient examples leads the art-workman to a more enlarged and more reasoning appreciation of his art; gives him greater freedom in the exercise of it; and, above all, leads him to a more zealous and intelligent study of nature. I will only add two more suggestions. 1st. That as such a collection would not be made for a mere spectacle, but for actual use, it should not be deposited in vast and imposing halls and galleries, but should be so subdivided as to give the student every possible facility for quietly studying any one department which he might be pursuing, without the distraction which the enormous multiplicity of the objects would otherwise occasion. In reading a book, we should be sadly annoyed if we were obliged to see a number of its pages or its illustrations at once; and so it is with a museum; the student only wants to see the part to which his studies are directed. 2ndly, I would suggest, as South Kensington is not a place very accessible to the student or the art-workman, that a system be organised of lending out objects to particular districts, in which rooms for the studies of art-workmen shall be opened; and that the specimens so lent shall be changed periodically (perhaps every month), and thus a constant and ever-changing course of study facilitated.

I will now conclude by suggesting some points for consideration, as to how our great work can be carried on with the greatest possible advantage to the great cause we have in view. There are two parties to this undertaking,—the representatives of the demand, and of the supply; and it can only be successfully carried out by their hearty and continued co-operation.

The representatives of the demand are the architects. It is not their personal interests in the least degree which are at stake; for buildings would be erected, and architects employed and paid, just the same, whether the arts subsidiary to architecture are cultivated or neglected; nor can the demand be said to come mainly from the art-workman himself, though it does more nearly affect his personal interests. Those among them whose apprehensions of art have been aroused to activity join heartily and earnestly in the demand; but as in the case of religion, those who most need instruction are the least alive to their necessities; so, among architects themselves, it is those who most keenly appreciate the nobleness of their art, and have best cultivated it as a fine art, who most strongly feel the necessity for aiding the art-workman, on whom depends the realisation of the more artistic portions of their designs. Not only, however, are the architects, and the best among them, the representatives of the demand, but they are also the parties who best—I might almost say who alone—understand what is the nature of that demand; who know, from their daily experience, what are the objects necessary to meet it; and who, from their own travels, their own studies, and from the contact in which their practice places them with ancient buildings, know also whence and how those objects are to be supplied. It is, therefore, self-evident that the aid of the architects most conversant with the subject is essential to the success of the effort; and when we add to this that those architects have already, by their own individual exertions and of their own free motion and sense of the necessity, most efficiently launched the work, and founded an architectural museum which must be the nucleus or the model of whatever is effected, the case is rendered still more obvious.

The representatives of the supply are the Government Department of Art. To them has been committed that great cause, the promotion of applied art in this country.

The museum of objects of art which they are forming must of necessity be of the greatest benefit to this object. It brings within the reach of the manufacturing art-workman the finest objects for his study, such as he could otherwise never have hoped to gain access to. What we ask of them, then, is to aid us and work with us in doing the same for the architectural art-workman, who equally needs and equally deserves their aid

If they will not do so, or if, in doing so, they refuse the aid and advice of those who alone understand what is needed, the world and posterity will know on whose shoulders the onus will lie. If, on the other hand, they appreciate and frankly acknowledge this, perhaps, the highest of their duties, they will merit the eternal gratitude of every lover of art; and I am sure that I utter the feelings of my brother architects when I say that we are prepared to abdicate our self-imposed task in their favour, and to unite with them heart and soul, and without jealousy or rivalry, in carrying out this most noble and most needful work.

The exact regulation under which this united action will be best effected I will not here attempt to define: "where there is a will there is a way;" and I content myself with asserting that on our part at least there is a hearty good will; and that I see no difficulty whatever as to the way.

THE STATICS OF BRIDGES.*

The Chain.—Disturbances.

Suspension bridges are liable to two classes of deflection or displacement under a change in the amount and disposition of the loading. The first, a slight symmetrical wave caused by the stretching or contraction of the chain. The second, a displacement of a more marked and visible kind, which alters its form with every fresh arrangement of the load, and only disappears when the loading is uniformly distributed.

A heavy load travelling over a suspension bridge will also produce vibration, and if the motion is rapid it will tend to create much greater disturbance than would be due to its presence as a simple question of statics. But as these papers do not deal with the dynamics of the subject, any inquiry will here be confined to the change of form due to the modified conditions of equilibrium, without going into the question of the agitation and inertia of the chains and load.

We have already (*ante* page 50) shown a method of determining (by a diagram) the curve proper to a chain sustaining a load distributed in any given manner, and the same means would serve for finding the position of the deflected chain under a new disposition of loading. But for small displacements some approximate mode of calculation is to be desired, the point to be determined being not so much the form *per se* of the curve of equilibrium, as the minute differences between the original and the distorted curve.

This delicate and subtle investigation seems far from having shared in the general attention which has been given to the simpler studies of parabolic and catenary curves. We have seen no examination of the displacement of a free chain save a paper which appeared last July in this Journal (vol. xxiv. p. 207.),* in which the matter has been ably treated on the broadest basis, under certain assumptions for the sake of generalisation, which are duly noted at the stages where they are made.

It does not come within our present scope to attempt a general formula for the displacements of catenaries. But the extreme simplicity of the parabola, which has been seen to be practically the curve for suspension bridges, favours the hope that a law of small disturbances for these bridges may be determined with great exactness. We therefore limit ourselves to the parabola as the basis for investigating the disturbances of ordinary suspension bridges, narrowing our view of the subject in order to special accuracy in that part of it that concerns our present purpose.

While examining the statics of the question, the geometric consideration of the length of the curve of the chain before and after deflection must also be given heed to. Apart from any stretching of the links (which must be reserved for separate enquiry), it is manifest that the actual curve of displacement must be exactly of a length with the original curve. If the points from which the chain hangs at the towers are to be taken as absolutely fixed, the constancy of the length of the chain will bring all small displacements under the following law:—

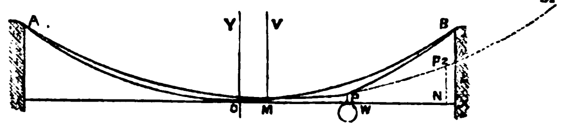
$$\int \frac{dy}{dx} \cdot dz = 0.$$

The integral being taken from tower to tower, and z being $= y' - y$, where y' is the ordinate of the curve after, and y before, displacement. This law (of which a demonstration will be found vol. xxiii., p. 355) is not peculiar to the parabola, but applies universally.

Under the guidance of this law it is now proposed to investigate a small displacement as exhibited (on a magnified scale) in Fig. 39.

AOB is a chain carrying a load (inclusive of its own weight) of which the horizontal distribution is assumed to be uniform, and

Fig. 39.



at the rate w per foot forward. The span $= s$ and the rise $= h$, the points of suspension at A and B being on a level. The chain will hang in a parabola of which the vertex is at the half-span O, and OY the axis; and the following equations will give the general conditions:—

$$\text{Parameter } (p) = \frac{s^2}{4h} \quad \ldots \quad \ldots \quad \ldots \quad \ldots (1)$$

$$\text{Load } (L) = ws \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2)$$

$$\text{Horizontal tension } (T) = \left(\frac{ws^2}{8h} =\right) \frac{wp}{2} \quad \ldots \quad \ldots (3)$$

$$y = \frac{x^2}{p} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (4)$$

A displacement is caused by suspending a weight W from the point P in the right-hand section of the chain. $W = qL = wqs$, and the horizontal distance of P from the half-span O is $= rs$. Thus r is the fraction obtained by dividing the distance of the disturbing weight from the half-span by the entire span, and can never numerically exceed $\frac{1}{2}$. While q expresses the ratio of the disturbing weight to the distributed load, and will commonly be not very considerable. The following equations show the altered conditions:—

$$\text{Parameter} = p + p_2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots (5)$$

$$\text{Load} = L + W = w(1+q)s \quad \ldots \quad \ldots \quad \ldots (6)$$

$$\text{Horizontal tension} = T + T_2 = \frac{w(p+p_2)}{2} \quad \ldots \quad \ldots (7)$$

In assuming AP and PB to be both arcs of one parabola after

* Continued from page 173.

* "Deflection of Suspension Bridges." By Homersham Cox, M.A.

deflection, we neglect as inconsiderable the slight change in the distribution of loading which would result from displacement.

The parabola now has its vertex shifted to the right of O, (or towards the more heavily loaded tower,) and would if unbroken continue in the line PP_2B_2. The concentration of the load W at the point P has however the effect of abruptly changing the direction of the tangent at that point in the same manner as if the arc PP_2 were left out, and the upper portion P_2B_2 transferred to PB. The length of this imaginary arc PP_2, which if inserted at P would restore the continuity of the parabola, must be such as to answer to a load equal to W (or wqs); from which it appears that the horizontal distance between P and P_2 (or between W and N) must be $= qs$.

The position of the lowest point of the chain after displacement will of course be in the line MV, which marks the point of greatest moment, and can be readily determined. The horizontal distances of P from the towers A and B respectively being $(\frac{1}{2}+r)s$ and $(\frac{1}{2}-r)s$, the load at P (which is $= wqs$) will be divided, inversely as those distances, into the portions $wq(\frac{1}{2}-r)s$ carried by A, and $wq(\frac{1}{2}+r)s$ carried by B. The total load will therefore be thus divided:—

$$\text{On A} \quad . \quad . \quad w[\tfrac{1}{2}+q(\tfrac{1}{2}-r)]s \quad \ldots \quad \ldots (8)$$

$$\text{On B} \quad . \quad . \quad w[\tfrac{1}{2}+q(\tfrac{1}{2}+r)]s \quad \ldots \quad \ldots (9)$$

and the line MV must be situated at the point where the load thus divides.

Call x_0=abscissa of the vertex of the parabola after deflection,

$$\text{Then } x_0 = q(\tfrac{1}{2}-r)s \ldots \quad \ldots \quad \ldots (10)$$

As long as the relation between the weight W and the position of P is such that $q(\frac{1}{2}-r)$ does not exceed r, the vertex will take a position between the half-span and P, and will coincide with M. When $q(\frac{1}{2}-r)$ becomes $= r$, both the vertex and M will coincide with P. And when $q(\frac{1}{2}-r)$ is greater than r, M will still remain at P, which will therefore be the lowest point of the chain, but the vertex will be beyond the chain in the imaginary arc PP_2.

Let y_0=the ordinate of the new vertex, and x_2 and y_2 be the co-ordinates of the point P_2, and x_1 and y_1 the co-ordinates of P, after deflection.

$$\text{Then } y_0 = h - \frac{[1+q(1-2r)]^2}{p+p_2} \cdot \frac{s^2}{4} \quad \ldots (11)$$

$$x_2 = (r+q)s, \text{ and } x_1 = rs,$$

$$y_2 = y_0 + \frac{[2r+q(1+2r)]^2}{p+p_2} \cdot \frac{s^2}{4}, \text{ and } y_1 = y_0 + \frac{[2r-q(1-2r)]^2}{p+p_2} \cdot \frac{s^2}{4}$$

$$\therefore \; y_2 - y_1 = \frac{8qr(1+q)}{p+p_2} \cdot \frac{s^2}{4} \quad \ldots \quad \ldots (12)$$

The last expression gives the rise of the arc PP_2.

Take y' as the ordinate at any point after deflection:* then between A and P

$$y' = y_0 + \frac{[x-q(\frac{1}{2}-r)s]^2}{p+p_2} \quad \ldots \quad \ldots (13)$$

and between P and B

$$y' = y_0 + \frac{[x+q(\frac{1}{2}+r)s]^2}{p+p_2} - (y_2-y_1) \ldots \quad \ldots (14)$$

From equations 4, 13, and 14, we find the expressions for z (which is $= y'-y$), and thence by differentiation $\frac{dz}{dx}$ is found: $\frac{dy}{dx}$ will be $= \frac{2x}{p}$. From these data $\int \frac{dy}{dx} dz = \frac{2}{p} \int x dz$ between A and P and between P and B can be determined.

This integral between the extreme limits A and B will be equal to the sum of the partial integrals, and is found after reduction to be

$$= \frac{s^3}{6p^2(p+p_2)} [-2p_2 + pq(3-12r^2)]$$

and, according to the principle already laid down as governing small displacements, the preceding expression must be $= 0$. From this it follows that

$$p_2 = \frac{3}{2} pq(1-4r^2) \ldots \quad \ldots \quad \ldots (15)$$

Or the parameter of the parabola is increased in the ratio of 1 to $1+\frac{3}{2}q(1-4r^2)$.

* We assume the abscissa to remain the same; the error involved in this assumption being trifling when the disturbance is small.

The horizontal tension after deflection, from (7) and (15), is

$$T+T_2 = \frac{wp}{2}\left(1+\frac{3}{2}q(1-4r^2)\right) \ldots \quad \ldots (16)$$

Having the parameter we can now determine the actual displacement. To begin with the half-span. The vertical displacement at O, from (13) and (11),

$$= y_0 + \frac{q^2(1-2r)^2}{p+p_2} \cdot \frac{s^2}{4}$$

$$= h - \frac{[1+q(1-2r)]^2 - q^2(1-2r)^2}{p+p_2} \cdot \frac{s^2}{4}$$

For h substitute its value by equation (1)—viz. $\frac{s^2}{4p}$, and for p_2 substitute its value from (15), and reduce.

Then Vertical displacement at the half-span O

$$= -\frac{q(1-2r)(1-6r)}{2+3q(1-4r^2)} \cdot \frac{s^2}{4p} = -\frac{q(1-2r)(1-6r)}{2+3q(1-4r^2)} \cdot h \ldots (17)$$

If the disturbing weight is applied at the half-span (r being $= 0$), a depression will be produced

$$= -\frac{q}{2+3q} \cdot h \quad \ldots \quad \ldots \quad \ldots (18)$$

and an increase of horizontal tension will result, (see (16),)

$$= \tfrac{3}{2}qT \quad \ldots \quad \ldots \quad \ldots (19)$$

So long as r is less than $\frac{1}{6}$, or the disturbing weight less than one third of the distance from the half span to the tower, the expression (17) remains negative, showing depression at O. When $r=\frac{1}{6}$ there is no depression at O. When r exceeds $\frac{1}{6}$, the chain will rise at O.

These results cease to correspond closely with experiment when the disturbing weight is very considerable, and the proportion of rise to span great, the actual disturbance falling short of the theoretical approximation.

The position in which the given weight $W=wqs$ will cause most rise of the chain at O is that in which

$$r = \frac{2q+1}{4q} - \frac{\sqrt{12q+9}}{12q}$$

As q is diminished r approaches the inferior limit $\frac{1}{3}$, showing that a small weight will occasion most rise at O when placed rather more than twice as far from that point as from the tower.

The horizontal displacement at the half-span O is found by taking the integral of $\frac{dy}{dx}.dz$ between the limits $x=-\frac{1}{2}s$ and $x=0$; bearing in mind that when the result is negative it indicates a horizontal spreading of the chain. The integral is reducible to the form

$$-\frac{s^3}{2p(p+p_2)} qr(1-2r)$$

For $2p(p+p_2)$, substitute (from 15), $p^2[2+3q(1-4r^2)]$, and for $\frac{s^3}{p^2}$ substitute, from (1), $\frac{16h^2}{s}$, and reduce. Then,

$$\text{Horizontal displacement at O} = -\frac{16h^2}{s} \cdot \frac{qr(1-2r)}{2+3q(1-4r^2)} \ldots (20)$$

The negative sign must be taken as indicating motion from the left tower A towards the tower B carrying the greater load. The value of r which makes this motion at O greatest is, for any given value of q, found from the equation

$$r = \frac{3q+2-\sqrt{6q+4}}{6q}$$

as q is diminished r approaches the inferior limit $\frac{1}{4}$, showing that a small weight will cause most horizontal motion at O when it is placed nearly midway between that point and the tower.

The vertical displacement at P, the point where W is suspended,

$$= -hq\frac{(1+12r^2)(1-4r^2)}{2+3q(1-4r^2)} \quad \ldots \quad \ldots (21)$$

And the horizontal displacement at P

$$= -\frac{16h^2}{s} \cdot q\frac{r(1-16r^4)}{2+3q(1-4r^2)} \quad \ldots \quad \ldots (22)$$

(*To be continued.*)

IMPROVEMENTS IN PARIS.

In the course of last year a project was announced of putting the quartiers of Picpus and Bercy in direct communication with the faubourg Saint Antoine by a group of new thoroughfares traversing the lands of the ancient abbey; these improvements have just been commenced, and already several houses at the angle of the rues de Reuilly and du Faubourg, have been demolished to make a passage for the new rue de l'Empereur, one of the projected new streets. This new street is to be divided into two portions; one commencing at the demolitions above mentioned and to be prolonged as far as the boulevard Mazas; another leading from the boulevard Mazas to the carrefour de Rambouillet.

The first, only just commenced, will be bordered by the outbuildings of the *hospice* and the Reuilly barracks, passing through the waste grounds temporarily occupied by pedlars' stalls and the itinerant carts of strolling performers; but the second portion is already in part traced out, and possesses some very fine habitations. Near the end of this large thoroughfare another street commences in the direction of the faubourg St. Antoine, and opens out in front of the rue Sainte Marguerite; this is also partly covered with buildings.

The carrefour de Rambouillet, where the two new streets are to meet, is also the point of intersection of the rues de Charenton, de Rambouillet, and the Petite rue de Reuilly; a circular open space, part of which is furnished with new houses, will be the centre of union of some of the most important streets of the faubourg St. Antoine.

The lands of the abbey of St. Antoine, to be intersected by all the streets of this new quarter, occupy the space included between the Grande rue du Faubourg, the boulevard Mazas, the Reuilly barracks, and the habitations of the rue Lenoir. This spot, more considerable than other of the Paris *bourgs*, includes a principal street, alleys and courts, cafés, &c., besides fields with rustic habitations. The greater portion of the principal street will be absorbed by the prolongation of the rue St. Bernard; already several constructions, properly aligned, have been run up, and the inhabitants are impatiently waiting for a direct outlet into the faubourg. One of the Maisons de Secours of the 12th arrondissement has been built on the continuation of this street. Close to the abbey of St. Antoine on the south side, below the Vincennes railway, several other new buildings are springing up, and are to form portions of the new boulevard de Picpus, which is to unite the new boulevard de Vincennes with the place de la Bastille.

The handsome porch of the Saint Etienne-du-Mont church, the restoration of which was commenced last year, is nearly clear from the scaffolding, and will be completed in a few months. Owing to the decay of the ornamental portion which was nearly effaced it has been renewed thoroughly from one end to the other, with the addition also of indispensable accessories, which had never been put up since the commencement of the church. The statues of St. Hilaire and St. Benôit have been placed on cornices above the front of the second story, the Virgin and the angel Gabriel in the lateral niches of the *rosace*, and the vases with flames serve to deaden the effect of the projections. St. Benôit and St. Hilaire recal to mind each of the two parishes united under the name of St. Etienne-du-Mont. This portal, the work of the early portion of the 17th century, is one of the most remarkable of that epoch. Its general vertical section is that of a pyramid in stories, whose base consists of the first order of architecture. The principal doorway of the church, approached by a flight of steps, is surmounted by a triangular pediment, supported on four columns built into the work, with niches in the intervals for the statues of St. Etienne and St. Geneviève; above this first story is another of the second order of architecture, four columns, as in the last described, with semicircular niches in the spaces, and a star-shaped rosace in the centre, of the Renaissance style; above this a curved broken pediment: this second order is surmounted by a pointed gable, the tympanum being relieved by a pierced circular bay with twisted ribs; this bay is inclosed by pilasters of handsome cut stone. The organ is undergoing extensive alterations, and another temporary one has been put in use.

THE PROPERTIES OF IRON, AND ITS RESISTANCE TO PROJECTILES AT HIGH VELOCITIES.*

By William Fairbairn, F.R.S.

We have no correct record as to the exact time when wrought-iron plates were first employed for the purpose of building vessels. It is, however, certain that iron barges were in use on canals at the close of the last century. In 1824, Mr. Manley, of Staffordshire, built an iron steamboat for the navigation of the river Seine, and this was the first iron vessel that attempted a sea voyage. She was navigated from this country to Havre, by the late Admiral Sir Charles Napier, and although constructed for shallow rivers, she nevertheless crossed the channel in perfect safety. From that time to 1830 no attempt was made to build iron vessels, and nothing was done towards ascertaining the properties of iron as a material for ship-building.

A series of experiments, instituted by the Forth and Clyde Canal Company in 1829-30, to ascertain the law of traction of light boats at high velocities on canals, led to the application of iron for the construction of vessels; and the lightness of these new vessels, combined with their increased strength, suggested the extended application of the material in the construction of vessels of much larger dimensions, and ultimately to those of the larger class, both in the war and mercantile navy. Considerable difficulty, however, existed with regard to the navy; and although the principle of iron construction as applied to merchant vessels and packets was fully established, it was nevertheless considered inapplicable, until of late years, for ships of war. It is true, that until the new system of casing the sides of vessels, first introduced by the Emperor of the French, in 1854, was established, the iron ship was even more dangerous under fire than one built entirely of wood. Now, however, that thick iron plates are found sufficiently strong, under ordinary circumstances, to resist the action of guns not exceeding 120-pounders, for a considerable length of time, the state of the navy and the minds of our naval officers have entirely changed. We must, therefore, now look to new conditions, new materials, and an entirely new construction, if we are to retain our superiority as mistress of the seas. There yet remain amongst us those who contend for the wooden walls, but they are no longer applicable to the wants of the state; and I am clearly of opinion that we cannot afford to trifle with so important a branch of the public service as to fall behind any nation, however powerful and efficient they may be in naval construction. Having satisfied ourselves that this desideratum must be attained, at whatever cost, I shall now endeavour to point out such facts as in my opinion relate to the changes that are now before us, and simply endeavour to show—

1st. The description of iron best calculated to secure strength and durability in the construction of ships of war.

2nd. The distribution and best forms of construction to attain this object; and,

Lastly. The properties of iron best calculated to resist the penetration of shot at high velocities.

Properties of Iron.—If we are desirous to attain perfection in mechanical, architectural, or ship-building construction, it is essential that the engineer or architect should make himself thoroughly acquainted with the properties of the materials which he employs. It is unimportant whether the construction be a house, a ship, or a bridge. We must possess correct ideas of the strength, proportion, and combination of the parts, before we can arrive at satisfactory results; and to effect these objects the naval architect should be conversant with the following facts relating to the resisting powers of malleable and rolled iron to a tensile strain. The resistance in tons per square inch of—

Yorkshire iron is	... ...	24·50 tons
Derbyshire "	... ...	20·25 "
Shropshire "	... ...	22·50 "
Staffordshire "	... ...	20·00 "

Strength of Rivetted Joints.—The architect, having fortified himself with the above facts, will be better able to carry out a judicious distribution of the frames, ribs, and plates of an iron ship, so as to meet the various strains to which it may be subjected, and ultimately to arrive at a distribution where the whole in combination presents uniformity of resistance to repeated strains, and the various changes it has to encounter in actual service.

* Abstract of a paper recently read before the Royal Institute.

There is, however, another circumstance, of deep importance to the naval architect, which should on no account be lost sight of, and that is, the comparative values of the rivetted joints of plates to the plates themselves. These, according to experiment, give the following results:—

Taking the cohesive strength of the plate at	100
The strength of the double-rivetted joint was found to be	70
And the single-rivetted joint	56

These proportions apply with great force to vessels requiring close rivetting, such as ships and boilers that must be water-tight, and in calculation it is necessary to make allowances in that ratio.

Strength of Ships.—Of late years it has been found convenient to increase the length of steamers and sailing vessels to as much as eight or nine times their breadth of beam, and this for two reasons; first, to obtain an increase of speed by giving fine sharp lines to the bow and stern; and second, to secure an increase of capacity for the same midship section, by which the carrying powers of the ship are greatly augmented. Now, there is no serious objection to this increase of length, which may or may not have reached the maximum. But, unfortunately, it has hitherto been accomplished at a great sacrifice to the strength of the ship. Vessels floating on water and subjected to the swell of a rolling sea—to say nothing of their being stranded or beaten upon the rocks or sandbanks of a lee shore—are governed by the same laws of transverse strain as simple hollow beams, like the tubes of the Conway and Britannia tubular bridges. Assuming this to be true—and indeed it scarcely requires demonstration—it follows that we cannot lengthen a ship with impunity without adding to her depth, or to the sectional area of the plates in the middle along the line of the upper deck.

If we take a vessel of the ordinary construction, or what some years ago was considered the best—300 feet long, 41 ft. 6 in. beam, and 26 ft. 6 in. deep—we shall be able to show how inadequately she is designed to resist the strains to which she would be subjected. To arrive at these facts we shall approximate nearly to the truth by treating it as a simple beam; and this is actually the case, to some extent, when a vessel is supported at each end by two waves, or when rising on the crest of another, supported at the centre with a stem and stern partially suspended. Now in these positions the ship undergoes, alternately, a strain of compression and of tension along the whole section of the deck, corresponding with equal strains of tension and compression along the section of the keel, the strains being reversed according as the vessel is supported at the ends or the centre. These are, in fact, the alternate strains to which every long vessel is exposed, particularly in seas where the distance between the crests of the waves does not exceed the length of the ship.

It is true that a vessel may continue for a number of voyages to resist the continuous strains to which she is subjected whilst resting on the water; but supposing in stress of weather, or from some other cause, she is driven on rocks, with her bow and stern suspended, the probability is that she would break in two, separating from the insufficiency of the deck on the one hand, and the weakness of the hull on the other. This is the great source of weakness in wrought-iron vessels of this construction, as well as of wooden ones, when placed in similar trying circumstances.*

Changes in progress.—Having directed attention to the strength of ships, and the necessity for their improved construction, we may now advert to the changes by which we are surrounded, and to the revolution now pending over the destinies of the navy, and the deadly weapons now forging for its destruction. It is not for us alone, but for all other maritime nations, that these Cyclopean monsters are now issuing from the furnaces of Vulcan; and it behoves all those exposed to such merciless enemies to be upon their guard, and to have their Warriors, Merrimacs, and Monitors, ever ready, clothed in mail from stem to stern, to encounter such formidable foes. It has been seen, and every experiment exemplifies the same fact, that the iron ship with its coat of armour is a totally different construction to that of the wooden walls which for centuries have been the pride and glory of the country. Three-deckers, like the Victory and the Ville de Paris of the last century, would not exist an hour against the sea-monsters now coming into use.

The days of our wooden walls are therefore gone; and instead of the gallant bearing of a 100-gun ship, with every inch of canvas set, dashing the spray from her bows and careering merrily over the ocean, we shall find in its place a black demon, some five or six hundred feet long, stealing along, with a black funnel and flag-staff, on her mission of destruction, and scarcely seen above water excepting to show a row of teeth on each side, as formidable as the iron carcass that is floating below. This may, with our present impressions, be considered a perspective of the future navy of England—probably not encouraging—but one on which the security of the country may ultimately have to depend, and to the construction of which the whole power and skill of the nation should be directed. I have noticed these changes, which are fast approaching, from the conviction that the progress of the applied sciences is not only revolutionising our habits in the development of naval construction, as in every other branch of industry, but the art of war is undergoing the same changes as those which have done so much for the industrial resources of the country in times of peace. It is therefore necessary to prepare for the changes now in progress, and endeavour to effect them on principles calculated, not only to ensure security, but to place this country at the head of constructive art. It is to attain these objects that a long and laborious class of experiments have been undertaken by the Government, to determine how the future navy of England shall be built, how it should be armed, and under what conditions it can best maintain the supremacy of the seas. This question does not exclusively confine itself to armour-plated vessels, but also to the construction of ships, which in every case should be strong and powerful enough to contend against either winds and waves or to battle with the enemy. It is for these reasons that I have ventured to direct attention to the strength of vessels, and to show that some of our mercantile ships are exceedingly weak, arising probably from causes of a mistaken economy on the one hand, or a deficiency of knowledge or neglect of first principles on the other.

Now, it is evident that our future ships of war of the first class must be long and shallow; moreover, they must contain elements of strength and powers of resistance that do not enter into the construction of vessels that are shorter and nearly double the depth. If we take a first-rate ship of the present construction, such as the Duke of Wellington, and compare it with one of the new or forthcoming construction, carrying the same weight of ordnance, we should require a vessel nearly twice the length and little more than half her depth. Let us for example suppose the Duke of Wellington to be 360 feet long and 60 feet deep, and the new construction 500 feet long and 46 feet deep; we should then have for the resistance of the Duke of Wellington to a transverse strain tending to break her back, $W = \frac{a\,d\,c}{l}$. Taking 60 as the constant, and the area of the bottom and upper deck as 1060 square inches, we have $W = \frac{1060 \times 60 + 60}{340} = 12{,}223$ tons as the weight that would break her in the middle. Let us now take the new ship, and give her the same area top and bottom, and again we have $W = \frac{1060 + 46 \times 60}{500} = 5851$ tons, which is less than half the strength. From this it is obvious—if we are correct in our calculations—that the utmost care and attention is requisite in design and construction to insure stability and perfect security in the build of ships.

Mechanical Properties of Iron.—It is unnecessary to give more examples in regard to strength, and the proportions that should be observed in the construction of our future navy. I have simply directed attention to it as a subject of great importance, and one that I am satisfied will receive careful consideration on the part of the Admiralty and the Comptroller of the Navy.

The next question for consideration is the properties of iron best calculated to resist the penetration of shot at high velocities, and in this I am fortunate in having before me the experiments of the Committee on Iron Plates, which may be enumerated as under:—

Specific Gravity.	Tensile Strength in Tons per square inch.	Compression per Unit of Length in Tons.	Statical Resistance to Punching in Tons; 1-inch Plate.
7·7621	24·802	14·203	40·1804

Remarks.—The specimens subjected to compression gradually squeezed down to one-half their original height, increasing at the same time in diameter till they attained 90 tons on the square inch.

In these experiments, four descriptions of iron were selected,

* See Vol. I. of the Transactions of the Institution of Naval Architects, on the Strength of Iron Ships.

marked A, B, C, D; the two first and last were taken from rolled and hammered iron plates, excepting C, which was homogeneous, and gave higher results to tension and dead pressure than the others. In density and tenacity they stood as follows:—

Mark on Plates.	Density.	Tenacity in Tons.
A Plates	7·8083 ...	24·644
B Plates	7·7035 ...	23·354
C Plates, homogeneous	7·9042 ...	27·032
D Plates	7·6322 ...	24·171

Here it will be observed, that the strengths are in the ratio of the densities, excepting only the B plates, which deviate from that law.

On the resistance to compression, it will be seen that in none of the experiments was the specimen actually crushed; but they evidently gave way at a pressure of 13 tons per square inch, and were considerably cracked and reduced in height by increased pressure.

From the experiments on punching, we derive the resistance of B, C, D plates to a flat-ended instrument forced through the plate by dead pressure as follows:—

Mark on Plates.	Shearing Strain in Tons per square inch.	Ratio, taking A as Unity.
A Plates	19·511 ...	1·000
B Plates	17·719 ...	0·907
C Plates	27·704 ...	1·168
D Plates	17·035 ...	0·873

Here it may be noticed that the difference between the steel plates of series C, and the iron plates of series A, is not considerable, though in all others the steel plates exhibit a superiority in statical resistance.

Having ascertained, by direct experiment, the mechanical resistance of different kinds of iron and steel plates to forces tending to rupture, it is interesting to observe the close relation which exists between not only the chemical analysis as obtained by Dr. Percy, but how nearly they approximate to the force of impact, as exhibited in the experiments with ordnance at Shoeburyness.

Dr. Percy, in his analysis, observes that of all the plates tested at Shoeburyness, none have been found to resist better than those lettered A, B, C, D, with the exception of C. The iron of plate E contained less phosphorus than either of the three A, B, D; and it is clearly established that phosphorus is an impurity which tends in a remarkable degree to render the metal "cold short," *i.e.*, brittle when cold.

The following table shows the chemical composition of these irons:—

Mark.	Carbon.	Sulphur.	Phosphorus.	Silicon.	Manganese.
A ...	·01636 ...	·104 ...	·106 ...	·122 ...	·28
B ...	·0327 ...	·121 ...	·173 ...	·160 ...	·029
C ...	·023 ...	·190 ...	·020 ...	·014 ...	·100
D ...	·0436 ...	·118 ...	·228 ...	·174 ...	·250
E ...	·170 ...	·0577 ...	·0894 ...	·110 ...	·330

Comparing the chemical analysis with the mechanical properties of the irons experimented upon, we find that the presence of 0·23 per cent. of carbon causes brittleness in the iron; and this was found to be the case in the homogeneous iron plates marked C; and although it was found equal to A plates in its resistance to tension and compression, it was very inferior to the others in resisting concussion or the force of impact. It therefore follows that toughness combined with tenacity is the description of iron plate best adapted to resist shot at high velocities. It is also found that wrought-iron which exhibits a fibrous fracture when broken by bending, presents a widely different aspect when suddenly snapped asunder by vibration, or by a sharp blow from a shot. In the former case the fibre is elongated by bending, and becomes developed in the shape of threads as fine as silk, whilst in the latter the fibres are broken short, and exhibit a decidedly crystalline fracture. But, in fact, every description of iron is crystalline in the first instance; and these crystals, by every succeeding process of hammering, rolling, &c., become elongated, and resolve themselves into fibres. There is, therefore, a wide difference in the appearance of the fracture of iron when broken by tearing and bending, and when broken by impact, where time is not an element in the force producing rupture.

If we examine with ordinary care the state of our iron manufacture as it existed half a-century ago, we shall find that our knowledge of its properties was of a very crude and most imperfect character. We have yet much to learn, but the necessities arising from our position as a nation and the changes by which we are surrounded, will stimulate our exertions to the acquisition of knowledge and the application of science to a more extended investigation of a material destined, in course of time, to become the bulwark of the nation. It is, therefore, of primary importance, that we should make ourselves thoroughly acquainted not only with the mechanical and chemical properties of iron, but that we should moreover be able to apply it in such forms and conditions as are best calculated to meet the requirements of the age in which we live.

Entertaining these views, I cheerfully commenced with my talented colleagues the laborious investigations in which we are now engaged; and looking at the results of the recent experiment with the 300-pounder gun on the one hand, and the resisting targets on the other, there is every prospect of an arduous and long-continued contest.

From the Manchester experiments to which I have alluded, we find that with plates of different thicknesses the resistance varies directly as the thickness, that is, if the thickness be as the numbers 1, 2, 3, &c., the resistance will be as 1, 2, 3, &c.; but those obtained by impact at Shoeburyness show that, up to a certain thickness of plate, the resistance to projectiles increases nearly as the square of the thickness. That is, if the thickness be as the numbers 1, 2, 3, 4, &c., the resistance will be as the numbers 1, 4, 9, 16, &c., respectively. The measure therefore of the absolute destructive power of shot is its *vis viva*, not its momentum, as has been sometimes supposed, but the work accumulated in it varies directly as the weight of the shot multiplied into the square of the velocity.

There is therefore a great difference between statical pressure and dynamical effect; and in order to ascertain the difference between flat-ended and round-ended shot, a series of experiments were undertaken with an instrument or punch exactly similar in size and diameter, and precisely corresponding with the steel shot of the piece ·85 diameter employed in the experiments at Shoeburyness. The results on the A, B, C, and D plates are as follows.

Character of Plates.		Resistance in lbs.	
		Punch flat-ended.	Punch round-ended.
Half-inch thick	A Plates	57,956	61,886
	B Plates	57,060	48,788
	C Plates	71,035	85,524
	D Plates	46,080	43,337
Three-quarter inch thick	B Plates	84,587	98,420
	D Plates	82,381	98,571
Mean		67,017	72,754

These figures show that the statical resistance to punching is about the same whether the punch be flat-ended or round-ended, the mean being in the ratio of 1000 : 1085, or 8½ per cent. greater in the round-ended punch. It is, however, widely different when we consider the depth of indentation of the flat-ended punch, and compare it with that produced by the round-ended one, which is 3½ times greater. Hence we derive this remarkable deduction, that whilst the statical resistance of plates to punching is nearly the same, whatever may be the form of the punch, yet the dynamic resistance or work done in punching is twice as great with a round-ended punch as with a flat-ended one. This of course only approximately expresses the true law; but it exhibits a remarkable coincidence with the results obtained by ordnance at Shoeburyness, and explains the difference which has been observed in these experiments, more particularly in those instances where round shot was discharged from smooth-bored guns at high velocities. To show more clearly the dynamic effect or work done by the weight of shot which struck some of the targets at different velocities, the following results have been obtained:—

Target.	Weight of Shot striking Target.	Work done on Target.	
		Total.	Per Square Foot.
	lbs.	Foot lbs.	Foot lbs.
Thorneycroft 8-inch Shield	1253	—	29,078,000
Thorneycroft 10-inch Embrasure ..	1511	—	37,140,000
Roberts's Target	946	822,000	19,726,000
Fairbairn's Target	1024	324,000	23,311,000
Warrior Target	3229	312,000	62,570,000
The Committee's Target	6410	—	124,098,780

From the above, it will be observed, that the two last targets have sustained in work done what would if concentrated be sufficient to sink the largest vessel in the British navy.

We are all acquainted with the appearances and physical character of artillery, but few are conversant with the nature of the operations and the effects produced by shot on the sides of a ship or on resisting forts and targets.

The shot of a gun—to use the expression of my colleague, Mr. Pole—is simply the means of transferring mechanical power from one place to another. The gunpowder in the gun developes by its combustion a certain quantity of mechanical force, or work as it is now called, and the object of the shot is to convey this work to a distance, and apply it to an object supposed to be otherwise inaccessible. The effect of this, according to Mr. Pole's formula, is W=its velocity in feet per second; V=weight of the shot in lbs. Then, by the principle of *vis viva*, the quantity of work stored up by the moving mass, measured in lbs. 1 foot high, is $=\frac{WV^2}{2g}$, g being the force of gravity=$32\frac{1}{4}$.

Thus, if we have a shot, like that recently used against the Warrior target, 156 lb., moving at the rate of 1700 feet per second, the work done will be

$$=\frac{156+(1700)^2}{64\frac{1}{2}}=7{,}008{,}238 \text{ one foot high.}$$

Showing at once the immense power that this small body is able to deliver on every resisting medium tending to arrest its course and bring its particles to a state of rest; or in other words, it is equivalent to raising upwards of 3000 tons a foot high in the air.

The application of Iron for Purposes of Defence.—Having examined, in a very condensed and cursory manner, the present state of our knowledge in regard to iron, and its application to the purposes of shipbuilding, let us now consider in what form and under what circumstances it can best be applied for the security of our vessels and forts. To the latter the answer is, make the battery shields thick enough; but a very different solution is required for the navy, where the weight and thickness of the plates is limited to the carrying powers of the ship. It has been observed with some truth that we have learnt a lesson from the recent naval action on the American waters; but it must be borne in mind that neither of the vessels engaged nor the ordnance employed were at all comparable to what have been used at Shoeburyness.

To those who, like myself, have gone through the whole series of experiments, the late engagement will appear instructive, but not calculated to cause any great alarm, nor yet effect any other changes than those primarily contemplated by the Government, and such as have been deduced from our own experiments. It is, nevertheless, quite evident that our future navy *must be entirely of iron*; and judging from the last experiment with the Armstrong smooth-bore gun, it would almost appear as a problem yet to be solved, whether our ships of war are not as safe without iron armour as with it. If our new construction of ships are strong enough to carry armaments of 300-pounder guns, which is assumed to be the case, our plating of 6 or 7 inches thick would be penetrated, and probably become more destructive to those on board than if left to make a free passage through the ship. In this case we should be exactly in the same position as we were in former days with the wooden walls; but with this difference, that if built of iron the ship would not take fire, and might be made shell-proof. It is however very different with forts, where weight is not a consideration, and those I am persuaded may be made sufficiently strong to resist the heaviest ordnance that can be brought to bear against them. In this statement I do not mean to say that ships of war should not be protected; but we have yet to learn in what form this protection can be effected to resist the last powerful ordnance, and others of still greater force which are *looming in the distance*, and are sure to follow.

A great outcry has been raised about the inutility of forts; and the Government, in compliance with the general wish, has suspended those at Spithead,—I think improperly so, as the recent experiments at Shoeburyness clearly demonstrate that no vessel, however well protected by armour-plates, could resist the effects of such powerful artillery; and instead of the contest between the Merrimac and the Monitor, and that of the 300-pounder gun, being against, they are to every appearance in favour of forts. Should this be correct, we have now to consider how we are to meet and how resist the smashing force of such powerful ordnance as was levelled against the Warrior target.

During the whole of the experiments at Shoeburyness I have most intently watched the effects of shot on iron plates. Every description of form and quality of iron has been tried, and the results are still far from satisfactory; and this is the more apparent since the introduction of the large 300-pounder, just at a time when our previous experiments were fairly on the balance with the 40, 68, 100, and 126 pounders. They now appear worthless, and nothing is left but to begin our labours again *de novo*.

It has been a question of great importance, after having determined the law of resistance and the requisite quality of the iron to be used as armour-plates, how these plates should be supported and attached to the sides of the ship. Great difference of opinion continues to exist on this subject,—some are for entirely dispensing with wood; probably the greater number contend for a wood backing, the same as the Warrior and the Black Prince. I confess myself in the minority on this question; and, judging from the experiments, I am inclined to believe from past experience that wood combined with iron is inferior to iron and iron in its power of resistance to shot; and I am fully persuaded that ultimately the iron armour-plates must be firmly attached to the side, technically called the skin, of the ship. It must, moreover, form part of the ship itself, and be so arranged and jointed as to give security and stability to the structure.

The experiments instituted by the Committee on Iron Plates have been well considered and carefully conducted; they commenced with a series of plates selected from different makers, of varying thicknesses, and these have been tested both as regards quality and their powers of resistance to shot. They have, moreover, been placed at different angles and in a variety of positions; and we had just arrived at the desired point of security when the thundering 300-pounder smooth-bore upset our calculations, and levelled the whole fabric with the ground. We are however not yet defeated; and true to the national character we shall, like the knights of old, resist to the last—

"And though our legs are smitten off,
We'll fight upon our stumps."

And thus it will be with the Iron Committee and the Armstrong and the Whitworth guns.

In conclusion, allow me to direct attention to a drawing of the Warrior target with wood backing, and its compeer entirely of iron. The first underwent a severe battering previous to the attack from the 300-pounder, but the other sustained still greater with less injury to the plates, notwithstanding the failure of the bolts in the first experiment. It must however be admitted that plates on wood backing have certain advantages in softening the blow, but this is done at the expense of the plate, which is much more deflected and driven into the wood, which from its compressibility presents a feeble support to the force of impact. Again, with wood intervening between the ship and the iron plates, it is impossible to unite them with long bolts so as to impart additional strength to it; on the contrary, they hang as a dead weight on her sides, with a constant tendency to tear her to pieces. Now, with iron on iron we arrive at very different and superior results. In the latter, the armour-plates if properly applied will constitute the strength and safety of the structure; and, notwithstanding the increased vibration arising from the force of impact of heavy shot, we are more secure in the invulnerability of the plates, and the superior resistance which they present to the attack of the enemy's guns. In these remarks I must not however attempt to defend iron constructions where they are not defensible, and I am bound to state that in constructions exclusively of iron there is a source of danger which it is only fair to notice, and that is, that the result of two or more heavy shot or a well concentrated fire might not only penetrate the plates, but break the ribs of the ship. This occurred in the last experiment on my own target, where a salvo of six guns concentrated four on one spot, not more than 14 inches diameter, went through the plates and carried away a part of the frame behind. The same effect might have taken place on the Warrior target; and certainly 9 inches of wood is of little value when assailed by a powerful battery of heavy ordnance and a well concentrated fire.*

* Since the above was written, another experiment has been made on the Warrior target with the 300-pounder smooth-bore gun. From this it appears that the wood backing between the armour-plates and the skin of the ship cannot safely be dispensed with, and that some compressible or softer substance than iron and iron is necessary to

In closing these remarks, I have every confidence that the skill and energy of this country will keep us in advance of all competitors, and that a few more years will exhibit to the world the iron navy of England, as of old with its wooden walls, unconquerable on every sea.

THE GENERAL ARRANGEMENT OF THE FRENCH CONTRIBUTIONS TO THE INTERNATIONAL EXHIBITION 1862.

THE subjoined particulars, which are condensed and translated from the official account, published under the superintendence of the Imperial Commission, cannot well fail to be of interest when the comprehensive nature of the collection sent from France, and the admirable completeness of the arrangement for organising and displaying it, are borne in mind.

French Industry, it is stated by the Imperial Commission, is by no means completely represented in the Exhibition of 1862. Lack of room has frequently compelled the Commission to decline the offers of distinguished manufacturers, or to grant but an inadequate space to their productions. The number of applications for admission, and above all the extent of space applied for, has surpassed all the preparations that could have been thought of at the time when the labours of the Commission began. The commercial treaty was referred to as likely to introduce great hesitation among the manufacturers, and a systematic refusal to exhibit had even been advised by some. Contrary to these fears, and notwithstanding this advice, the French manufacturers have responded in a body to the appeal of the Commission.

Figures will convey the best idea of this zeal. The Imperial Commission fixed its general regulations on the 15th June, and by the 15th September had to deal with 8154 applicants in the departments of agriculture and industry, presented by the admitting juries of France, and for whom a horizontal area of 41,900 square metres was demanded. This utilisable space corresponds to a total area of 120,000 square metres; while the entire Palace of London, including picture galleries and refreshment courts, only contains an area of 108,000 metres.

The horizontal area granted to France in three successive allotments by Her Majesty's Commissioners was 13,740 metres. With such large requisitions for space, and so limited an amount disposable, the Imperial Commission, with the assistance of the juries, was obliged rigorously to sift alike the exhibitors and products admitted. The number of exhibitors ultimately admitted and supplied with space amounts for all classes of the French department to 4780 (reduced really to 4669 in consequence of the fact that 111 exhibit under distinct numbers in various classes). In addition to this number productions from Algeria and the French Colonies are exhibited by 826 exhibitors.

To accomplish so much as this, and to do justice to 4669 applications out of 8154, with one ninth of the space demanded by the applicants available, the Commission was obliged to take such measures as seemed most suitable for employing the space allotted to France. First, therefore, the passages and gangways were reduced to a minimum, and then the formation of groups of exhibitors was encouraged in every possible way. The number of such groups voluntarily constituted, exceeded those of any previous exhibition, and the Commission, believing it to be for the interest of the exhibitors themselves that such groups should be generalised as much as possible, has always requested all the exhibitors included in one block to unite in the construction (at their joint expense) of the fittings necessary for the exhibition of their goods. Loss of space and other inconveniences have been thus diminished, and it has become practicable to carry out with absolute certainty a pre-arranged plan, and consequently to know with absolute precision the amounts of horizontal and vertical space available, while a harmony in the general arrangement, form, and height of the fittings, was secured, such as could not exist in fittings prepared without any regard to their collective effect.

deaden the blow, and absorb the fragments of the shot and the broken plates, which in this instance lodged in the wood, and did not perforate, but only cracked the skin of the target. From this fact it cannot be denied that this exp riment is more satisfactory than those on the iron on iron targets; and however desirable it may be to realise a more effective construction as regards the strength of the ship, it cannot be doubted, in so far as the security of the ship and the lives of those on board are concerned, that a vessel with wood backing is safer in action than one composed entirely of iron. In the present state of our knowledge the experiments are therefore against iron and iron, as regards security from the effects of shot, but they are unfavourable as respects the strength of the ship.

The entire utilised area divided among 36 classes is 5498 square metres, while the area occupied by gangways amounts to 8242.

The general principles of arrangement were, that in the ground-floor galleries surrounding the central court are placed substances used for food, the raw material of various manufactures, and manufactured articles produced from inorganic materials. In the ground-floor gallery, under the picture gallery, the machinery not in motion, and specially agricultural machinery, is placed. The remainder of the machines at rest and all the machinery in motion are in the French section of the western annexe. In the first-floor galleries are grouped manufactured goods made from organic materials, scientific objects, and objects connected with instruction; and lastly, in the French court itself, the passages leading to the nave, and the French portion of the nave, are collected those productions which have some affinity with works of art,—those which result from the industry called into being by fashion and art.

In the French official catalogue full details are given, some of them of a nature never before attempted to be introduced into a catalogue. Attention ought especially to be directed to the indication attached to each exhibitor's name of the nature of the establishment in which the goods were produced. These are distinguished as, Factory (*usine*), meaning an establishment where steam or water power is employed, and a large number of hands are engaged; Workshop (*atelier*), meaning an establishment distinct from the exhibitor's house, but working with no, or very moderate "power," and ordinarily employing but few hands; Private Manufacture (*atelier domestique*), a part of the residence of the exhibitor, and in which the hands are limited to members of one family, apprentices excepted; Combined Manufacture (*fabrique collective*), combination of establishments of either grade, under the general supervision of the exhibitors, and each doing a portion of the work necessary for the production of the article.

The indications thus marking the nature of the establishment exhibit in a general way the nature of the organisation of various trades. For example, they demonstrate that in most industrial callings, and above all in those which are the most nearly allied to the fine arts, articles are produced for the most part by distinct workmen, labouring at their own homes, by the piece, for regular customers (*une clientèle*). The contrast which exists between the manners of artizans of this class, and those employed in factories, is one of the most remarkable features of the industrial organisation of France; and it was a matter of interest to give it prominence. The exhibitor is also required to state the proportion which, in his opinion, the value of the goods manufactured by him per annum for exportation bears to the total annual value of his whole production; the date of the establishment of his manufactory or *atelier*, and the medals or awards which he obtained in the exhibitions of 1851 and 1855, together with the ordinary description of the articles he exhibits.

FOREIGN ENGINEERING MODELS AT THE INTERNATIONAL EXHIBITION.

THE engineers of the Continent have shown themselves not backward to enter the lists at Kensington; and it is both pleasant and instructive to note their skill in a science, some of the most important branches of which owe their first rise and development to the veterans of our own country. France contributes a number of admirable models, designs, &c.; and the French Minister of Commerce and Public Works (M. Rouher), has caused a volume to be prepared containing very lucid and full descriptions of the works thus represented. We can only glance at a few of the more important or remarkable of these.

Of the Cherbourg Breakwater a model is exhibited, to a scale of 1-1000th of the actual dimensions, and the Minister of Marine has contributed a notice of the progress of the undertaking from its commencement in 1740 to its completion in 1853. This breakwater cost, for a length of 3700 metres, 67 millions of francs, or 18,000 francs (about £720) per metre forward, exclusive of the forts. The construction of the work in its present form is due to the design of M. Fouques Duparc, under whose system it was carried on from 1831 to its conclusion in 1853. The lowest portion of the foundation (properly so called) is of hydraulic beton, contained between two rows of granite blocks on the two faces, north and south. This is carried to low-water spring-tides, from which level the work is carried up in masonry, faced with granite. Towards the open sea, the foot of the wall is protected by a huge screen of blocks of stone, descending to 5 metres below low water. But at the extremities of the work, where the most violent effects of storm were to be apprehended, ordinary blocks of stone were deemed insufficient, and recourse was had to artificial blocks of 20 cubic metres in bulk, composed of gneiss or sandstone rubble, in Portland cement, mixed with Medina cement to ensure more rapid set. These blocks, of which the earliest were placed in 1846, have generally speaking successfully withstood the chemical action of the sea water up to the present time. The action of heat upon the granite facing, and more especially on the parapet, for the lengths of the two branches (nearly 1300 metres, and nearly 2000 metres, respectively) is very marked in its effects in summer, the transverse joints alternately opening and closing. No silting up of the roadstead appears to have followed the construction of the breakwater, although in storms there is some deposit of fine sand and gravel on the eastern bank of the harbour.

The Lattice-girder Bridge over the Rhine at Kehl, connecting France with the Grand Duchy of Baden, was constructed under the joint superintendence of French and German engineers. A model of a caisson for the foundation to a scale 1-10th full size, and models of one pier in course of construction, and completed, each 1-25th full size, are exhibited. The foundations were sunk by a modification of the method of compressed air, known in France as the system of M. Triger, from the circumstance of its having been invented by that gentleman, and employed in sinking shafts through wet strata. In England it is better known as Hughes's pneumatic process, our countryman having been the first to show the application of the principle to the formation of bridge foundations under water, by means of cylinder piles or caissons. According to the method usually followed, the communication between the caisson and the surface is maintained by a single shaft, which is surmounted by an air-cage or air-lock, furnished with the necessary valve doors and air cocks, and containing the winch for raising the material excavated below. This shaft is thus commonly of considerable size, and as it has to be kept charged with air to a pressure sufficient to exclude the water from the caisson in which the men have to work, much pumping is required. After water has been readmitted into the cylinder, for the purpose of loosening the earth below, or on occasion of adding a fresh length to the air shaft, considerable time is consumed in pumping in the air before the water is again lowered so as to enable the excavators to return to their work.

In the foundations of the Kehl Bridge, the caisson was furnished with two plate iron cylinders of moderate diameter, which were alternately employed as air shafts. One cylinder having been lengthened while the other was in use, no further delay was necessary than that required for transferring the air cage from the one to the other, and making the joint air-tight, and a lower valve was placed in each cylinder as a special provision for the change. Between the two air shafts, and opening into the centre of the caisson, was a large working shaft, in which the water was permitted to rise to its natural level, and through which the excavated material was raised by a dredging apparatus.

In the foundations first put in (those of the pier nearest the French bank) the working shafts were cylindrical and of iron plate; but as serious hindrance was found to arise from the buckets catching against the sides, so as even occasionally to break the chains, these shafts were afterwards made of elliptical section, and carried up as wells in the concrete and masonry placed on the tops of the caissons, the interior being lined with brickwork on edge rendered with Roman cement, and the iron plates being dispensed with. The masonry as it was carried up was kept clear of the plates of the air shafts, so as to allow of their being drawn up on the completion of the sinking of each caisson, and used over again.

In forming the foundations of the first pier, a kind of coffer-dam appears to have been constructed on the top of each caisson as it descended, but in the other piers this plan was abandoned, the masonry being at once placed on the tops of the caissons. (It should be noticed that these were convex, and strengthened underneath by longitudinal and transverse girders.) The following is a statement of the time occupied in sinking the caissons for the abutments and the two river piers respectively.

Abutment on the French bank:—
55 working days of 16 hours: rate of sinking per hour, 0·0209 metre.

Abutment on the Baden bank:—
31 working days of 11 hours: rate of sinking per hour, 0·0470 metre.

River pier, French side:—
25 working days of 10·56 hours: rate of sinking per hour, 0·0760 met.

River pier, Baden side:—
24 working days of 11·08 hours: rate of sinking per hour, 0·0750 met.

The increased facility in sinking the last foundations as compared with the first (which will be observed from the preceding figures to be *nearly as* 4 *to* 1), resulted solely from the modifications made in the original arrangement as the work proceeded. These modifications are stated to have been the following:—Connecting the adjacent caissons firmly together;—Dispensing with timber coffer dams, and executing the foundation in one entire block of masonry above the top of the caissons;—Preserving the working shaft (or "water shaft") at the centre of each caisson, making it oval instead of circular, and lining it with brick on edge rendered with Roman cement;—Lining in the same manner the walls inclosing the iron air-shafts;—Filling in as expeditiously as possible, between the stiffening ribs of the roof and walls in the interior of each caisson, with masonry in the form of a vault;—Providing a pair of screw jacks to each corner of each caisson, taking their bearing from suitable timbering in the upper platform of the scaffold, and serving, first to lower the caissons to their exact place in the bed of the river, and afterwards as guides to keep them in their true position as the work of sinking through the gravel went on;—Lastly, employing vertical dredging apparatus worked by steam in each water-shaft.

A model 1-20th the full size, and two drawings, are exhibited of the Iron Bridge over the Garonne at Bordeaux, connecting the Orleans and Southern lines of Railway.

This bridge is about 500 metres between the abutments, and consists of seven bays, of which the two extreme are 57·36 metres, and the five others 77·50 metres from centre to centre of piers. The superstructure consists of two open wrought-iron girders 6·35 metres deep, the top and bottom flanges connected by standards and cross bracing. The girders are connected with each other at the top by a system of cross bracing to steady them, and at the bottom by the transverse girders which carry the platform and rails.

The piers are formed each of two cast-iron cylinders 8 metres apart from centre to centre, and filled with beton. Each cylinder is 3·60 metres diameter, and 0·04 metre (about $1\frac{9}{16}$ in.) thickness of metal, and built up in 28 rings of about 1 metre high. The foundations of the abutments are of an ordinary character.

The depth of the water, varying from 4 to 7 fathoms; the rapidity of the stream, which is from 6 to 10 feet a second; and the existence of tides, which cause twice in the twenty-four hours a rise of 6 metres (nearly 20 feet), form the peculiar difficulties of the case, in order to meet which recourse was had to the tubular foundations.

In sinking the tubes in the bed of the river the system of compressed air was employed, with the following special modifications, which it must be observed were introduced during the progress of the work.

1. The air-lock was formed within the cylinder itself, and thus its position could readily be shifted as the sinking proceeded, for which it was only needful to unfix the plates forming the doors of entrance and exit, and refix them higher up, bolting them to the rings composing the cylinder, which were provided with internal fillets or flanges.

2. Hydraulic presses were used for applying weight to the tube, so as to drive it down with a force frequently exceeding 200 tons.

3. The stuff excavated was raised by means of power communicated from a steam engine. This arrangement involved the difficulty of transmitting a power generated in the open air to apparatus confined in compressed air. Accordingly a shaft was employed, working through a stuffing-box, the driving belt being lengthened or shortened as the case required. The shaft worked a windlass within the cylinder, the necessary means of throwing it out of gear being provided.

By these arrangements it was found practicable to sink a length of 2·65 metres of cylinder in the twenty-four hours.

It is very instructive to find that the increased rapidity in sinking secured by the gradual introduction of the modifications above enumerated was extremely marked; and this, notwithstanding the fact of the cylinders last driven being the deepest sunk. Thus, the second cylinder in the second pier was sunk at an average rate of 0·79 metres per day, the time occupied being

10 days, and the depth in the river bed 7·90 metres, giving 78,168 cubic metres of excavation. Whereas the first cylinder in the sixth pier was sunk in 9½ actual working days; so that, although the total depth sunk was 17·03 metres, and the excavation 166,859 cubic metres, the number of days occupied was somewhat less than in the former case, while the depth sunk was more than double. We give the figures from the French official notices already referred to.

The superstructure was erected by means of a temporary bridge fixed first across one half the stream, and then across the other half, so as to keep a width of 250 metres always free for navigation.

The proof was severe:—8000 kilogrammes per running metre (or nearly 2½ tons per foot forward), first on one road, then on the other, and lastly on both roads at once, leaving the testing load 8 hours on the bridge. Under these weights the elasticity of the girders was in no degree impaired, and the deflection while the load remained on the bridge was 0·017 metre (about ⅝ inch) for the extreme bays of 57·36 metres span, and 0·022 metre (not quite 1 inch) for the intermediate bays, of which the clear span was 77·06 metres.

The bridge was also tested by running trains over both roads at various speeds and in both directions, and the deflections under this proof varied from 0·015 metre to 0·022 metre.

The Viaduct at Fribourg carrying the railway from Lausanne to Fribourg and the Bernese frontier, across the valley of the Sarine, is illustrated by a model 1-25th the real size, showing one bay complete, and another in course of construction. Its total length between the faces of the abutments is 328·84 metres, and it rests on six piers placed at intervals of 48·80 metres. The height from the level of rails to that of the water of the stream at its lowest is 76 metres. Each pier is composed of an upper portion 44 metres in height, of metal, and a base of masonry founded on the solid earth. The highest pier measures 80 metres in all from foundation to level of rails. The portion in metal consists of a cast-iron base and top, and 12 cast-iron columns fixed battering, and well braced together. The section of the columns is that of a cylindrical nucleus carrying four feathers, to which the ends of the bracing are attached. To facilitate the erection of the piers the 44 metres were subdivided into eleven heights of 4 metres, the junction of the columns being secured by means of flanges planed true and socket joints, and horizontal bracing being introduced at each of these stages. The superstructure is composed of four wrought-iron trellis girders. Friction-rollers are dispensed with, the flexibility of the iron piers being relied on for the play due to the changes of temperature.

Owing to the great height, it was decided that timber scaffolding could not be relied on for the safe and accurate execution of the work. It was therefore resolved first to construct the four girders, and then to slide the whole forward on rollers until its end was projected over the base of the first pier. Powerful crabs, worked by about eight and twenty men, were fixed on the masonry of the abutment, working chains and pulleys, by means of which the materials for the iron superstructure of the pier (carried on a truck to the end of the bridge) was successively lowered until the whole was completed. This process was then repeated in the construction of the next pier, and so on until all were finished. The strength of the girders for the first and second bays was specially calculated to enable the bridge thus to act as a cantilever for a length equal to the first bay, besides which chain-bracing was introduced between the second bay and the forward end of the first bay, to keep the deflection within as narrow limits as possible. To obviate the danger of the piers being deflected from the true perpendicular, by the bridge being rolled forward over them, they were stayed from each other and from the abutment by iron cables, maintained in straight lines by being suspended by rods from little chains. The drawing the bridge forward from one pier to another (a distance of 48·80 metres) required six men, working for six hours.

A model of a Railway Bridge over the Rhine, near Mentz, is exhibited by Messrs. Klett and Co., of Nuremberg. In this, attention is principally drawn to the superstructure, which is of wrought-iron, constructed on the system of M. Pauli by the above named Bavarian engineering firm.

The entire viaduct is 3375 feet long, and consists of four principal bays of 332 feet clear span each, at a skew of 27° from the square, six bays of 110 feet, thirteen of 49 feet, two of 82 feet, and seven of 49 feet. The model represents to a scale one-tenth full size, one of the four principal bays for a single line of railway, the piers being of sufficient width for a double line, which it is intended ultimately to have. The roadway is formed by two longitudinal trellis girders carrying the transverse girders, which again support longitudinal plate girders (one under each rail), upon which the transverse wooden sleepers are secured. Each trellis girder derives its support from a deep wrought-iron truss, consisting of a plate bow and suspension chains, an arrangement similar to that of the trusses for the Royal Albert Bridge at Saltash, but differing from it in the quantity of diagonal bracing which is introduced between the bow and the chain, and in the bow being of double-headed boiler plate section, instead of being in the form of a tube. In neither of these points do we find the construction an improvement upon Saltash, for where the entire depth is so considerable, and the diagonal bracing necessarily of great length, we do not see that much reliance can be placed upon an action which to be perfect must involve an alternation of compressive with tensile strains. We therefore regard this structure as a mutually supporting combination of arch and chain, rather than a braced girder; and, although doubtless an original idea as far as M. Pauli is concerned, the priority in fact would appear due to the late Mr. Brunel.

(To be continued.)

REVIEWS.

On Heat in its relations to Water and Steam; embracing New Views on Vaporisation, Condensation, and Explosions. By C. Wye Williams, A.I.C.E. Second Edition. Longman & Co.

The first edition of this original and useful work was noticed at page 378 of the volume of this Journal for 1860; and also at pages 29 and 82 of the volume for 1861. A reference to those notices will show why we indorse the reasoning demonstrations and conclusions of Mr. Williams, notwithstanding the overthrow of the theories, empirical rules, and conclusions of chemists, engineers, and philosophers of high standing. Mr. Williams, with a few glass beakers and a Florence flask, has done more to develop the laws of heat in their relations to water and steam than all the previous costly experiments of governments and of individuals. In science as in morals, when false doctrines are propounded and maintained by great intellects, it often happens that paralogy for a considerable time defies the powers of truth and sound reason. Mr. Williams, we imagine, cannot complain on this score, since editions of his work are now being prepared in the French, German, and Italian languages by scientific men. The success of this work may in a great measure be attributed to the perspicuity of its language, the clearness of its demonstrations, and the systematic order of its arrangement.

On Boiler Explosions Mr. Williams says—

"Numerous instances have occurred where explosions of boilers have taken place on the steam engine being set to work after an interval of rest. This circumstance has given rise to many speculations, and it certainly appears unaccountable that the very act of liberating the steam, and thus, as it were, relieving the boiler of a portion of its pressure, should be followed by a practical augmentation of it. It is manifest, therefore, that there must have been some direct, though hitherto unexplained cause for such increased pressure, when a diminished one might reasonably have been expected. It is clear, also, that there must have been some rapid, and even sudden action, which is irreconcilable with a gradual generation of steam, and increase of heat.

In explanation of this anomalous augmentation of pressure, several writers have assumed what they term a sudden 'flashing of the water into steam.' This, however, is so wholly opposed to the effect which characterises the gradual addition of heat, and the progressive change from the liquid to the vaporous state, as to be wholly inadmissable. It would imply some sudden action on the part of the water, as a body or mass, apart from its elementary particles, and without any additional accession of heat. Besides, the sudden flashing of water into steam, which means the sudden conversion of liquid into vapour, is opposed to all known ideas of the nature of matter in the liquid state, and that change of condition from attraction to repulsion among its particles which would be the necessary consequence of their becoming vaporous.

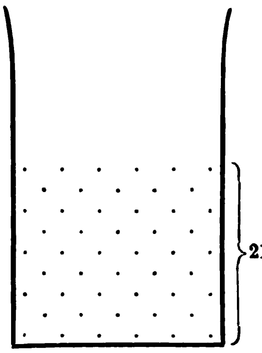
Other writers are of opinion that when, on the opening of the valve, the steam is allowed to escape, an undue agitation of the water is produced, by which it is dashed against the hotter portion of the furnace plate, and more especially if any part had been left uncovered by a neglect in the supply of feed water; assuming that a largely increased quantity of steam, with a corresponding increase of pressure, would be the result.

This theory is at once disposed of by the fact that explosions are equally attendant on an overcharge, as an undercharge of water, and that it attributes results on the largest scale to comparatively insignificant causes,—a maximum of effect from a minimum of power.

A detail of the supposed causes of the sudden production of large quantities of steam, and consequent explosions, with numerous well selected cases, was given a year or two ago in a series of papers in the London *Engineer*. It is unnecessary, therefore, here to do more than briefly enumerate the leading heads under which those causes may be arranged, —viz., first, 'electricity;' second, 'decomposed steam;' third, 'over-pressure;' fourth, 'explosions at ordinary pressure;' fifth, 'the momentum of combined steam and water.' This last is examined in reference to a statement made in a letter from Mr. D. K. Clark, published in the *Mechanic's Magazine*, Feb. 9th, 1860.

Let us now consider this subject practically. In section 6, on Ebullition, and 8, on the Presence of Steam in Water, it has been shown that so soon as the water has become saturated with steam, and the temperature of 212°, or thereabouts, has been reached, an uniformity both of

FIG. 1.



temperature and pressure begins to prevail, and continues both above and below the water level, indicating an uniformity in quantity of steam in both places. In other words, that each cubic inch of space in the boiler contains the same quantity of steam. The annexed figs. will sufficiently illustrate this.

Let Fig. 1 be an open vessel half filled with water, having two thermometers suspended in it, the bulb of the one being below the water level, and that of the other above it. On heat being applied from beneath, steam will be generated and become diffused through the water until the point of saturation and the temperature of 212° has been reached: the thermometer above the water, as presently will be shown, varying according to circumstances.

Let Fig. 2 represent the vessel covered and steam-tight, and the heat further applied. In this case the chamber above the water line will become equally filled with steam, and both thermometers will then stand at

FIG. 2.

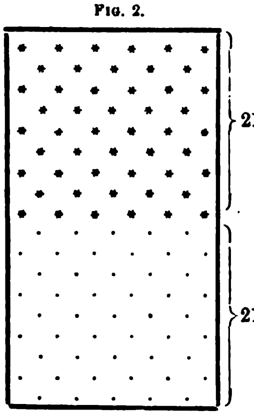
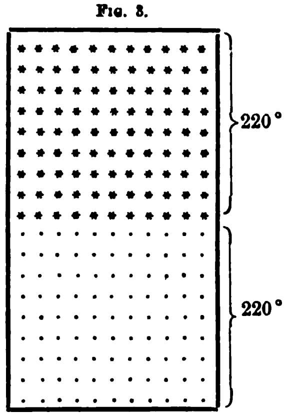


FIG. 3.



212°, as there marked, the dots representing the steam atoms below, as the stars do those above, the water line.

Let Fig. 3 represent the same vessel under a further application of heat, and when an accumulation of steam will continuously and uniformly take place both in and above the water, as there shown by the increased and corresponding number of dots and stars in both places. In this case then we have a continuing uniformity of quantity, temperature, and pressure—say at 220°, or any higher degree, as the heat may be applied.

Let us now practically test these three states by the following experiments. In illustration of Fig. 1, heat was applied under an open vessel half-filled with water, and having two thermometers in it, the one in the water and the other one inch above it. The following was the result, fractions of minutes or degrees of heat not being noted (See table):— We here see that from the moment the heat was applied there was an unremitting evaporation or escape of steam from the water into the air above it, and indicated by the thermometer as noted in column 2.

Temperature in the water.	Temperature above the water.	Time for every ten degrees of temperature.
70°	70°	
80	75	3 minutes
90	81	2 „
100	87	2 „
110	92	1 „
120	97	1 „
130	102	1 „
140	106	1 „
150	111	1 „
160	116	1 „
170	120	1 „
180	125	2 „
190	131	1 „
200	137	2 „
210	143	2 „
212	149	

On the temperature reaching 212°, the state of the water and steam in it may be taken as represented in Fig. 1, and as being at the point of saturation.

The next experiment, in illustration of Fig. 2, was made in a steam-tight vessel with two thermometers, being half filled with water. The following were the results:—

Temperature in the water.	Temperature above the water.	Time in minutes.
70°	70°	
80	75	1 minute
90	84	1 „
100	94	1 „
110	104	1 „
120	114	1 „
130	124	1 „
140	134	1 „
150	144	1 „
160	154	1 „
170	164	1 „
180	173	1 „
190	183	1 „
200	193	1½ „
210	204	1½ „
212	212	

Here the steam rising out of the water into the close chamber above it, with the consequent increase of temperature, followed close on that of the steam in the water. This was what might have been expected; the steam however, being generated in the water, and then passing into the space above it, must necessarily take the lead in quantity in the former. Nevertheless, its escape is so rapid, that it is throughout but a few degrees less in quantity than in the water itself.

This experiment illustrates what is represented in Fig. 2, the points below and the stars above being equally numerous in both places, and indicating an uniformity of temperature when at the boiling point under atmospheric pressure.

In both these experiments we have an unquestionable refutation of the prevailing theory of the steam being only generated at the boiling point. Were that theory correct the temperature in the space above the water line could not have been affected, but which was occasioned solely by the formation and escape of the steam, and which we see took place from the moment the heat was applied.

The third experiment, in illustration of Fig. 3, was a mere continuation of the heat, with a further increase of steam and temperature—both thermometers indicating a continued uniformity of quantity, temperature, and pressure.

These experiments are so easily made, and withal so reliable, that it is a matter of surprise they have not been repeated or commented on by writers before they commit themselves to the unexplainable theories we find recorded. Now the thermometer, being so trustworthy a test both of temperature and pressure, furnishes a sufficient refutation of those here enumerated. No boiler, then, should be used without having one inserted in it, so as to pass into the water, where it will become a more reliable test than the ordinary mercurial pressure gauge. We have everywhere tables of the comparative temperature, force, and pressure of steam; yet, strange to say, we find very little attention paid to them in practice."

In support of his views Mr. Williams next introduces one of his convincing experiments, already illustrated at page 85 of this Journal (vol. for 1861). He then continues:—

"We have here a miniature practical effect of what takes place in a boiler under similar circumstances, the violence of the action being increased in proportion as the area of the water space exceeds that above it. This experiment should not be made with distilled or filtered water, but with water containing its ordinary quantity of motes or foreign matter, that ebullition may take place.

The necessary inference is, that the risk of explosions is greatly increased by the increase of water in the boiler, every cubic foot of which, beyond what is absolutely necessary for the generation of steam, being an additional source of danger, when there is any sudden liberation of the steam which it contains into the reduced space above it.

Now the determining the mere question as to the relative value of a large or small boiler for an engine of any given power, on the score of efficiency or economy, is of itself worth the whole labour of the inquiry. Again, the determining on sound intelligible principles the comparative value of the areas of space below and above the water line, is a matter of great practical importance. These are points, however, which receive no attention from those to whom the construction and details of boilers are usually entrusted. If even we ascend higher, and look to those at the head of the first engineering establishments in the kingdom, we find the same neglect of those chemical principles on which the perfect combustion of the fuel absolutely depends. Look for instance to the plan of the boilers of the Great Eastern, designed by the late Mr. Brunel. It is only necessary to say that we there find, on the one hand, the greatest and most palpable violation of all natural and chemical laws, as regards effecting combustion and the generation of heat; and, on the other, the application of that heat in the generation of steam. The result is, not merely a large and wasteful expenditure of fuel, but a serious impediment to the generation of steam by the presence of soot, which lines the interior of the tubes.

In confirmation of the existence of steam below the water line, it may be asked how otherwise it could be explained that the temperature, both in the water and in the chamber above it, should be so instantly and simultaneously reduced? That the temperature above the water should be rapidly lowered to that of 212° is at once understood, as the result of the escape of the steam; but wholly unintelligible, as regards the space below the water surface, except on the supposition that that space contained steam as well as water.

If the heat had been absorbed by the water still in the liquid state this sudden depression of the temperature could not possibly have taken place. It would be utterly opposed to all known principles, as regards the transmission of heat between bodies, that either solids or liquids could be instantaneously deprived of their heat. The parting with heat by one body, and its being taken up by another, must be progressive, the one giving out heat only as the other can absorb it. As well might we expect that one ton weight of iron or lead, at a high temperature, could part with its heat instantaneously to another, as that a ton of water, supposed to be merely heated, could instantaneously part with its heat, and be reduced, say from 312° to 212°.

The rapidity with which the thermometer immersed in the water indicates a corresponding depression with that in the space above it, ought, therefore, to convince us that it was not the water as a liquid mass that contained the heat, or acted on the thermometer, but the steam, each atom in its escape from the water medium carrying away its own heat. In a word—that the cause of the indicated and simultaneous reduction of temperature was the same in both cases, namely, the escape of the steam which each contained.

Steam may almost instantaneously be discharged from the water, and the temperature as instantly reduced to 212°, the saturating point; whereas mere heat, supposing it had been absorbed by the water, could not possibly be so disposed of. This single fact should be conclusive on the subject."

The work before us detects and defines many of the laws that govern heat in its relations to water and steam; however, a perfect knowledge of the philosophy of steam cannot be attained until more is discovered of the part performed by electricity in connection with it.

The whole chapter on boiler explosions is worthy of the most careful attention of steam engineers, boiler makers, and all interested in the application of steam as a motive power. Indeed, the world is largely indebted to Charles Wye Williams for his original views, sound reasoning, backed by clear and accurate experiments, and conclusive demonstrations.

Iron Breakwaters and Piers. By E. B. Webb, M. Inst. C.E. &c. London: Lockwood. 1862.

Mr. Webb has designed and patented a breakwater, which he considers to be free from the disadvantages of either floating or solid structures. The following is an account of the considerations to which the inventor has had special regard, and the description of the arrangement by which the proposed end is to be attained.

"The objects sought are obtained—

1stly. As to stability, by fixing the breakwater to the bed of the sea.

2ndly. As to prevention of silt, by allowing the tidal and other currents to pass freely through the breakwater.

3rdly. As to cost, by using (by preference) cast-iron in its cheapest form.

Description of the Breakwater.

This breakwater in its simplest form is supported on cast-iron cylindrical piles, sunk into the ground either by screws, or by the process adopted in the construction of the Morecambe Bay Viaducts. The piles are filled internally, to above high-water mark, with concrete. To these are fixed girders or beams of iron, placed, as a convenient distance, at ten feet apart; but the distance can be varied in accordance with the locality. The girders have sockets, in which are fixed the ends of pipes forming that portion of the surface of the breakwater which rises above low-water mark. It will generally be found advantageous to place this surface at an inclination to the horizon. The pipes resemble gas or water mains, but they are of a simpler and cheaper construction. The ends of these pipes are securely fixed in the sockets of the girders by creosoted wooden wedges; and these wedges, whilst keying up the ends of the pipes, relieve the girders from the effects which the blows of the waves, acting upon iron against iron, might otherwise produce. The spaces between the pipes admit a certain portion of the waves to pass through, diminishing the force of the blows of the waves, and preventing any disturbance of the surface-water inside the harbour. A set of similar pipes is fixed vertically between the piles in the front row to a depth varying, according to circumstances, from six to twelve or more feet below low-water."

Mr. Webb has given special attention to the durability of cast-iron in sea-water, and the subject is one of such importance that we extract his observations; while not professing to show that all cast-iron may be trusted to withstand the deteriorating action of the sea, our author brings forward several instances in which its judicious employment has been proved by its remaining uninjured after many years' submersion.

Durability of Cast Iron in Sea Water.

Cast-iron in sea water is liable to two descriptions of deterioration—generally by the absorption of oxygen, and occasionally, with certain qualities of metal, by a softening of the outer surface.

The oxydation of cast-iron in sea water does not proceed rapidly, even when its surface is unprotected and its quality that most favourable for a union with oxygen. An idea of the rate of oxydation may be formed from the following statement by Mr. R. Mallet, (as the result of numerous experiments,) that "cast-iron freely exposed to the weather at Dublin, and to all its atmospheric precipitations, was corroded nearly as fast as if in clear sea water, when the specimens in both cases were wholly unprotected."

In iron breakwaters, the question as to durability will refer chiefly to the parts below low-water; for the protection of the superstructure against slow and unimportant oxydation may be readily insured. It has been stated, that the oxydation of iron surfaces continually covered with water goes on more slowly than when the metal is exposed alternately to air and water. In addition to this circumstance, favourable to the easy protection of ironwork standing in the sea, it will be found that in the majority of localities the sea itself provides, in the shape of mollusks, an excellent protection to the submerged portions.

The softening of cast-iron is a process not clearly understood. Cast iron will soften in the cylinders and pipes used in mines, as well as in piles standing in sea water. After softening under sea water it will at times become hard again on exposure to the air. Cast-iron, however, is very far from being generally liable to the process of softening.

In consequence of the great variety in the quality of cast-iron, instances are not wanting which apparently support directly opposite opinions. Cast-iron has been taken up after immersion in sea water, utterly decomposed. In many such cases, it is known that the iron has been purposely cast of the softest metal, and in others it may fairly be presumed that soft metal has been employed. On the other hand, there are numerous instances of cast iron having remained perfectly sound and uninjured after an immersion for many years in sea water. From very numerous examples of long immersion without injury, the writer will select a few which he has personally examined.

Dock Gates, Sheerness.

There are several pairs of cast iron dock gates at Her Majesty's dockyard, Sheerness. They were designed by the late Mr. Rennie. The heel posts, mitre posts, and ribs, are of cast iron. The gates are sheeted from top to bottom with cast iron plates, perfectly water-tight. Three pairs of gates have been exposed to the action of sea water since 1821, and a fourth pair since 1827.

The writer examined these gates in January of this year, 1862, and he found that the framing and plates were in perfect condition. From the dockyard officials he learnt that no portion of the cast iron had ever been replaced, in consequence of deterioration of the metal, and that no plate had given way, although there is a head of water equal to 26 feet at spring tides. Three pairs of these gates have, therefore, resisted the action of sea water, uninjured, for fully forty years, and a fourth pair for thirty-five years.

The writer observed, however, that the cast-iron sector plates, against which the gates shut, are softened in places to some little extent, but only where the iron is in contact with a mass of lead, which has been used to form a water-tight joint; the galvanic action created by the contact of the two metals having, doubtless, caused the softening of the iron.

At Chatham, the writer saw a number of iron castings which had been removed thither from a dock at Pembroke, where a caisson has replaced the gates. After an immersion in sea water at Pembroke for many years these castings are found to be in so perfect a state, that they will shortly be put in use at the new entrance to No. 1 dock at Chatham, there again to be exposed to the action of sea water.

Lowestoft Harbour (Basin Entrance).

The late Sir W. Cubitt having witnessed the rapid destruction of timber in the sea at Lowestoft, and being satisfied as to the durability of cast iron in sea water, determined upon casing the entrance of the Lowestoft basin with cast iron piles. The work was commenced in 1832, under Mr. George Edwards. The writer examined these piles last year, and he found them uninjured, They are, for all practical purposes, as sound and as perfect as when they were driven—upwards of twenty-eight years ago.

Southend Pier (Extension).

Mr. James Simpson (Past-President of the Institution of Civil Engineers), in designing the extension of this pier, after careful consideration of the durability of cast iron in sea water, selected that metal for his piles. The extension was executed in 1844. In February, last year, the writer examined these piles: he found them in a most perfect state. They are square, and the angles are as sharp as when they left the foundry. Mr. Simpson specified the quality of the iron from which these piles were to be cast, because he found, from examination of specimens of cast-iron which had been exposed to the action of sea-water, that the durability depended upon the quality. These piles, after having been exposed to sea-water during seventeen years, are perfectly uninjured.

Herne Bay Pier.

The Pier at Herne Bay, nearly three quarters of a mile in length, was designed by the late Mr. Telford. It was built of timber in 1831. After standing for about seven years, the piles were generally so far destroyed by the worm, that it was decided to use cast iron, to a great extent, in the repairs. Accordingly, in 1838, a great number of cast iron square piles were driven. Very recently the writer examined this pier. He found the cast iron in a most perfect state. The angles of the piles were sharp, and the surface as smooth and as sound as when the castings left the foundry. The piles, as usual, are covered with shell-fish, which keep the surfaces moist during ebb tide. Not more than one-half of the whole piles in the pier are of iron; those of wood are either cut through by the worm, or are under that process of destruction. The timber piles have required constant repairs and renewals. Upon the cast-iron not a shilling has been expended. The pier in consequence of the destruction of the timber, which is immersed in the sea, is in a most dangerous condition Had Mr. Telford, in the first instance, selected cast iron for the piles of his pier, the substructure would have been as sound to-day as when put down in 1831. With the exception of the cast iron piling, which has been under the action of sea water twenty-three years uninjured, this pier may now be termed a ruin.

Margate Jetty.

A jetty erected at Margate in 1831 rested on timber supports fitted into cast iron piles. These piles did not stand sufficiently high from the bed of the sea, and the lower portion of the timber, exposed to sea-water, was destroyed by the worm. In 1853, nearly all of them were taken up and sold for old metal at the price of pig iron; and in the same year, a new iron pier, resting on cast iron piles, was erected by Messrs. J. B. and E. Birch. A number of the old piles, after having been immersed in the sea-water for upwards of twenty years, were last year to be seen on the pier at Margate. The writer has carefully examined them; they are as sound as when they left the foundry; in no instance can any softening of the metal be detected. A still stronger proof, however, is to be found in some of the cast iron piles of the old jetty, which are still *in situ* at the head of the present jetty. In these piles no deterioration whatever can be discovered. The shell-fish with which they are covered form a perfect protection against oxydation. These piles have stood in the sea during thirty years, and are perfectly uninjured.

If, then, numerous and undoubted examples of cast iron do exist which have withstood the action of sea-water, without any deterioration, for upwards of a quarter of a century, we must come to the conclusion, that where cast iron has been injured or decomposed in open sea water within a less period, the cause is to be found chiefly in the quality of the iron not being suitable for the work in which it is placed. The power, therefore, of various classes of cast iron to resist the action of sea-water, will vary according to quality.

The cast iron used by Mr. Murray in the dock gates of Sunderland may be cited in proof of the foregoing statement. After an immersion for some years, the rollers under the gates were found to have been acted upon by sea water, but other portions of cast-iron placed in the body of the gates remained uninjured. As the rollers had to be turned in the lathe, they were doubtless cast of soft material, but the other portions of cast iron, not requiring to be cut by tools, were of harder metal. The former gave way, but the latter remained perfect.

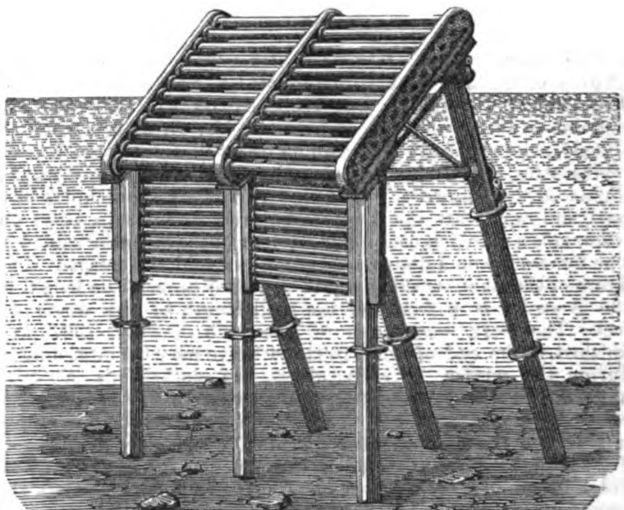
The words "cast-iron" admit of almost the same latitude of signification as the word "timber." Because we dare not use poplar on account of its liability to decay, it does not follow that no structures are to be erected of other qualities of wood.

At a meeting of the Institution of Civil Engineers (February 13, 1844), Mr. J. Simpson stated, that with good grey cast-iron, having a good surface, little injurious effect from the sea-water was to be dreaded. He also stated that he was then about to use cast iron extensively for piles, and that he had examined cast iron piles which had been in sea-water for sixteen years without any detrimental effect being produced.

It appears that the action of sea-water is powerful in the greatest degree when the iron is composed of large crystals, and especially when there is irregularity in the crystalisation. It may be said that the softer the iron the greater is the liability to decomposition.* Between the limits of extreme softness and decay on the one hand, and extreme hardness and durability, with brittleness, on the other, we have to make the selection. It has been stated† that chilled cast iron corrodes faster than green sand castings, that all castings intended for use in sea water should be cooled in the sand to insure uniformity in the crystals and that Welsh iron is the best. From a careful investigation of the subject the writer has arrived at the conclusion, that a strong description of cast-iron may be employed, capable of enduring the action of sea water for an indefinite length of time.

In cases where, from the use of an unsuitable quality of iron, or from contact with some other metal (such as lead or copper), softening of the iron has taken place, it will generally be found that the glazed skin produced by the sand of the mould in the process of casting, has been removed by tools, accident, or wear. An iron breakwater can be erected without any removal of this protecting glazed skin; no holes will be required to be bored, and no surfaces cut by tools.

As an instance of the detrimental effect of placing another metal in contact with cast-iron, it may be stated that the cast-iron plates affixed to ship's bottoms (according to the proposition of Sir H. Davy) for the protection of the copper sheathing, rapidly became softened."



PERSPECTIVE VIEW OF WEBB'S CAST-IRON BREAKWATER.

The above illustration exhibits a perspective view of the cast-iron breakwater for localities where the rise and fall of the tide is small. Two rows of piles only are required, and the girders may be cast in whole lengths. In the illustration the face-pipes are placed in one line, whilst in some cases they are arranged in a zigzag line, tending more effectually to break up the waves. A combination of fixed and winged face-pipes is sometimes employed. The face-pipes are fixed in the girders by means of creosoted wedges.

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* In Brande's Manual of Chemistry, (vol. i., p. 754, edition 1848,) the following remarks are made upon cast-iron:—"White cast-iron is very hard and when broken of a radiated texture. Acids act upon it but slowly, and exhibit a texture composed of a congeries of plates, aggregated in various positions. Grey or mottled cast-iron is softer and less brittle; it may be bored and turned in the lathe. When immersed in dilute hydrochloric acid it affords a large quantity of black insoluble matter, which Daniell considers as a triple compound of carbon, iron and silicium, and which has some very singular properties. The texture of the metal resembles bundles of minute needles."

In a paper inserted in the 'Edinburgh Philosophical Journal' (vol. vii., p. 201), Dr. McCulloch remarks that "the blackest pig-metal appears to yield the greatest quantity of black-lead, and in the most solid state."

The Mining Journal, of January 11th, 1862, under the head of "Artificial Plumbago," states that, "for some time past, Dr. Crace Calvert F.R.S., has been engaged in experimenting upon the composition of a carboniferous substance existing in grey cast-iron, or, to use a more popular definition, in producing plumbago from cast-iron. The effect of his experiments has been to arrive at results which throw much light upon the chemical composition of the substance, proving it to be composed of iron, carbon, nitrogen, and silicium."

† Minutes of Proceedings, Institution of Civil Engineers, vol. i., p. 72 (Session 1840.)

The object had in view in the particular form of breakwater recommended in the pamphlet before us will be seen to be partly to resist the wave, and partly to absorb it, or rather break it up by letting fragments drop through as it mounts up the slope. Against a solid breakwater the crest of the wave rises until its whole momentum is exhausted. This will of course not be the case with the present gridiron construction, and Mr. Webb argues, from Niagara and waterfalls generally, that at a few feet from the breakwater inside the harbour there would be no surface motion. We incline to think this conclusion one which can be satisfactorily established only by experiment, as the intercepted wave and the waterfall are not under exactly the same conditions. In the latter the fall of water is continuous instead of periodic, and the water, after plunging some depth below the surface, is carried off by a rapid current constantly in action.

Another point adduced in favour of this breakwater is its prevention of the deposit of silt by allowing tidal and other currents to pass freely through. There can be little doubt that this circumstance would materially lessen the external silting up that would otherwise take place. At the same time, it must be observed that the breakwater cannot fail to retard the upper part of such currents more or less, and how far this might cause any deposit within the harbour would be a proper subject for inquiry. In positions where rapid currents exist, the question of scour at the bottom of the structure might also arise.

Mr. Webb's pamphlet demands the careful attention of all who are interested in harbours or piers. The cost of his system of construction, as compared with stone, is exceedingly small. At the same time, it would be difficult to determine without actual trial how far it may be applicable under all circumstances and in all localities.

The Church of St. John, Islington.—The Roman Catholic Church of St. John, at Islington, which had been closed for decoration and repairs, was reopened on the 24th ult. It contains an important work in fresco by Mr. Armitage, who had already painted a large and genuine fresco in one of the chapels, representing St. Francis receiving the rules of his order from the Pope. Mr. Armitage's new fresco surrounds the semicircular apse, and represents the Twelve Apostles grouped in pairs on either side a seated figure of Our Saviour in the act of benediction. The figures are on a diaper background of gold and purple. The figure of Christ if standing would be 11 feet high. The height of the Apostles is 8 feet, and the total length of the fresco 52 feet. The work was begun on the 16th of July, 1861, and finished at the end of June 1862, with five months' intermission during the winter. Mr. Armitage has clothed his Apostles uniformly in a long white under garment, with a yellowish outer robe. The richness of colour which the draperies do not supply is got from the frescoed diaper against which they are ranged. They hold their attributes, or the instruments of their martyrdom. John and James (the greater) stand next to the Saviour's left, the former with the roll and pen of the Apocalypse, the other resting on the sword. Behind these stand Philip and James (the less), with the fuller's club with which he was beaten to death, and next to them Simon Zelotes, with eyes upturned and hands clasped in rapt devotion, and Thaddeus, with the arrows. Peter stands on the right hand of Christ, firmly grasping his keys. At his side stands Andrew, with his palm of martyrdom. Behind them Matthew grasps his volume of the Gospel and the pen of the Evangelist; while incredulous Thomas points allusively to his side. Bartholomew, an aged man, bearing the knife with which he was flayed alive; and Matthias, with earnest, reverent face and clasped hands, complete the twelve. As frescoes, the figures of the Apostles have singular merit. The painter is satisfied that his work will be durable, no lime having been allowed to enter into the colouring of the flesh, and the intonaco itself having been used for the white of the draperies. The general effect is noble and devotional, and the style of the figures unusually large, noble, and manly. Mr. Armitage has designed the decoration of the rest of the apse, filling its upper compartment with the winged emblem of the Evangelists, and ornamenting the mouldings with patterns borrowed from authorities of the 9th and 10th centuries. All who are interested in the question of the public employment of fresco in decorative painting should examine for themselves this important new example of the practice. Mr. Armitage's productions in St. John's deserve to rank in the first class of works of the kind in London.

ON A TIMBER GROWN IN WESTERN AUSTRALIA, WHICH IS PROOF AGAINST THE WHITE ANT AND SEA WORM.

We have been favoured by a correspondent with the following interesting notes respecting a timber found in Western Australia, which, after numerous and severe tests, has been ascertained to be by nature impervious to the attacks of the worm; and may be used in salt water with security. Specimens of the timber, with piles, &c. that have been actually in use in sea-water, and where exposed to white ant for many years, may be seen at the International Exhibition, in the West Australian court (No. 26). The timber in question is commonly called "mahogany" in Western Australia, and it very much resembles that wood in appearance. The native name is "jarrah," and the botanical name of the tree "Eucalyptus." It has properties which make it peculiarly applicable for works in the tropics, or on the sea-coast—viz., that neither the white ant nor the sea worm will touch it, and that it suffers very little from exposure to the sun or atmosphere. It can be delivered in India or the Mauritius in picked logs, or in baulk (provided a quantity of not less than 200 loads is purchased at one time), for less than 4*s.* a cubic foot; and if arrangements were made for a larger quantity—say of not less than 400 loads—it might be delivered for 3*s.* 6*d.* a foot, or less. The principal part of the timber trade of the colony of Western Australia is at the Vasse, from whence extensive shipments have been made to the eastern colonies of Australia, Ceylon, and some of the Indian railways. A quantity has also been supplied for Government works in the Mauritius.

The timber grown on the hills, or at the foot of them, is very superior to that grown near the coast—at least, in those parts of the latter where the soil is sandy—many of the trees from the latter locality being shaky at the centre, and generally less compact. To give some idea of the price of the timber in the colony, it may be stated that the average consumption at Freemantle for Government purposes was about 500 loads per annum; and that, in 1856, a contract was entered into for the supply of a quantity of timber at Freemantle for 57*s.* 6*d.* per load. A small advance was afterwards made on this price, but since that time the trade has been extended sufficiently to allow of the employment of machinery, and the construction of trams for the conveyance of the timber to the port of shipment, so that the prices are much reduced. In cutting up the sand-grown timber, a waste of about 18 per cent. occurred. The loss in cutting up the logs from near the hills was not nearly so large as 18 per cent., as the cores of these logs were in general sound.

The chief expense incurred in obtaining this timber is the cost of transport to the place where it is to be used, and therefore the logs should be prepared so that as little waste as possible may arise when they come to be cut up for use. They should either be cut into baulks, which would be the most convenient form for shipment, and afford the greatest security against unsound timber passing survey, or they should be sawn square in the forest. It is probable that there would not be much difference in the price, because a contractor would get more out of a log by cutting it into baulk than by sawing it square, and the extra timber obtained would pay for the extra labour in sawing. If the timber were brought in a quantity exceeding 400 loads, it would be worth while for the captains of the convict ships, about three of which per annum leave Western Australia for Ceylon or India, seeking cargo, to take it in as cargo for India, &c., and it is believed that in this case freight could be obtained for little over £1 per ton. The charge for freight would probably not exceed 24*s.* per ton, or 36*s.* a load, which would be about 8¾*d.* per foot—say 9*d.* The engineer of the Columbo and Kandy Railroad, in Ceylon, said, in 1858, that he could afford to give £7 a load for timber fitted for piles, stringers, or sleepers; and since that time a considerable order has been given to parties in the colony, on account of this timber, so it is fair to presume that the price at Ceylon did not much exceed £7. The cost of these sleepers at Madras has been 10*s.* each, which is about the same as that of the Indian woods of the best class. It has been supplied to Adelaide, South Australia, and Melbourne, Victoria, in scantlings fit for railway purposes, for less than the price above estimated.

Captain Wray, Royal Engineers, says "as regards its properties, I have used upwards of 3000 loads of it in buildings, jetties, and bridges, and I have examined timbers which have been exposed to the action of the white ant and sea-worm, in situations where t would have been destroyed if liable to destruction from either of these causes, and I never saw any penetration deeper than the sap wood, though deal or other timber close by was completely eaten away. This indemnity from destruction is generally attributed to its containing large quantities of gum resin. The strength and elasticity is about equal to Riga fir. This was ascertained by a series of experiments on beams, with a bearing of twelve feet, conducted by Mr. Manning, Clerk of Works at Fremantle. The weight of the timber makes it inapplicable to movable joiners' work, such as doors or sashes; but this is immaterial, as the white ant, only working in the dark, will not attack these, unless a building is left unoccupied for a lengthened period. I know of no objection to it, except that it is somewhat slow to season, and if exposed before seasoned will fly, and cast perhaps rather more than other timbers. The plan lately adopted in Western Australia to season it was to leave the logs in the sea for a few weeks, and then draw them up on the beach, and cover them with a few inches of seaweed, taking care to prevent the sun getting at their ends. My experience led me to the conclusion that logs might lie in this way without injury for almost any length of time. Boards were cut 7 inches wide, and stacked so as to admit of a free circulation of air for five or six months before using."

The Consulting Engineer of the Madras Railway says, "the wood is well spoken of by our engineers." The trial has not as yet been long enough to enable the qualities of the wood to be thoroughly tested on the Madras railway, but the engineer says, in January, "that those placed on the road in July are in good condition at this date, and form an efficient substitute for teak in girder bridges." Some specimens from Western Australia now in the International Exhibition, will supplement these remarks in respect of proof of durability, both under sea water and in situations where it is liable to attack by the white ant, as there are exhibited logs that have been in use as piles, &c. &c., for periods of from twenty to thirty years, without receiving the slightest injury.

INSTITUTION OF CIVIL ENGINEERS.

The Council of the Institution of Civil Engineers have awarded the following premiums for papers read during the Session 1861-62:—

1. A Telford Medal, the Manby Premium in books, and a Stephenson Prize of 25 guineas, to Charles Augustus Hartley, M. Inst. C.E., for his "Description of the Delta, and of the works recently executed at the Sulina Mouth of the Danube."
2. A Telford Medal, and a Miller Prize of 15 guineas, to John Henry Muller (of the Hague), for his paper "On Reclaiming Land from Seas and Estuaries."
3. A Telford Medal, and a Miller Prize of 15 guineas, to John Paton, M. Inst. C.E., for his paper "On the Sea Dykes of Schleswig and Holstein, and on Reclaiming Land from the Sea."
4. A Telford Medal to James Abernethy, M.Inst.C.E., for his "Description and Illustrations of the works at the Ports of Swansea, Silloth, and Blyth."
5. A Telford Medal, to John Bailey Denton, M. Inst. C.E., for his paper "On the Discharge from Underdrainage, and its effect on the Arterial Channels and Outfalls of the Country."
6. A Watt Medal, to Joseph D'Aguilar Samuda, M. Inst. C.E., for his paper "On the Form and Materials for Iron-Plated Ships, and the Points requiring attention in their Construction."
7. A Council Premium of books, to James Brunlees, M.Inst.C.E., for his paper on "Railway Accidents—their causes and means of prevention."
8. A Council Premium of books, to Captain Douglas Galton, R.E., F.R.S., Assoc. Inst. C.E., for his paper on "Railway Accidents, showing the bearing which existing legislation has upon them."
9. A Council Premium of books, to Henry Charles Forde, M. Inst. C.E., for his paper on "The Malta and Alexandria Submarine Cable."
10. A Council Premium of books, to Charles William Siemens, F.R.S., M. Inst. C.E., for his paper "On the Electrical Tests employed during the construction of Malta and Alexandria Telegraph, and on insulating and protecting Submarine Cables."
11. A Council Premium of books, to James Atkinson Longridge, M. Inst. C.E., for his paper on "The Hooghly and the Mutla."
12. A Council Premium of books, to James Oldham, M. Inst. C.E., for his paper "On Reclaiming Land from Seas and Estuaries."

ST. JOHN'S ALTAR, CHURCH OF ST. FRANCIS ASSISSI, NOTTING HILL.

(With an Engraving.)

St. John's Altar, in the chapel of the Seven Dolors of Our Lady, connected with the church of Saint Francis of Assissi, Portland-road, Notting-hill, stands between two angle columns, and occupies one of the cants occasioned by the chapel bending partly round the apse, a necessity in consequence of the irregularity of the site. The frontal of the altar is of alabaster, panelled by cusped arches, and with pediments over, incise and marble and glass mosaics filling in the spandrils; also incises of black cement decorate the sills, bases, and triangular pieces over caps. The first super-altar has a row of incised pateræ with marble centres running the whole length, and returning round the sides; the second is crenelated, the spaces between each crenelation being filled in with an incised decoration, with projecting spars in the centre of each flower. A molded cusped frame of alabaster filled with a picture forms the reredos. This picture is the principal subject, it represents St. John giving Holy Communion to the Blessed Virgin. The diaper on the gold back-ground is an arrangement of eagles with intermediate stars. On the right of the Blessed Virgin is the crowned lily, and on the left of Saint John the palm. The nimbi are also symbolically decorated. The two pictures on gold background in the frontal represent Saint John and his type, Daniel; in the former the eagle and palm are introduced, in the latter the lions. These paintings were executed by the well-known artist Mr. Westlake, and have been treated as purely decorative, consequently kept flat in colour, and are outlined with a strong black line. The altar, with its carving and mosaics, was executed by Mr. Earp, from the design and sketches of Mr. Bentley, architect, of Southampton-street. Strand, London.

THE PRESERVATION OF STONE.

In a former article on the Preservation of Stone we undertook to report from time to time any invention or process that might be introduced to effect this most desirable object, if based upon really scientific premises. We need hardly say how impossible it will be to come to any infallible conclusion as regards this matter, without the aid of time; yet we are fully capable of judging how far that test of time is worthy of being applied.

It will be fresh in the memory of most of our readers that in our second article on this subject, on analysing the then existing methods, we asserted the fact as unquestionably proved, that no existing process for the preservation of stone was worthy of adoption. The discussion at the Royal Institute of British Architects, though not so plainly ignoring all systems that had been submitted to practical tests, went to show that the Institute was unwilling to indorse any system as worthy even of further trial, and was evidently glad to get rid of a responsibility that had been almost imperceptibly placed upon it. The importance of a preserving medium for our public buildings need not be urged, when it is known that so experienced a body as the Institute handed over the subject to a committee appointed by Government to investigate the whole matter, and discover whether a curative did really exist or not. That the investigation, carried forward in the most patient and painstaking manner, resulted in the negative, will be recollected in a recapitulation of their decision as recorded by the leading journal of the day: "That the only point placed beyond question is the non-existence of a remedy for the evil admitted."

In the final clause in the report of the committee, they thus counsel our First Commissioner:—"In conclusion, the committee venture to recommend that the architect of the Palace at Westminster, assisted by scientific chemists, should examine and record the actual state of the stonework of the building at the present moment; that experiments should be made by their direction, under various conditions of height, exposure, and aspect, with such preservative agents and materials as the chemists may suggest from time to time; and that researches should be continued into the effects of the various alkaline silicates, phosphates, and other substances which have been brought under the notice of the committee, or suggested in Germany, France, or elsewhere. That where decay arises from damp, means should be taken to protect the stone, as has been before suggested. That any stone extensively decayed should be removed and replaced; but that in particular the earliest symptoms of decay should be carefully watched and examined, with the view to the application of some immediate remedy. The committee believe that a very large portion of the stone in the Palace of Westminster is of a very durable nature; and they entertain a confident expectation that a remedy will soon be found to arrest or control the decay when it has unfortunately begun to appear."

What, then, has been done towards adopting this wise counsel? We are compelled to affirm, little or nothing. Certainly, an excuse may be urged that important subjects have occupied the attention of our First Commissioner, and that the all-engrossing International Exhibition has allowed many important matters to slip into the shade; but now that the height of all this excitement has passed, and before we lose the season for such operations—which will be virtually to lose the whole year—we would call the attention of our First Commissioner to the subject; as also the attention of those gentlemen whose past labours render them fully conversant with the subject, and able to judge of the fitness of recently discovered remedial measures. The desire to redeem our pledge in aiding, so far as we may be able, the researches of these gentlemen, and the development of any process based on true principles—such indeed as have been so carefully laid down by them—has led to the insertion of this our third article on this subject.

The first patent specified according to date (since the issue of the late Government Report), is that of James Cane Coombe and James Wright, and consists in the use of fluo-silicic acid; if however the stone to be operated upon contain no lime, magnesia, or other alkaline earth, this is previously incorporated with the stone by manipulation, and on the addition by brushing or otherwise of the fluo-silicic acid, the fluo-silicate of lime or magnesia is formed by the chemical action set up between the substances; indeed an effervescence takes place, the carbonic acid is displaced, and the more potent agent supposed to be left in its stead. A few words only will suffice to show the weak points of this process. In order to its effectual operation the acid must first disintegrate the surface of the stone; the theory is, that after this breaking up of the old combination, a re-combination of materials is immediately formed. We cannot really admit that practice at all favours this theory. A slow interchange of element might result in a harder and more enduring combination, but that such a disruption as that caused by the acid (the proof of which lies in the effervescence that takes place) can possibly lead to as rapid a concretion, is not borne out by theory, or the practical tests which we have applied ourselves or seen applied. Again, quoting the words of the specification, "whatever superfluous matter remains may be removed by brushing," thus indicating the cause from which the increased porosity of stone so treated arises; and in confirmation of this we quote a question put by Prof. Frankland to one of the scientific men examined before the parliamentary committee on an analogous process, the use of a silico fluoride of aluminium,—"Do you think that this evolution of carbonic acid would not tend to render the stone more porous; that is to say, would not this evolution of carbonic acid tend to keep open the pores of the stone?" "Yes; in a measure I think it would." If all inventors and discoverers were thus alike candid in the explanation of the demerits as well as the merits of their favourite theory, the labour of critical investigation would then be spared.

The next specification in order of date is that of Mr. Joseph Briggs, and will call for little comment from us, the most extraordinary part of the specification being that it should be described as a coating for stone with anything like a claim to novelty of application, which exists in as large a degree, we think, as does utility in the process. Pitch is liquefied in a cauldron, and to this is added lime, and lastly sand or clean grit. The stone to be operated upon requires to be heated, and in lieu of pitch—tar, asphalte, dead oil, or any other similar material may be used. With this, the patentee's own description, we leave the process in the hands of our readers without further comment.

Mr. Jesse Rust claims in his specification the adoption and use of fluoride of silica with baryta or magnesia, also in solution. This patent received provisional protection only, relinquished, as we suppose, because identical with two existing patents, and therefore untenable except by litigation. We have already stated that other patents will embody the whole details of this.

The next specification is that of F. M. Ransome and E. L. Ransome, which runs the gauntlet of the ambiguity of the patent law. The patent is one for the coating and preservation of stone, and also for securing to the patentee a novel configuration of filter-bed. With the latter we have now nothing to do, and would dismiss it with the remark that numberless patents are invalidated when proved to be of commercial value by the want of due care or prudence in introducing subject matter of two different kinds. We return, however, to the treatment of stone. The process in this case is one that appears to us devoid of merit. "The object being so to apply soluble silicate that it may for the most part be retained in combination with the pulverised substances on the surface of the stone, &c. to which it may be applied, and this is effected by the mixture of pulverised substances with it." The soluble silicate is then to be rendered insoluble by the chloride of calcium, and the surface of the stone is found, so says the patentee, to be better preserved by the addition of this inert pulverised matter than when the silicate of soda and calcium alone are used, according to the former process of the same patentee, and which formed one of the number ignored by the parliamentary committee.

Again we find ourselves with Messrs. Coombe and Wright, who seem to have discovered in their researches the value of that extraordinary material, silicate of potash. The whole pith of their second patent lies in a few words, as given by themselves in the preamble: "We propose also, in all cases where the stone does not contain sufficient potash, to apply a solution of the same or its salts previous to, or even after, using the fluo-silicic acid." Hence in the specification they propose to use silicate of potash with their former agent fluo-silicic acid. This specification certainly leads to the same conclusion as the first, that acid, be it strong or weak, is certainly a most unadvisable element to introduce into the stone; and we cannot but award due acknowledgment to the tact that leads them to describe the destructive effect of the acid upon the stone as a means of *cleansing the surface* of the stone. The addition of the silicate of potash may add to the value of the patent, but we much question whether it does not considerably detract from its validity.

We have now to consider two patents entered at the office on the same date, and, strange to say, the patentees employ the very same materials; the result of the treatment of these materials however being as wide apart in utility as the coincidence was strange that led both patentees to patent the use of the same bases on the same day. Mr. W. S. Leek thus describes his claims: "My invention consists in using a combination of silica and alumina, held together either mechanically or chemically; and in order to obtain a fluid matter suitable for application to stone, &c., I use *gelatine* with the aforesaid substances." Need we add more? We think that hearing the word gelatine pronounced after silica and alumina is sufficient for most of our readers without further comment.

The competing patentee of this date is Mr. F. S. Barff; and as we cannot now afford space to enter into details of this process, to do it the justice it demands we must notice it in our next number, merely stating here that it has received honourable mention from the jury, in Class 2, section A, of the International Exhibition, and quoting a paragraph from our contemporary, 'The Chemical News,' on the subject, adding that we quite coincide with the opinions expressed therein; and would recommend, to those interested in this subject, a consideration of the process, which we shall lay before our readers in our next.

"In 471, Messrs. Bartlett & Co. exhibit soluble silicates, artificial stones, and preparations illustrating their stone preserving process. The last is sufficiently interesting and novel to demand particular notice. All our readers know that, under ordinary circumstances, a solution of alumina and potash and a solution of silicate of potash when mixed together would give an immediate precipitate. Mr. Barff, however, has made the curious discovery that there are degrees in strength and of alkalinity at which the mixed solutions give no immediate precipitate, but in time dry up to a solid, opaque, glassy mass, which is capable of resisting the action of hot and cold water, and also of hydrochloric and sulphuric acids. There seems to be formed, in fact, a sort of artificial felspar, in which all the solid ingredients of the solutions unite. The method of applying such a solution to a building is simple enough; it has only to be paid on like paint or an ordinary wash, and, heavy rain not interfering, it soon dries up, and coats the building with a solid, glassy covering, capable, no doubt, of resisting atmospheric influences for any number of years."

The last patent to pass under review is that of Jean B. Hulard and Louis G. Poupel, of which we cannot give our readers a better description than in the words of the specification, which run thus:—"This invention relates to an improved process for hardening stones and plaster of Paris, and making them impervious to wet. The same consists in providing the said materials with one or more successive coatings of a liquid composition, formed of the following ingredients:—

	Avoirdupois lb.	oz.	dwt.
"Slag from blast furnaces	0	7	1
Borax	0	1	2
White lead	0	1	12
Sulphate of alumina	0	1	12
Acetate of lead	0	0	14
Sulphate of zinc	0	0	14
Silicate of soda or potash	4	6	9
Kaolin	0	7	1
Linseed oil	1	1	10¼
Water	2	3	4½"

Of this category we can only say that it savours of the one so humorously described by Mr. Tite, when the subject was under discussion at the Institute of British Architects; and, confessing that we have not tried the conglomeration, we think it little more promising than the sanguinary composition just alluded to of bullocks' blood and brickdust flavoured with a little of the essence of milk. We had hoped such propositions for the purpose in view had an end.

LAYING OUT RAILWAY CURVES.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—In one of the late numbers of the Civil Engineer and Architects Journal I observed that you gave Mr. Rankine the credit of being the first to publish the method of laying out the curves of railways by the angles at the circumference. I have been under the impression that I was the first to put this method into a practical form; and as evidence that I was early in the field, I beg to send per book post a copy of a pamphlet which I published on the subject in the year 1847. I first began to lay out curves on that system in the year 1840; and found it very advantageous when laying out the line of the Great Western Railway through the Chalford valley, along steep sidelong ground, in the year 1843. I am, &c.

Carmarthen, July 1862. ROBT. BRODIE, M.I.C.E.

[We have long been acquainted with the pamphlet referred to by our correspondent, and had a high opinion of its great practical value. In our last volume (p. 275, col. 1), we had occasion to make favourable reference to it.

Mr. Brodie's letter confirms our previous idea that the conception of ranging by the angles at the circumference is original so far as he is concerned, the method having been practised by him in 1840, whereas Prof. Rankine's paper on the subject was not read until the year 1843. The fact appears to be that this elegant and expeditious mode of setting out curves has been arrived at independently by more than one engineer, and practised by those who discovered it for a considerable time before it was written or read about. Prof. Rankine, in his 'Manual of Civil Engineering,' does not claim the credit of invention, but states that he first read a paper on the subject in 1843. We believe Mr. Brodie's pamphlet to have done very much in making the method generally and practically known, and there are many to whom this system of ranging will always be associated with his name.—ED.]

THE ROYAL ACADEMY EXHIBITION.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—In a recent article in your Journal upon the Royal Academy Exhibition, your reviewer has called attention to an alleged resemblance between the spire of Christ Church, Pentonville (about to be erected under my superintendence) and an admirable modern work which is named. In fairness to myself, will you have the goodness to afford me an opportunity of denying this. I cannot trace a resemblance, either in plan or elevation; and in designing it I had no wish or intention to copy the works of others.—I am, &c.

EDGAR P. BROCK.

37, Bedford-place, W.C., July 15, 1862.

The Eastern Belgian Society.—This society is to hold its meeting in the second fortnight of 1863. Domestic animals, produce, and machines of all sorts are to be exhibited, and the display will be similar to that held at Luxemburg in the Boulevard d'Avroi in 1852. £1600 have been raised as contribution in the way of subsidy by the state, the province of Liege, and the chief town of the latter. Useful is the late order issued by the Belgian minister of commerce; and, though they justly claim to be ranked next to us in practical work, we can take a leaf out of their book. The state telegraphic wires and attending staff are put at the gratuitous disposal of the public in case of alarm by fire. The railways are bound by law to give free pass to firemen and all *materiel* necessary for the extinction of conflagrations; in cases of extreme emergency express trains are to be furnished when demanded.

New Lunatic Asylum for the City of London.—On the 29th ult. the foundation stone of a pauper lunatic asylum for the City of London was laid at Stone, near Dartford. It is to accommodate 250 patients, and the estimated cost is £50,000. The site consists of upwards of 30 acres in a commanding and healthy locality between Dartford and Greenhithe, and was purchased for £3300. The building will be erected from designs by Mr. Bunning, the City architect. All the preparatory arrangements have been made under the direction of a special committee appointed by the court of Common Council.

Chemin de Fer du Centre.—According to the "Independance Belge," the returns of the Chemin-de-fer du Centre, are, May 1861, f. 38,668·03; May 1862, f. 37,639·63, which figures prove that the present stagnation of railway traffic is not partial, in Europe at least.

The Memorial to the Prince Consort.—The Committee of the Prince Consort Memorial have just laid before the public an outline of their new scheme, since the idea of a monolith obelisk was abandoned. They have, with the aid of several architects, prepared a report, which, however, cannot be considered final, since it leaves much undetermined, but it defines the character of the proposed monument, points out a site, and recommends a limited and private competition in the selection of the design. The West corner of the strip between Rotten Row and the Kensington Road is the site proposed. It is about half way between the site of the Exhibition of 1851 and that of 1862. The proximity of this spot to the unoccupied frontage of the Commissioners' Estate north of the Horticultural Gardens, suggested the notion of combining the features of a group of statuary and an ornamental building, to be divided by the road, and in the same general effect. The result is a proposal to erect about opposite to the Coalbrookdale Gates "an architectural base for groups of sculpture," surmounted by a conspicuous statue of Prince Albert, and upon the other side of the Kensington-road, parallel to the conservatory of the Horticultural Society's Gardens, a large hall for meetings connected with science and art. The arguments in favour of this arrangement are thus summed up by the Committee:—"By being placed in the park the monument has a national character, while its position in relation to the estate sufficiently indicates the connexion which we had regarded as an essential part of our general plan. Had the monument been placed on the south side of the Kensington-road, it would have been so near the hall as to be overpowed by it, while by being within the estate it would have lost something of its public importance." . . . "The hall, besides its special use, would, with its corresponding lateral approaches to the Horticultural Garden, constitute the principal front to the whole estate. It would also, on many accounts, be an essential accompaniment to the opposite monument, by completing the connexion between it and the institutions which now exist, or may hereafter be established near it." The nine architects invited to submit designs for the double memorial have been reminded that the amount of the available fund is an "important condition." The designs and estimates are to be sent in by the 1st of December next. Mr. Tite and Mr. Smirke have declined the invitation to compete.

The new Palais de Justice, Brussels.—This edifice is to occupy about 2½ hectares, or 25,000 square metres. If, on account of the height of the building, the exceptional class of material and the architectural ornamentation be adopted, the cost is estimated at 500 francs a square metre, or 200 francs more than a private house. If the actual space occupied by the useful portion of the building, deducting court-yards and spaces not capable of ornament, the above price will be double.

The Drainage of the Fens.—A movement has been made by several of the principal landed proprietors interested in lands in the upper districts drained by the Witham for an improvement in the outfall. The scheme embraces a thorough deepening of the River Witham from Bardney to Boston, and a new channel at the mouth of the haven. After a long Parliamentary litigation the Middle Level Drainage and Navigation Bill has passed the committees of both Houses to whom it was referred. The objects of the Bill were—first, to separate the Middle Level from the Bedford Level Corporation, and to take the funds of the corporation arising in the Middle Level and to apply them to Middle Level works only; secondly, to abolish the Nene Navigation Commission; thirdly, to repeal the Barrier Banks Act; fourthly, to amend the Middle Level Acts in matters of administration and detail; and fifthly, to amend the district Acts in the Middle Level so as to generalise their provisions and extend the powers of district commisioners to the making of roads and facilitating their dedication as public highways. The decision come to by Parliament will in effect make the Middle Level Commissioners sole masters of their own affairs in future.

The Madeleine, Paris.—"The Madeleine, although one of the modern churches of Paris," says the *Siècle*, "is now undergoing extensive repairs. The flight of steps at the northern front has suffered so much from the infiltration of the rain water that it is found necessary to reconstruct it. The same operation was performed at the southern front some years ago. Repairs of a still more serious character have also been found indispensable. Owing to the settling of the foundations, a crack has recently made its appearance in the principal front, extending from the lintel of the grand portal quite to the top of the inner pediment. As frequently happens with large buildings, the construction of this church was repeatedly interrupted, and its plans considerably modified. No less than 78 years elapsed between the commencement of the edifice and its completion."

CLASSIFIED LIST OF PATENTS SEALED IN JULY, 1862.

3275 Brooman, R. A.—Manufacture of charcoal—(com.)—December 31, 1861
785 Todd, B.—Manufacture of antimony—March 17
338 Mennons, M. A. F.—Treatment of coprolites—(com.)—February 10
1352 Johnson, J. H.—Manufacture of soda and potash and their carbonates—May 6

114 Timmins, T.—Utilisation of produces resulting from manufacture of gas—Jan. 15
139 Roberts, T., Dale, J.—Manufacture of gunpowder—January 18

243 Phillips, G. & G.—Distillation and rectification of alcohols or spirits—January 30
1028 Mertens, G. D.—Brewing—(com.)—April 10

13 Patrick, W. B.—Manufacture of sugar—January 1
62 Wilson, D.—Preparing coffee—January 9

28 Arundell, J. W.—Treating and dressing ores—(com.)—January 4

168 Martin, A. J.—Treatment of fusil oil—January 21

123 Myers, T.—Composition for preventing oxidation of metallic surfaces—Jan. 17
147 Nicholson, E. C.—Dyeing colours, &c.—January 20
1350 Johnson, J. H.—Manufacture of red lead (com)—May 6

14 Davis, E. F.—Gas burners—January 1
37 Warner, A.—Manufacture of gas—January 4
67 Brooman, R. A.—Manufacture of gas and gas burners—(com.)—January 19
650 Kromschweder, H. H.—Gas meters—March 10
297 Webster, J.—Gasfittings—February 4

270 Fauvel, L.—Method of testing tubing for leakages—February 1

159 Brooman, R. A.—Road sweeping machines—(com.)—January 21

34 Howden, J.—Steam engines and boilers—January 4
1164 Amos, J. C.—Steam pumps—April 21
1199 Allen, J. F.—Valve gear—April 24
1340 Johnson, J. H.—Steam generators—(com.)—May 5
85 Scott, T.—Steam engines—January 11
92 Parker, J.—Steam engines, boilers, &c.—January 13
127 Rowan, J. M.—Steam hammers—January 17
283 Joy, D.—Steam hammers—February 3
167 Beir, A. J.—Steam valves—January 22
178 Ripley, A.—Piston—January 23
119 Monckton, E. H. C.—Obtaining motive power—January 16
153 Binks, C.—Generating steam—January 21
438 Nasmyth, J.—Rotary engines—February 19
246 Rippingalle, E. A.—Steam engines—January 30
83 White, J.—Lubricators—January 11
316 Henry, M.—Motive power—(com.)—February 6

44 Shaw, F.—Railway brakes—January 7
712 Clark, W.—Railway brakes—(com.)—March 15
73 Wigzell, M.—Carriage ventilator—January 10
135 Stevens, J. J.—Railway point indicator—January 18
143 Jobling, T. W.—Use of locomotives in mines—January 20
498 Newton, W. E.—Joints or chairs of permanent way (com)—February 24

59 Siemens, C. W.—Telegraphs—January 19
239 Harby, J. B.—Method of preserving electric cables and wires—January 29

58 Cook, H.—Electrical despatch tubes—(com.)—January 8

57 Bradshaw, W.—Watches—January 8

5 Walker, J.—Construction of forts, &c.—January 1

89 Gilbert, T.—Swivels for guns—January 13
22 Jeffries, G.—Breech loading firearm—January 2
1592 Palmer, W.—Revolving firearms—May 27
149 Doremers, R. O.—Cartridges—January 20

289 Newton, W. E.—Printing machines—(com.)—January 29
165 Gerish, F. W.—Printing machines—January 22

494 Partridge, T.—Printing railway tickets—February 24

157 Rawlins, J. H.—Manufacture of paper—(com.)—January 21
235 Clark, W.—Manufacture of paper—(com.)—January 29

75 Oales, J.—Washing machines—January 10
1118 Ford, W. J.—Sewing machines—(com.)—April 16
278 Cook, T.—Machinery for folding envelopes—February 1

56 Bessemer, H.—Manufacture of malleable iron and steel—January 8
1012 Davies, W.—Puddling furnaces—April 9
146 Bird, J.—Crank axle—January 20

250 Clark, W.—Wrenches—(cum.)—January 30
759 Warner, F.—Cocks or taps—March 18
91 Soar, T.—Knockers—January 13
106 Bousfield, G. T.—Nails and spikes (com.)—January 21
130 Tow, W.—Stoves and fireplaces—January 18
65 Wilson, D.—Hydraulic presses—January 9
203 Sameson, A.—Hydraulic presses—January 25
164 Roberts, I.—Hydraulic motive engines—January 22
318 Bellhouse, E. T.—Hydrostatic presses—February 6

185 Longhurst, J.—Chains and cables—January 24
291 Roullier, C. M.—Manufacture of straps, bands, and chains—February 4

276 Cook, T.—Punching machine—February 1

3276 Edward, A., Edward J.—Spinning machines—December 31
45 Higgins, J.—Spinning machines—January 7
46 Tatham, J.—Spinning machines—January 7
1187 Newton, A. V.—Looms—(com.)—April 23
137 Dreyfous, S.—Spinning machine—(com.)—January 18
287 Newton, W. E.—Spinning machine—(com.)—February 8
304 Ashworth, H.—Spinning machine—February 5
300 Taybor, W. E.—Carding engines—February 5
425 Combe, J.—Machinery for winding cops, and in the treatment of cops for warps and other purposes—February 17
470 Ashton, W.—Machinery employed in the manufacture of braids and similar articles—February 22
229 Brierly, J. H.—Clasp or fastener for reversible belts, &c.—January 29

239 Walton, W. & F.—Wire cards—January 31
131 Emmott, T.—Manufacture of velvets—January 18
175 Owen, H.—Manufacture of stockings—January 23
386 Lawton, J. F. & J.—Manufacture of flannel—February 18
20 Fell, W. A.—Manufacture of bobbins—January 2
279 Clark, W.—Manufacture of festooned edging—(com.)—February 1
308 Payne, J. B.—Treatment or preparation of hemp, flax, and other analogous fibrous substances for spinning—February 5
1008 Lawson, J.—Balling cotton and thread—(com.)—April 8

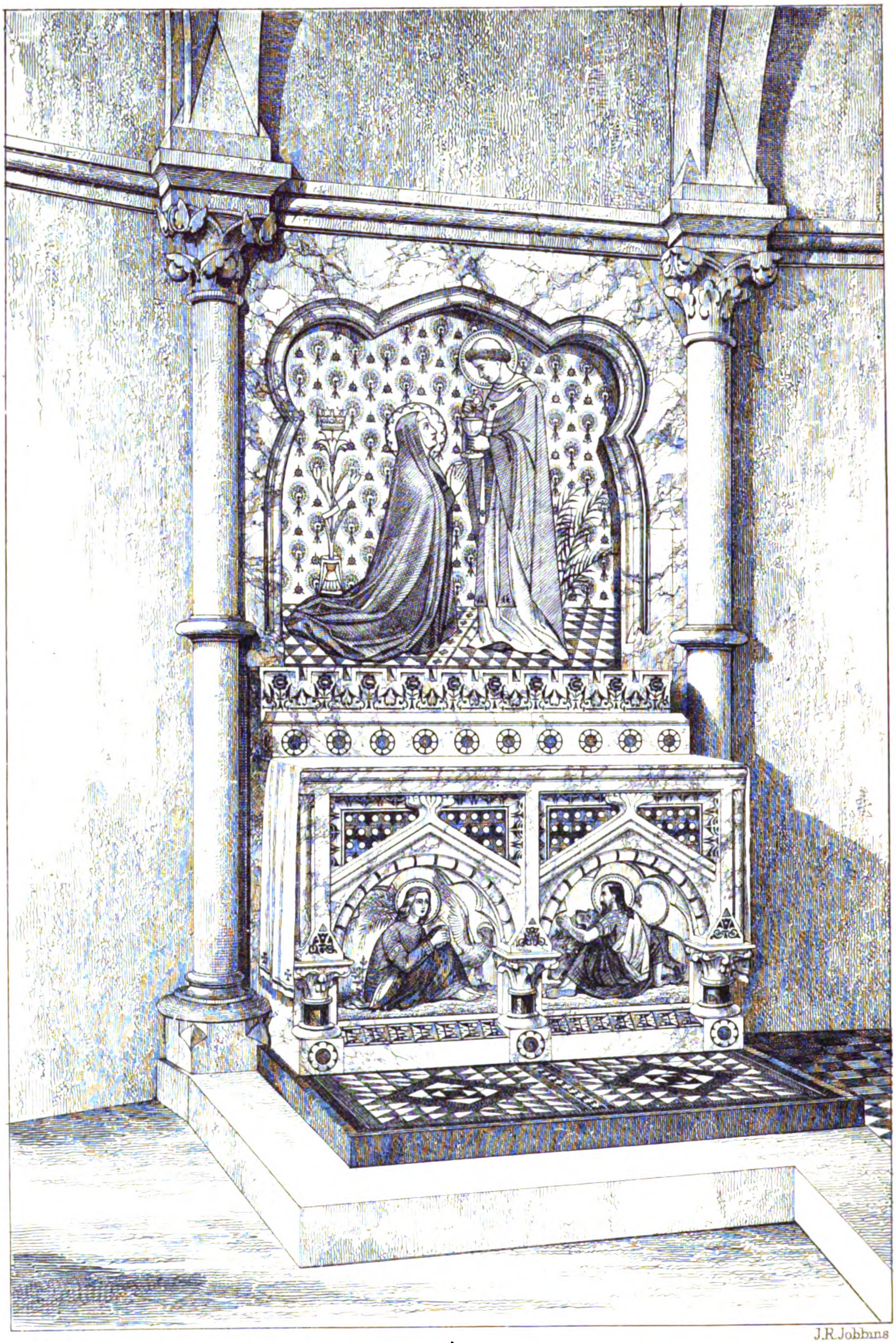
27 Gedge, W. E.—Cleaning grain—(com.)—January 3
71 Carter, J.—Draining plough—January 10
736 Barford, W.—Rollers—March 17
172 Wallace, J.—Reaping machines—January 23
160 Burgess, W.—Mowing machines—January 21
928 Newton, A. V.—Horse bits—(com.)—April 2
174 Ropes, W. H.—Machine for coffee cleaning—(com.)—January 28
209 Orr, W.—Machinery for the manufacture of sugar—January 27

72 Johnson, R.—Coating for ships—January 10
205 Lilie—Coating for ships—January 27
967 Newton, W. E.—Ships' pumps—(com.)—April 4
1190 Heinke, C. E.—Apparatus for extinguishing fire—April 23
856 Gedge, W. E.—Apparatus for extinguishing fire (com.)—March 27
898 Woodberry, J. P.—Arming war vessels—December 31
627 Newton, W. E.—Armour plates—(com.)—March 13
282 Hill, L.—Applying armour plating to war-ships—February 8
146 Lamb, A.—Life boats—January 20
400 Johnson, J. H.—Machinery for propelling ships and boats (com)—February 14
1185 Johnson, J. H.—Apparatus for taking deep sea soundings, and for recording the speed of ships (com.)—April 23

3264 McHaffie, N.—Ventilators—December 31
6 Clark, T. C.—Heating apparatus—January 1
1439 Blake, G.—Heating apparatus—May 13
11 Rhodes, B.—Manufacture of pipes—January 1
689 Hughes, E. T.—Furnaces for consuming smoke—(com.)—March 13
25 Stracey, G.—Manufacture of artificial fuel—January 3
90 Warlich, F. C.—Manufacture of artificial fuel—January 13
2 Szerelmey, N. C.—Manufacture of leather cloth—January 1
141 Barbat, L.—Manufacture of hats—January 20
644 McLeod.—Hats—March 10
500 Wordrow, I.—Manufacture of hats—February 25
870 Lublinski, R.—Manufacture of umbrellas—March 28
1343 Cobourg, T.—Manufacture of boots and shoes—May 6
166 Pace, E.—Venetian blinds—January 22
1288 Newton, A. V.—Manufacture of hollow glass ware (com)—April 26
290 Manwaring, G.—Flushing apparatus for closets, sewers, and other water service—February 4
449 Lee, G. F.—Tourniquets—com.—February 20
94 Brooman, R. A.—Vessels and cases—(com.)—January 13
1015 Mather, C.—Spittoons—April 9
8 Brooman, R. A.—Manufacture of lace scissors—(com.)—January 1
184 Clark, W.—Manufacture of artificial flowers—(com.)—January 24
40 Betjemann, G. & G. W., & J.—Dressing cases—January 6
51 Heath, A.—Ink stands—January 8
195 Mougin, J. C. F.—Bassinet—January 25
1422 Johnson, J. H.—Apparatus for cutting turf—May 8
1505 Briddell, E. J.—Artificial marble—May 17
125 Cleland, W.—Bath—January 15
43 Brown, F.—Kitchen ranges—January 6
60 Smith, J., & Wellstoods—Kitchen range—January 9
48 Wallis, A., Haslam, C.—Rotary screens—January 7
155 Barlow, H. B.—Speed indicators (com)—January 21

220 Church, A. H.—Preserving stone—January 28
228 Rodmer, R.—Artificial stone—January 28
720 Scott, H. D.—Cement—March 15

Pl. 18



J.R.Jobbins

ST JOHN'S ALTAR,
IN THE CHURCH OF ST FRANCIS ASSISI,
PORTLAND ROAD NOTTING HILL.
J. F. BENTLEY, ARCHT

THE ALBERT MEMORIAL.

The nature of the proposed monument to the late Prince Consort is a subject of great interest, not merely on account of the monument itself, but also on account of the general principles of art involved in the discussion relating to it. The existing monuments erected in public sites in London are so generally unsatisfactory, that the consideration of the design of the new monument is calculated to stimulate investigation of the causes of past failures. Unhappily for the state of art in England, we have been too long accustomed to view art as a thing not susceptible of logical investigation: the trite saying, *de gustibus non est disputandum*, has been adopted as an excuse for avoiding analysis of the intrinsic principles of taste, and with respect to it we have submitted to merely dogmatic teaching. Of late years indeed this reproach has been to some extent removed, and several earnest writers have with more or less precision analysed the principles upon which the excellence of architectural design depends, but that those principles are not yet completely established is abundantly evident from the vagueness of the controversy respecting the Albert Memorial. The official papers relating to the Memorial avoid in a great measure discussion of those general questions which *must* be disposed of, either tacitly or expressly, before the design is adopted; or where general questions of taste are referred to in these papers, the language is not the firm and precise expression of incontrovertible propositions.

We propose here to examine somewhat in detail the more important of the papers just referred to. Since the abandonment of the design of a monolithic obelisk, the course adopted by the Memorial Committee appointed by the Queen appears to have been as follows. In May last the Committee invited seven architects collectively to give their opinion respecting a suitable design for the memorial. In the letter of June 5th the architects reported their opinion to the Committee. On the 27th of June the Committee made a report to the Queen respecting the character and site of the memorial. This report was subsequently approved of in a letter addressed by the Queen's command to the Committee in July; and in the same month the Committee issued a letter to the architects above mentioned and two others, severally inviting each of them to submit designs for the memorial.

The earliest of these documents to which we need refer is the letter of the seven architects consulted by the Queen's Committee. The Committee, while leaving the architects free to present their own opinions, suggested that the Memorial to the Prince Consort should be erected in connection with an "Institution of Arts and Sciences," which the architects understood to refer to the South Kensington Museum and School of Art.

The architects gave only a doubtful and conditional assent to this suggestion. They ask, "whether the nature and style of the memorial could be safely assumed before the plan and design of the building for the institution had been finally determined;" and think it would be more desirable to erect the memorial, not as a part of or in immediate connection with a very expensive edifice not yet determined upon, but as an independent monument in Hyde Park."

Their letter then proceeds to consider the suitability of the following kinds of monuments:—(1) an obelisk in several stones, (2) a column, (3) a Gothic cross, (4) a large group or groups of sculpture, (5) a building; a statue of the Prince Consort being in any of these cases the most prominent object. The first of these structures they disapprove of because of its inferiority to a monolithic obelisk, and because its magnitude would render it more important and conspicuous than the Prince's statue. To the second kind of structure they object, that a statue on the summit of a column is not in a favourable position for being seen. With respect to a Gothic cross the architects do not give an express opinion; but in the part of their letter where, according to the order of the paragraphs, such an opinion should occur, we have the following mysterious passage:—

"The objections to an obelisk, a column, or any erection of that description, apply also to structures in any style of architecture which would assume either of those forms."

It is possible that our readers may succeed better than we have done in apprehending the meaning of this passage. We have several times thought we had caught the sense of it, but on a fresh perusal have abandoned our interpretation. A column is objectionable, we are told: so is an obelisk: so is any erection of that description, whatever "that description" may be. The same objections are said to apply *also* to some other structures but the puzzle of the sentence lies in this, that those other structures, though obviously referred to as a distinct class, are described as being "in any style," and "of those forms" already mentioned; so that it is hard to see why they are not included in the class first spoken of.

There is no reason beyond that just hinted at for supposing that Gothic crosses are alluded to in the sentence quoted. They certainly have not the same forms as either obelisks or columns; it is possible however that they are regarded as having forms "of that description," though any classification of monuments which logically includes obelisks, columns, and crosses in the same class, is absolutely inconceivable.

This is not merely verbal criticism; our objection to the passage quoted is of a much graver kind. The passage either does or does not refer to Gothic crosses. According to the former supposition, the joint-authors have deliberately omitted to express any opinion upon the merit of those structures; and we are driven to the conclusion that they were unable to agree upon an important point in which they confess that their opinion was required. According to the second supposition, they compare crosses to obelisks and monumental columns. That is to say, they discern a resemblance between Gothic crosses—which must at least be allowed to display refined skill in their construction and reasonable principles, and great variety in their design—with obelisks, almost the simplest of all structures, and only one degree removed from the unhewn monuments of uncivilised nations; and monumental columns, which have been previously condemned for their absurdity, and are of simple and nearly invariable forms.

With reference to the fourth in their list of monuments, a large group or groups of sculpture, the architects consulted express an opinion that, "if in bronze this may be a group of statues without a building; or if in marble with a building to protect them."

We have already, in a former paper on this subject, stated our reasons for thinking that statues ought not to be erected in the open air without buildings to protect them. With respect to metal statues, we admit that the necessity of preserving them from decay by the protection of a building is less imperative than with respect to marble statues. But the æsthetic objections to unprotected statues apply, whatever be their material. There is, in the first place, the incongruity—the indecency and disrespect, we may almost say—of suffering the effigies of one whom we intend to honour to be exposed to the violence of every storm. In the second place, it is a matter of mere observation that statuary of every kind is more distinctly seen, and more effective in juxtaposition with a niche or other suitable structure, than when viewed with no other background than the sky, or distant objects. The ineffectiveness of metropolitan monuments is mainly due to their isolation. Take, for instance, the statue of the Duke of Wellington, erected upon the arch near Apsley House; seen against the sky, little beyond the bare outline of the statue is distinguishable by a vision not unusually acute. The same remark applies, though somewhat less forcibly, to the statues in Trafalgar-square, and other squares in London. They look bare, isolated, and forlorn. They lack dignity, and would lack dignity whatever their intrinsic merits, because they appear to have been deemed unworthy of the protection of suitable structures. To adopt an analogy by no means remote, a wholly uncovered statue resembles a picture without a frame. A valuable picture is placed in a good frame, not merely for protection—for that purpose the frame is often nearly useless—but because the eye demands that the boundaries of the picture should be thus distinctly marked; and because the value attributed to it is denoted by the costliness and beauty of the frame.

The last and practically most important subject discussed in the letter of the seven architects is "the question of some building to be erected with a view to general usefulness." On this subject the following observations are made:—

"It appears to us that by the generosity of the nation, apart from the learned societies, science and art are provided for in the British Museum, the museum in Jermyn-street, and the schools at South Kensington. What seems to be wanted is some spacious hall and its necessary adjuncts, as a place for general art meeting; or for such assemblies as are about to take place in London in connexion with social science and its kindred pursuits. We have nothing in London for such an object like the great halls of Liverpool, Leeds, and Manchester. If these views are well founded, and would be received with public or national favour, we see no reason why the vacant ground at the back of the Horticultural-gardens, south of the Kensington-road, as suggested by the Queen's Committee, should not be a fitting site for such a building. Architecturally (and apart from general questions of expediency, upon which there doubtless exists a great variety of opinions) nothing could be happier, in our opinion, than to occupy the north side of the road with the Prince Consort Memorial, and the other side with a grand central hall having approaches to the hall itself, and as at the present moment to the Horticultural-gardens; thus effectually screening from view the back of the Conservatory and the unsightly objects at present existing."

The plan here recommended of associating the monument with a "spacious hall" appears not to have been originally projected by the seven architects, but to have been partially at least suggested to them by the Queen's Committee. The architects allude to doubts as to the expediency of the project, but speak confidently as to its architectural merits. Our judgment—and, if we mistake not, the judgment of the public—widely differs from that arrived at by the architects on the architectural question, and by the Queen's Committee on the question of expediency.

With respect to the architectural question, we cannot agree that "nothing could be happier" than to make the monument in fact consist of two dissimilar parts separated by a public road. Surely one of the first requisites of a monument is unity. It is intended for a single purpose—that of an enduring memorial of the deceased prince, and this unity of purpose obviously suggests unity of design. The "hall" is intended to be, in fact, one part of the memorial, and the monument upon the opposite side of Kensington-road another; but how can these two parts, separated by a busy thoroughfare, appear to be a connected whole? They may appear so in the "sketch plan" which the architects annex to their report, but certainly will not appear so to an observer of the executed design. The eye and imagination of ordinary spectators will not be so complacent as to ignore the intervening road with its busy traffic, and to regard the two parts of the memorial as undivided.

We have in a previous paper stated our objections to utilitarian monuments. A structure which assumes the double character of a monument and a useful building is an attempt to combine discordant elements. The monument—*quâ* monument—is not useful; and the useful part of the structure is not monumental. The discordance of the monumental and utilitarian characteristics may be to some extent evaded by a separation of the monument from the useful building. But then this difficulty arises—the separation is destructive of the necessary unity of the memorial. The monument proper will be regarded by itself, and if it be deficient in grandeur and beauty, the eye and judgment will refuse to eke out its deficiencies by reference to the adjacent building. Moreover, there is something repugnant to good taste in the endeavour to reconcile the useful and the ornamental—in the parsimonious liberality which professes to honour the dead, but in reality seeks to serve the living. There remains the question of the utility of the proposed "spacious hall and its necessary adjuncts." Of the uses to which they are to be applied we have many accounts, but none of them clear and precise. The seven architects refer to one of the uses of the structure "as a place for general art meeting." The expression "art meeting" is not English. But let that pass, with the single observation that inaccurate language is generally a mark of inaccurate ideas. By "art meeting" is presumably intended a meeting for some purposes relating to the arts—most probably the fine arts. But what are those purposes? Is the proposed hall to be a lecture-room where papers upon the fine arts are to be read and discussed? Surely there are plenty of such places already in London. Or is the proposed hall to be a sort of club-room where those who are learned, or profess to be learned, in the fine arts may associate together—a sort of "house of call," in fact, for artistic gentlemen? Surely the cost of a structure for these strictly private purposes ought not to be defrayed by a public subscription. Surely the money collected under the influence of a generous public impulse to honour the Prince Consort and console the Queen, ought not to be thus diverted to selfish objects.

Another use of the "hall" to which the architects refer is a place for assemblies "in connexion with social science and its kindred pursuits." The answer to the demand for such a place is, that such assemblies can be held in buildings already existing in more convenient situations in London.

The Queen's Committee adopted somewhat different descriptions of the purposes of the proposed hall. According to their report to the Queen, the hall is required as "a central point of union where men of science and art could meet; where the result of their labours, with a view to the special purposes before indicated, could be communicated and discussed, and where deputies from affiliated societies throughout the United Kingdom could occasionally confer with the metropolitan authorities." Oh that the writers of official papers could be compelled to write plain English! If the "hall" is meant to be a club-room, why have not the Committee the courage to say so? Are they afraid that the public would not be enthusiastic in providing for the comfort and enjoyment of the "men of science and art?" Who are these "men"? What is their claim on public generosity? What criterion is to be adopted in order to select, from the numerous pretentious class who would be willing to rank themselves as "men of science and art," the smaller number who are to enjoy the use of the proposed hall?

These questions suggest serious objections to the projected institution. Another great objection is, that the institution is intended not to supply an existing and recognised want, but to supply a demand before it arises. Where are the "affiliated societies throughout the United Kingdom"? Will it not be time enough to provide for their deputies when the societies are constituted, and show a disposition to send deputies? Perhaps the societies will never be constituted. Perhaps the deputies may never come to London, to confer with the persons modestly termed "metropolitan authorities." It is possible that the provincial "men of science and art" may have the same sense of their own importance that the metropolitan "men" will doubtless have, and may decline to be deputed to confer with them, and to acknowledge them as authorities.

But suppose all these difficulties surmounted, what are the deputies and authorities to confer about? There are ample means already existing of publishing new discoveries in science and art. The *publication* of such discoveries is a matter of national importance, and one therefore to the furtherance of which, if necessary, public money might if with propriety be applied. But the private meetings of "men of science and art" —for purposes, probably, closely connected with coffee-drinking and mutual laudation—are not matters of public concern.

The Queen's Committee have, by a letter dated July 1862, invited the seven architects and two others, to send in designs for the memorial on the north side of Kensington-road, and the proposed buildings on the south side of the road. We are glad to observe some expressions in this letter from which it may be inferred that the erection of the memorial is to precede that of the other proposed structure. The letter refers to "the fund which may be available for the cost of the memorial itself; for the proposed straightening of the public road; for the arrangement of the area in Hyde-park, with its decorations; and if possible for the hall on the south side of the road." The erection of the hall is thus spoken of as an event contingent on the collection of funds for the purpose; and the funds already collected are, we apprehend, to be applied in the first place to the erection of the monument. This course appears to be imposed upon the committee by their obligations with respect to the fund of which they are trustees. It was subscribed for a monument to Prince Albert; not for a hall for the convenience of "men of science and art."

THE INTERNATIONAL EXHIBITION, 1862.

Railway Plant and Appliances.

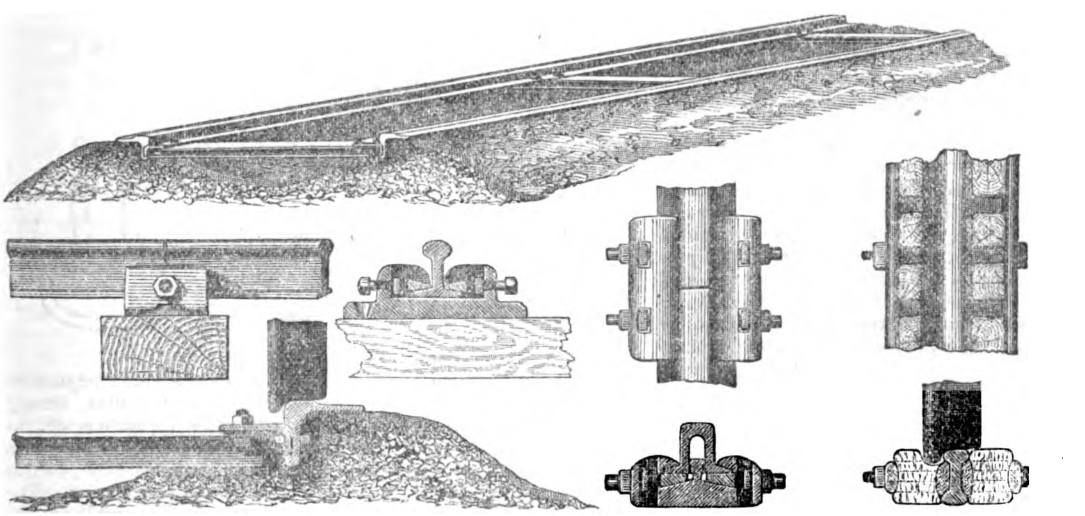
The thirty years and upwards since railway communication has been established have not been sufficient to determine which is the best form for rails, nor the best means of fixing them to the roadway, so as to make a level, firm, flat surface, over which the locomotive engines and carriages may pass at high speeds, with the least resistance, with the greatest safety, and with the smallest amount of wear and tear. In the uncertainty that continues on the subject numerous inventions are brought forward, each of which professes to possess special advantages, and to ensure greater security, and at less cost than the plans generally adopted. In the present International Exhibition, as in that of 1851, there are numerous specimens of rails, chairs, rail fastenings, railway crossings, and switches, and there are three examples of different modes of constructing the permanent way, most of which are placed in an alley in the western annexe, which few persons pass through, and at the back of the locomotive engines.

Commencing with the examples of railway construction, it may be observed that the original plan of laying down rails on the surface of the levelled roadway, by resting them on large rectangular blocks of stone into which the chairs were fastened, has been altogether abandoned, as the rigidity of the stone supports produced vibration that was not only disagreeable to passengers, but was injurious to the rolling stock, as it caused the fastenings to give way, and it was at the same time expensive. Wooden sleepers embedded in ballast were afterwards substituted for the stone blocks, and though apparently not so substantial, they have been found to be practically much better adapted to the purpose. The plans hitherto generally adopted have been to fix the rails into "chairs" fastened to the wooden sleepers longitudinally, as on the Great Western Railway, or to place the sleepers transversely to the line, and to fasten the chairs near to each end at exactly the same distance apart. Either of those systems of construction admits of a variety of form of rails and of the means of fastening them, but in the railway exhibited by Mr. Seaton (1298) the wooden sleepers and the rails are specially adapted to each other: he calls it the "patent safety saddle rail," and it is fixed on to longitudinal sleepers of a pyramidal shape, the lower portion of the rail being forked like a saddle, which fits on to the apex of the pyramid, and is fixed to it by bolts directly to the timber. The advantages claimed by the inventor for this mode of constructing the permanent way are, that the rail is supported by a solid and continuous bearing of timber, having a bearing surface on the ballast of seventeen inches in width; that the rail and sleeper are less liable to injury from wet, as the sloping sides present no surface on which water can rest; that neither chairs, keys, spikes, or other separate pieces are required, the bolts on each side keeping the rail perfectly tight in its seat; that it surpasses all other systems in economy of construction; and that, owing to the absence of chairs or other fastenings likely to be brought into contact with the flanges of the wheels, and to the perfect mode of joining of the rails by an under saddle-plate, there is much less liability to accidents. These are no doubt important considerations, and Mr. Seaton's system of construction seems theoretically to possess much merit. One objection to the plan, which forces itself to notice, on looking at the pyramidal sleepers and the mode of fastening the rails to them, is, that the grasp of the saddle on the timber does not seem sufficiently long for adequate strength of resistance, and the bolts being numerous would weaken the sleepers. This system of forming the permanent way has, however, been experimentally tried on several railways with good results, and a portion of the Great Western Railway, near Kensal Green, is referred to as affording a favourable example of its durability, after a trial of three years.

Another plan of constructing the permament way without sleepers or chairs is exhibited by Mr. H. L. Corlett (1244), and is illustrated in the annexed engravings (Fig. 1.) It is called by the inventor, a Continuous Surface-supported Railway, entirely of iron, the rails being cast with broad flanges, which rest upon the levelled ballast, and they are bolted together so as to "break-joint." The advantages claimed for this system are, durability of structure, improved drainage, a secure and level surface, and facility of executing repairs, combined with economy of construction. Nothing but practical experience can prove that this system possesses these advantages, for it seems very questionable whether a ballast support alone would be sufficient until it was well consolidated, and even then the rigidity of the bearing might occasion unpleasant if not injurious vibration. This kind of rail is laid down in the western annexe. In the same woodcut are included illustrations of joint-chairs and cellular brackets, bolted longitudinally at each side of a double T rail, also exhibited by Mr. Corlett.

Messrs. Edington and Sons, of Glasgow, exhibit specimens of iron-surface sleepers, with chairs cast in the same piece, which in the principle of their action seems to be a return to the original plan of fixing the rails to stone blocks. These sleepers have large circular hollow bases intended to be imbedded in the ballast, and there are niches in them for the reception of transverse iron bars that regulate the guage. As the chairs form part of the sleepers there is no difficulty about their fastenings. This plan has been adopted on the Egyptian, Indian, and other railways, and it is stated with considerable advantage. There is a degree of elasticity in this kind of sleeper that may be sufficient to remove the objection attending the solid blocks of stone. Similar kinds of sleepers are exhibited by Messrs. Simons and Co. of Renfrew.

Fig. 1.



Corlett's Continuous Surface-Supported Rail, &c.

Fig. 2.

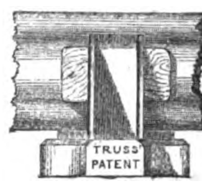
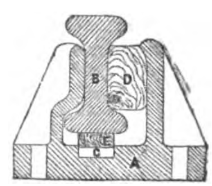


Fig. 3.



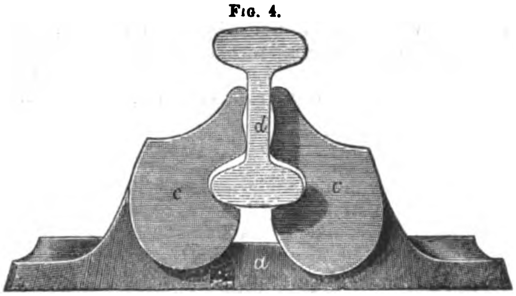
Truss's Cushioned Railway Chairs.

There is exhibited a great variety of rails and chairs and methods of joining and fastening rails. Several contrivances are shown for fastening the double T rail in such a manner as to protect the under surface from abrasion, so that when it is turned it may serve the purpose of a new rail. The plans adopted are either to fasten the rail to the chair by its side and upper shoulder, without allowing the lower end to rest on the chair, or to form a bed whereon the lower end may rest uninjured. The chair invented by Mr. Ramsbottom, the locomotive superintendent at Crewe, and exhibited by the London and North-western Railway Company, is of the former kind. The rails are held by the sides and shoulders by wrought-iron keys, and are not in contact with the bottom of the chairs, which are made of wrought-iron, with a very broad base to prevent them from being pressed into the sleepers.

An example of the other plan of protecting the under head of the rail is exhibited by Mr. Truss, of Gracechurch-street (1305 in the eastern annexe), and is shown in the accompanying wood-cut, Figs. 2 and 3. A space at the lower part of the chair (A) is filled with a prepared woollen packing (C), and on it is placed the wood-seating (E), the rail (B) being fixed on the chair by a wood key (D), in the usual manner.

A more ingenious contrivance is the one exhibited by Mr. F. Wise, of Buckingham-street, Adelphi (1309), invented by Mr. Ramié. It is a self-acting chair, which secures the rail without any wedge or key, the weight of the engine and carriages serving to hold it tighter at the time when greater steadiness is required. The accompanying elevation and section, Figs. 4 and 5, show how the effect is produced. The chair consists of three parts. The main casting *a*, is fastened to the sleeper in the usual manner, and it is formed with curved abutments *b*, *b*, upon which the loose "tumble" jaws *c*,*c*, that hold the rail *d*, rest. The weight of the rail upon the lower part of the movable jaws, which are not attached

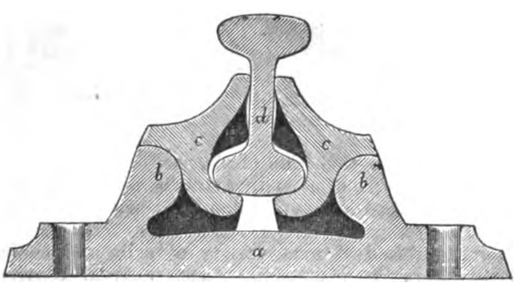
Fig. 4.



Ramie's Railway Chair.—Elevation.

in any way to the chair, causes the upper parts to close against the sides of the rail sufficiently to hold it securely in position, and the grip of the jaws is greatly increased when a train passes over the rail. It is stated that "several years' experience of the working of this chair under the heaviest traffic shows that it acts in the most perfect manner, and never allows chattering to occur between itself and the rail." One of the advantages claimed for this invention is, that it affords the greatest possible facility for placing, reversing, and removing the rail. This facility is indeed almost too great, for it would present the opportunity of doing wilful or wanton mischief by removing a rail at any part of the line without difficulty. Another objection to which this mode of fastening the rails is exposed is, that the constant yielding of the surface of the rail under traffic would increase the draught. This is an objection which may be urged against all yielding surfaces, for the effect is practically the same as if the wheels were ascending an incline. Even with wooden sleepers and ordinary chairs this effect must to some extent be produced, and experience alone can decide to what degree such yielding of the surface is advantageous or otherwise, so as to obviate on the one

Fig. 5.



Ramie's Railway Chair.—Section.

hand the inconvenience of extreme rigidity, and on the other hand to prevent the loss of power caused by continually dragging the train out of the hollows made by its weight on a yielding railway.

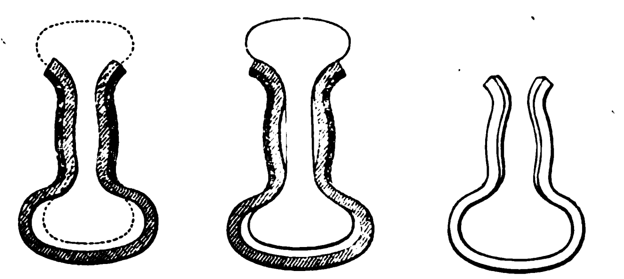
The spring-clip fish-joint of Mr. Dering, of Lockleys, Herts, (1246), is liable to the same objection as the two last-mentioned chairs, but in other respects it seems well adapted for the purpose. A strong spring of the shape shown in section in the accompanying wood-cut (Figs. 6, 7, 8) clasps the two ends of the rails tightly together without any fastening. By means of this joint, it is stated by the patentee, that safety, simplicity, and economy are attained by the absence of bolts, nuts, &c., one piece of metal taking the place of ten or fourteen separate parts, and, being self-acting, it requires no attention, for any wear or loosening that may occur is immediately remedied by the tendency of the spring to collapse. The length of the spring-clasp is about twelve inches. Fig. 6 is a section of the spring clip when not expanded by the rails; Fig. 7 is a section at the junction of the rails; and Fig. 8 is an end view of the clip.

Mr. Dering also exhibits rails joined by brazing, which plan, if not objectionable in practice, would effectually supersede the necessity of any mechanical joint whatever. A pair of rails joined together by brazing are exhibited, which were taken out of the Great Northern Railway after having been laid down four years, and though the whole traffic of the line passed over them during that time, the junctions are as sound as when first made. It is stated that when tested by sledge-hammering the rails break before the brazed joint yields. Honourable mention was awarded to Mr. Dering "for his tempered steel keys and trenails."

Messrs. Ransomes and Sims of Ipswich exhibit keys and trenails composed of strongly compressed wood previously dessicated. These keys cannot shrink, and when driven tight between the chairs and the rails retain their hold firmly, for the fibres of the wood become expanded by moisture and fill up all interstices and produce a constant pressure. They have been adopted with advantage in laying the Indian railways; and the permanent way of the Great Northern Railway is also laid with these compressed keys and trenails, to which circumstance the patentees ascribe the speed and comfort attained on that line.

The Anderson Foundry Company at Glasgow exhibit a peculiar mode of fastening the rails to the chairs by a steel spring, against which an iron key is driven (1229). By the elasticity of the spring a strong pressure is maintained on the key, and the rail is thus held firmly in its place in all weathers. A great variety of chairs and joints and modes of fastening are exhibited by Mr. E. Morris, Albert-square, Clapham-road (1275), and by the Permanent Way Company, Great George-street (1288), but there is nothing remarkable in their construction that deserves to be particularly noticed.

Fig. 6. Fig. 7. Fig. 8.



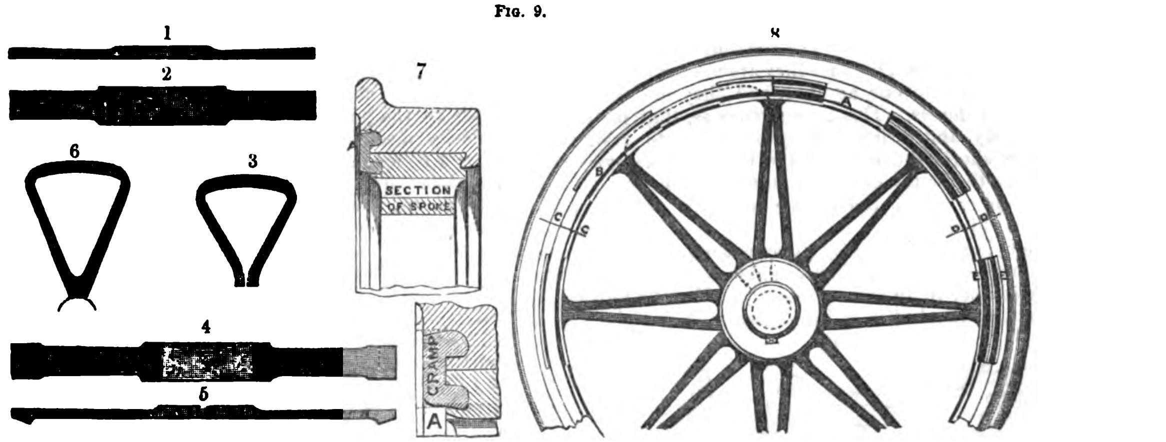
Dering's Spring Clip Fish-Joints.

Of rails and switches and crossings there are many examples. The Isca Foundry Company, Newport, Monmouthshire, among numerous other objects connected with the formation of the permament way, exhibit (1262) a welded steel crossing made with the Bessemer steel, the V part of which is perfectly welded together from the point to the intersection of the rails. The principal advantage of these crossings is their durability and economy, for it is stated that they will last longer than five or six of those made of iron, while the original cost is not more than 50 per cent. greater. The Bessemer welded steel possesses also the advantage over solid cast-iron or steel, that it can be altered and set to suit the lead of the rails, which the others cannot. The same company also exhibit specimens of Bessemer cast-steel switches. This kind of steel, which combines with the hardness of steel the malleability of iron, is becoming more and more extensively used; and it appears to possess qualities that render it peculiarly applicable to railway locomotion, whether in the construction of the tires of the wheels, the axles of engines and carriages, or in making those parts of the permanent way that are most exposed to wear. Honourable mention was awarded to the Isca Foundry Company for "Switches and crossings of Bessemer steel."

A frequent cause of railway accidents is the fracture of the wheels or tires of the locomotives and carriages, owing to the heavy weights and the severe strains that they have to bear; and much ingenuity has been exerted to produce a sound wheel with a solid firmly fixed tire. The method formerly adopted of securing the tires to the wheels by rivets has been so severely condemned by Capt. Tyler and Col. Yolland, the government inspecting officers of the railway department, that it is to be hoped that plan has been abandoned in recent practice; and there is only one indication of adhesion to it in the present Exhibition. All the tires exhibited are formed in a solid ring intended to be shrunk on the wheel, and in some cases the wheel and tire form together an united solid disc. Many of the exhibitors pride themselves on the quality of the iron of which their tires are composed; and there are several specimens, particularly in the eastern annexe, of tires that have been twisted and contorted when the iron was cold, for the purpose of showing its toughness and pliability. There are also several specimens of steel tires, of great size and thickness; and there are others again made with iron and faced with steel, of which there is a good example exhibited by Messrs. Brown & Co. (1240), in the eastern annexe, together with a strangely contorted iron tire, cold hammered. A medal was awarded to this firm "for a good process of making solid wrought-iron tires."

The subjoined wood-cut is an illustration of the railway wheels and tire fasteners exhibited by Messrs. Dixon and Clayton of Bradford (1247), and also placed in the eastern annexe. Nos. 1 and 3 are edge views, and 2 is a flat view of a bar of iron for making the spokes. Nos. 4, 5, and 6 represent spokes to form the solid wrought-iron wheel; the cramp fastening is shown in No. 7, which may be continuous, as at B, No. 8, with the tire and rim set down all round, or at intervals, as at C C. The letters E E indicate grooves in the edge of the wheel to receive the cramp fastener.

FIG. 9.



DIXON AND CLAYTON'S WHEELS AND TIRE FASTENINGS.

In the wheels and tires exhibited by Mr. Owen, of Rotherham (1285), the wheels are of solid wrought-iron, made in one piece under a powerful steam-hammer, by which means such perfect solidity is attained that it is stated by the manufacturers no trace of welding can be perceived on cutting the wheels to pieces in a lathe. The recommendations the tires are said to possess are, that each one is made from a solid mass into a circular form, so that no alteration of structure takes place by bending. The whole surface of the tire is hammered when at a welding heat, and the tires are afterwards heated and rolled into a perfectly true ring. The usual processes of turning and boring are thus avoided, and the external skin of the iron is preserved for wear.

In the south side of the eastern transept of the building there are several fine specimens of railway wheels and tires, made from steel. In the Sheffield "trophy," of Messrs. Nayler, Vickers & Co., they exhibit solid cast-steel driving-wheels, some of them 6 feet diameter, and railway disc wheels cast solid with the tires, and having wrought-steel axles. In an adjoining "trophy," containing a large display of various articles made from Bessemer steel, there are railway tires, of different sizes as cast in the rough, and as finished.

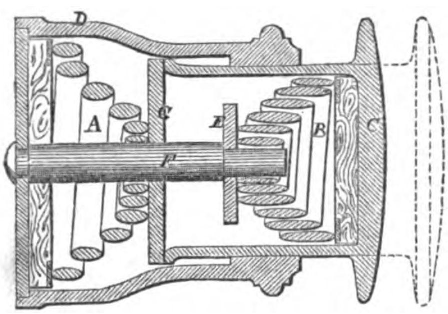
There are specimens, in the eastern annexe, of wheels of various kinds, fitted with Beattie's tire fastening, which was strongly recommended by Capt. Tyler in his report on railway accidents, in 1861; and of which a description, with illustrations. was given in the July number of this *Journal* last year. Most of them are exhibited by Messrs. Lloyds, Fosters & Co., of Wednesbury (1268), to whom honourable mention was awarded "for wheels, axles, and tires," and who exhibit also specimens of tires made by themselves and a turntable supported on iron balls that roll round in a circular groove. In an open area in the same part of the building, the Monkland Iron Company exhibit a monster tire, 12 feet in diameter, and weighing 2000 lbs., made from rolled iron. A great variety of other specimens of railway wheels and tires are also placed in the eastern annexe, some of them being in Class V., and a large number in Class I., among mineral products. In both classes are to be seen remarkably fine specimens of fibrous iron, and of steel.

The inventions for the prevention of accidents on railways, including improved breaks, buffers, and signals, are not so numerous in the present Exhibition as in 1851, but there is nevertheless a considerable display of such contrivances. The difficulty is not so great to invent the means of preventing accidents, as it is to induce railway directors to apply them, though it might be supposed, after the heavy damages which most companies have had to pay for injuries to passengers on their lines, that economical considerations alone, if no higher motive, would have urged them to adopt with eagerness any means whereby accidents might be avoided, or their destructive effects be diminished. With respect to breaks, there is something more to be considered in the principle of their construction than the stopping of a railway train when in rapid motion within the shortest possible space. A break that would bring a train to rest within sixty yards (as one exhibitor boasts that his buffer would do) would produce such a sudden shock as to nearly equal the effect of a collision with an obstacle on the line. The object to be attained is to diminish the speed gradually, and at the same time as quickly as is possible, without inconvenience to the passengers, and without injury to the rails or to the wheels. The ordinary break, which merely stops the rotary motion of the wheels, and produces its retarding effect by the friction of a small part of the tire against the rails, is a rude and ineffective means of stopping a train, and it tends to injure the rails and to break or weaken the tires. It seems strange that a plan which has long since been abandoned on common roads to check the motion of carriages on descending hills, should have been retained for stopping a train of carriages moving with great velocity with much heavier loads, and on roadways that especially require to be maintained in a sound and level condition. Many plans have been proposed for improving this rude mode of retarding the motion of a railway train, the most effective of which appears to be to increase the bearing surface on the rails by bringing breaks to act independently on their upper surfaces. Such a contrivance was shown in 1851, and a similar one is now exhibited by Mr. Wright, in what he terms the "bed-plate iron safety railway" (1312), which comprises other arrangements for the avoidance of accidents, in addition to the method of retarding the motion of a train by the application of a flat bearing surface on the rails. To carry out Mr. Wright's system entirely extra rails would be required outside the ordinary ones, for the purpose of bearing the break, and also to prevent a train from running off the line when passing rapidly over curves. This part of the plan would, however, entail so much expense, that there is little hope of its being adopted by railway directors; and even the inventor seems to limit his expectation of its being used to sharp curves. In another form of break, exhibited by Messrs. T. Dunn and Co., (1248), there is a contrivance for clasping hold of each side of the rails; but there are great objections both in principle and in practice to such a plan. To bring such a break into action would require the rails to be well raised above the chairs, and quite free from the ballast; and if the grasp on the rails were effective, the impetus of a train in rapid motion would tear them up. It is impracticable to retard the motion of a train by friction otherwise than by perpendicular bearing on the surface of the rails. Of the other breaks in the Exhibition there are not any that deserve special notice, for the principles of action in them all is the same as that generally practised, the variations in each case consisting chiefly in the different modes adopted for blocking the wheels.

Of buffers there are various kinds, made with steel springs, and with vulcanised india-rubber, and in some instances with a combination of the two, for which the exhibitors claim special advantages, it being their object to combine strength with lightness and power of resistance within a small space. The object of attaining greater resisting power within a limited range of action, which seems to be aimed at by the constructors of buffing apparatus, may be considered a very questionable advantage, for the shorter the time of action the greater must be the shock of sudden contact, which it is their purpose to diminish. In most cases of violent collision on railways the buffers, as ordinarily constructed, are of little use, because they are not properly formed at the ends to take into one another, and they are frequently placed at different levels. The consequence is, that instead of acting horizontally, and bringing the carriages to rest, after diminishing the shock, the ends of the buffers slide over each other, and tend to throw the carriages off the line, or to lift them upon one another or on to the engine, and thus aggravate the effects of such accidents.

The accompanying woodcut, Fig. 10, represents a section of Mr. Allan's compound buffer (1228), which is said to possess the property of increased resistance in an eminent degree. For the purpose of showing its action, the buffer is illustrated with its plunger at

Fig. 10.

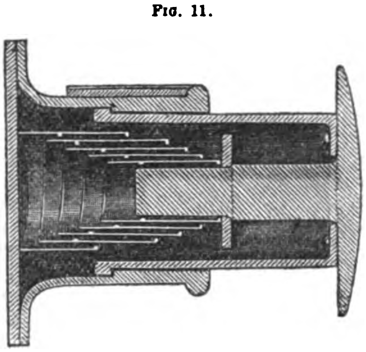


Allan's Compound Buffer.

half-stroke, the dotted lines showing the position when at rest. It will be seen that while the spring A acts between the bottom of the cylinder D and the inner end of the plunger C, the other spring B acts between the front of the plunger and the washer E fixed on the pillar F. By this means there is compound action, and the two springs produce an amount of resistance double that of an ordinary buffer.

Another construction of buffer is shown in the annexed illustration, Fig. 11, which represents in section the contrivance of Messrs. Spencer and Corlett (1244). The principal advantage of this buffer is that the plunger is without a central bolt, and is retained within the cylinder by projections which prevent it from falling out, whereby it is asserted that additional strength and diminished friction are attained. An important improvement in the con-

Fig. 11.



Spencer and Corlett's Buffer.

struction of buffers introduced since 1851 is, making the cylinders of wrought-iron, by which means they are lighter and stronger than when made of cast-iron. The volute spring, for the contrivance of which Messrs. Spencer & Sons, of Newcastle-on-Tyne, obtained a prize medal in 1851, has since undergone improvement by them; and it is employed in its improved form in the buffers exhibited.

The want of some means of communication between the engine driver and the guard and passengers has been experienced from the very commencement of railway travelling, yet upwards of thirty years have elapsed without the adoption of any effectual plan to supply that requirement, notwithstanding the many serious and even fatal occurrences that have taken place to prove the necessity of some such means of communicating. As in the case of railway breaks it is not from the lack of inventive ingenuity to contrive signals for the purpose that passengers and guard and driver cannot give notice to each other of danger to themselves or to the train, for many contrivances to effect that object have been invented and might be introduced at little expense, but the difficulty to induce railway directors to depart from the ordinary routine, or to adopt any plan that threatens to give additional trouble, has not yet been overcome by the many remonstrances made by the public. It is essential, in all plans of making signals by mechanical means to the driver or guard, that there should be a continuous connection from carriage to carriage, but the time required to hook together cords or rods on the top of each carriage would be so very trifling as to be not worth consideration; nevertheless the reluctance to move in the matter is so great, that we believe nothing short of a legislative enactment, or the occurrence of some very serious calamity from the want of such means of communication, will induce the directors to take measures to establish it on all the trains. There are several contrivances now exhibited, any one of which might be applied without difficulty. When the object is confined to making signals between the driver and the guard, a cord or movable rod attached to each carriage, with loose ends for the purpose of coupling, and with a bell at each end of the train, would be sufficient for the purpose. This simple plan, judging from the drawings and apparatus exhibited by Messrs. Chattaway (1294), has been adopted on the Bombay and Central India railway. If the guard and driver had the means of striking a bell at each end of the train, a code of signals might be easily arranged so as to enable them to make all necessary communications.

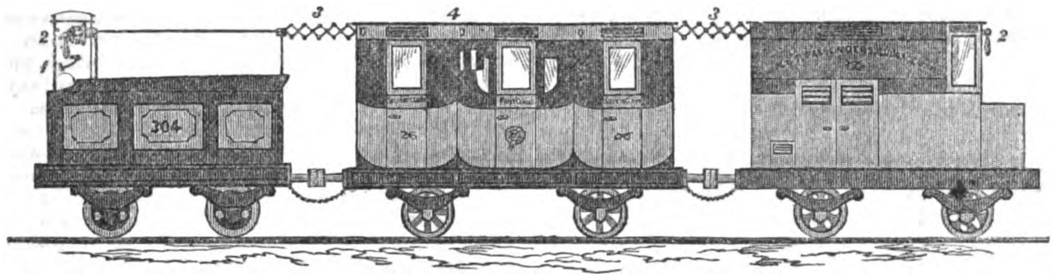
When it is intended to establish communications between the passengers and the guard, as well as between the latter and the engine-driver, a more complicated arrangement would be required. A model of a contrivance of this kind is exhibited by Mr. J. Davidson, of Leek (1245), and of which the accompanying engraving, Fig. 12, presents an illustration. There are movable rods in the top of each carriage, which are connected together by the couplings 3, 3. The communication is made by bells, that of the engine-driver being marked 1; 2, 2, are the handles by which the signals are to be worked. The mode by which passengers are enabled to work the signal is not shown in the engraving, but when the bell is rung by any passenger, an alarm slide, marked 4, projects from his compartment, to indicate to the guard where attention is required, and it is so contrived that when forced out it cannot be replaced until the guard has unlocked it. It will be observed that the couplings being jointed, they would adjust themselves readily to the variable movements of the carriages when in motion.

An ingenious mode of making verbal communications on railway trains is exhibited by Mr. Kingston, of Upper Stamford-street (1263), and has been favourably noticed by Col. Yolland, one of the railway inspectors of the Board of Trade. A vulcanised india-rubber tube is attached to the top of each carriage, and the tubing of the separate carriages is connected together by means of hollow ball-and-socket joints, for which purpose the ends of the tube in each carriage projects, and to those portions of the tube coiled springs are attached. By this means the ball and socket are readily connected, and being forced together by the springs they would maintain their positions, notwithstanding the wriggling motion of the carriages. So far as regards making a communication between the guard and driver, we conceive that the simplest and most easily applicable means would be by sound, either by a compressed air whistle or by explosive signals. This plan would be independent of all mechanical connections, therefore it would not be liable to the objections raised against the modes of communicating which are exhibited; and a code of signals might be contrived to answer all required purposes.

Of road and station signals, to indicate to the engine-drivers whether the line is clear or obstructed, the one exhibited by Messrs. Stevens and Son, of Southwark (1302) appears to be a considerable improvement on the semaphores usually employed. The pillar and the signal-arms are made of open iron-work on a strong cast-iron base; and as there is but a small surface comparatively presented to the action of the wind, it can withstand the force of violent gales, and it is also less liable to decay than timber pillars. The signals are worked by rods connected with handles near the base; and the semaphore is adapted to be used by day or night, and for up and down lines. Honourable mention was awarded to this firm for their "semaphore signals."

manner are liable to get out of order, but such a defect can be readily detected and remedied; and they are far better than self-acting time signals, which adjust themselves after the lapse of a given time, for in case of a break-down, or of unexpected retardation, the train may be close a-head, though the semaphore might indicate that the line was clear.

FIG. 12.



DAVIDSON'S METHOD OF COMMUNICATION IN RAILWAY TRAINS.

The model of a self-acting railway signal, intended for tunnels and sharp curves, exhibited by Capt. Stafford, of St. James's-square (1303), is well adapted to answer the purpose of warning the driver of a closely following train when the line is obstructed. The engine on entering a tunnel brings the danger signal into a conspicuous position, and on leaving the tunnel the signal is lowered by a connecting wire that is pulled by a projection acted on by the train. Signals that operate by direct action in this

In the foregoing survey of the railway appliances exhibited, it is very probable that we may have omitted to notice some that deserve attention, for many of the objects are distributed in so incongruous a manner in various parts of the building, that it is difficult to find them out. We have purposely omitted to mention the foreign contributions relating to locomotion on railways, of which there is a large and highly creditable display, reserving the consideration of them for another occasion.

KING RICHARD'S HOUSE, AT LEICESTER.

By Mr. GODDARD.

AMONG the Architectural relics of Leicester now no more, was standing some years ago an old building which was popularly called "King Richard's House." It was known to have been part of the Old Blue Boar; as at the commencement of the last century it was used as an inn, and known by that sign, though originally it bore the name of the "White Boar," the cognisance of King Richard III., but after his defeat this sign was torn down by the infuriated populace, and the owner or landlord compelled to change its title. Popular tradition has always identified the building with the ill-fated monarch, and the inquiries of our local antiquaries confirm the tradition. It was taken down in the month of March 1836; but fortunately, before its destruction, a drawing was made of the front by the late Mr. Flower, and that has been copied in many shapes in architectural works and various publications with which the reading public are familiar. I also visited the spot before the demolition was effected, and took the dimensions of every portion of the building, for the purpose of making a correct drawing of it, representing it as complete as when first erected. The results I have much pleasure in laying before the Archæological Congress.

The part of the original structure then remaining had apparently been one wing of the inn, as it stood when first built. It was of two stories. The front was about 25 feet wide and 37 feet high to the apex of the gable. It was a half-timbered house, of oak, the interstices filled in with plaster. The foundations to a certain height above the level of the ground were composed of stone and brick. The lower story was one large room about forty-one feet long and twenty-four feet wide within. The external part in front was covered over in great part with a brick wall, on the removal of which the original timbers of the windows were exposed. There were two wide windows of three lights each, divided by wooden uprights forming the framework, coved on the front edges and grooved to receive the lead lights. These timbers were placed upon blocks of granite, to prevent the damp from rising and decaying them, and were as perfect as when first erected. There was originally no doorway, although in the drawing by Mr. Flower one is represented; but this was cut out of the woodwork to allow admission to the interior, then used as a wool-room. In this apartment were traces of an original window of four lights (of similar character to that already described), in the south wall near the western extremity, looking in the rear of what I suppose was once the main building. In addition to the window there was a door near to it, which had evidently communicated with a corridor or passage in the rear of the main building. On the north side of the lower story was a fire-place, having stone jambs moulded, and a moulded projection over the mantel. The second floor overhung the lower story, the ends of the floor timbers being shown, and the principal ones supported by brackets. The beam lying over these ends was moulded and embattled, as seen in the drawing. The principal feature was however a projecting window of five lights, with moulded mullions and tracery of the Perpendicular period. This window was supported by brackets.

Above this was a second projection, with an embattled tie-beam and moulding, to sustain a gable, having an ornamental barge-board, cusped and otherwise sunk and moulded. In the interior the second story was much like the lower one. The floor was of brick. It had a fireplace similar to the one below, with the exception that it had three courses of brickwork between the plinth of the stone jambs and the floor, which was no doubt intended to act as a hearth or fender to protect the floor timber from fire.

The roof was open to the ridge, the construction of it being still visible. The whole of the timbers were framed and pinned together with oak pins. Not a nail, nor piece of iron of any description, was used in connection with the building, but the timbers were framed and scarfed together in the most ingenious manner. All the principal beams and other parts were decorated with painted scroll-work in black, red, and yellow, and of simple design. In addition to the window looking upon the street, there was another like that in the lower story already described. The entrance was by a door entering from a gallery also, like that below. The door was of a rude description, ledged, and composed of three boards, cleft, not planed, lapping one over the other, and was fastened by a wooden latch, moved through a finger-hole cut in the door, and by a bolt of wood below the latch. The roof was covered with strong Swithland slates.

Having described what actually remained, I now venture to conjecture what was the main plan of the entire building, as it appeared to the inhabitants when Richard the Third took up his lodging in it, as the principal hostelry in Leicester.

It seems to me that the structure had two wings and a centre; the building I have spoken of being the northern wing. The centre probably receded from the street four or five yards. In the middle was perhaps another gable, with wide gateway below, admitting to the rear of the premises and to the passages behind the front rooms.

This supposition is at variance with the picture, but as the

* Paper read at the Congress of the British Archæological Association, at Leicester, on the 4th ult.

latter was drawn to shew the buildings which surrounded it when the drawing was taken, and not as they presented themselves originally, it must be so regarded. Like the old inns in the metropolis, the Blue Boar had probaly open galleries behind approached by outside staircases, and communicating with the several chambers.

As the principal apartments were in the wings, and they were spacious, there is no reason why the upper room of the northern wing was not the sleeping room allotted to distinguished travellers, and therefore to Richard the Third when he slept in Leicester.

The paper was illustrated by a coloured drawing of the old Blue Boar, and a conjectural ground-plan of the entire fabric.

IRON PIERS FOR RAILWAY BRIDGES IN ALLUVIAL DISTRICTS.

(With an Engraving.)

CONSPICUOUS among the British Engineering Models at the International Exhibition may be observed Colonel J. P. Kennedy's models and drawings (2307, Class 10), illustrating "the Finance of Railways and other public works." Of these the most copious and important subject relates to the construction and erection of iron piers and superstructures for railway and other bridges and viaducts in alluvial districts. The results are derived from the system which he has adopted on the Bombay and Baroda Railway. That system has been already noticed in this Journal (vol. xxiv. p. 251), to which we beg to refer our readers. It is well adapted to the requirements of the colonies, in consequence of its economy in first cost, facility of transit in long voyages and of erection in situations where the supply of skilled labour and mechanical appliances are very limited.

The practice held forth is based upon the erection of 95 bridges across rapid rivers, most of them tidal, and flowing upon alluvial beds; the aggregate length of bridgework being about 6¾ miles. The length of line conceded for construction was 313 miles, of which about two-thirds are finished, and the balance is on the eve of completion. The financial powers of this line may be estimated from the unprecedented fact that single engines, four wheels coupled, have hauled along its entire length, and in each direction, trains of 72 carriages conveying 4000 passengers at the regulated speed of 20 miles an hour. Colonel Kennedy, from the outset of his operations, has aimed at securing low fares for his passengers, with high dividends for his shareholders. He expects that the cost of the line shall not exceed £11,000 per mile, notwithstanding its difficult character and the antagonism with which he has had to deal.

The extent of country to be supplied by railways in India is very great, averaging 1000 miles across from west to east, and more than double that distance from north to south. It is intersected by two principle ranges of mountains; the Vindea central range running from west to east, and the Syhadree range, 2000 feet high, running from the centre of India southwards along the west coast, with a steep declivity towards the sea on the western side but a gradual fall inland on the eastern. In the case of the Bombay and Baroda line great care was necessary in surveying the country beforehand, to make sure that all branch lines intended to be constructed afterwards would be practicable, and 4000 miles of ground were examined before any steps were taken in commencing the works: this was the more important in so mountainous a country, in order to get the best possible levels along the entire course of the line, and the result was a ruling gradient of 1 in 500. The population of the country and its capabilities of supplying produce are so great as to ensure an enormous traffic for all the railways, and financial difficulties alone have hitherto retarded the progress of railways. The vast importance of ready communication through India may be judged of from the fact that India already consumes a larger amount of British produce than any other country; hence it is that, while her colonies are the main support of the industrial classes at home, England must look to her colonies and to India especially for the maintenance and advancement of that industry; and facility of road traffic is therefore essential for increasing the demand for home productions and for returning larger supplies of raw material.

From the nature of the country it frequently occurs in India that the practicability of building a bridge in a particular locality is the consideration which determines whether there should be a road or not; and the same condition decides the question also as to a railway. The large majority of the lines have to follow the valleys and to cross the rivers frequently, requiring a special construction of bridge piers for the alluvial soil, where solid masonry piers are most costly if not impracticable. The piers are thus of vital importance: many kinds of superstructure may be adopted, but on the piers depend the practicability of making the railway. On the Indian lines miles of bridges have to be dealt with, which must be strong enough to withstand the fierce monsoon floods running at 6 to 10 miles per hour. Hence great strength and durability are necessary in bridge piers, combined with cheapness of construction; otherwise a railway could not be attempted with any prospect of a successful issue.

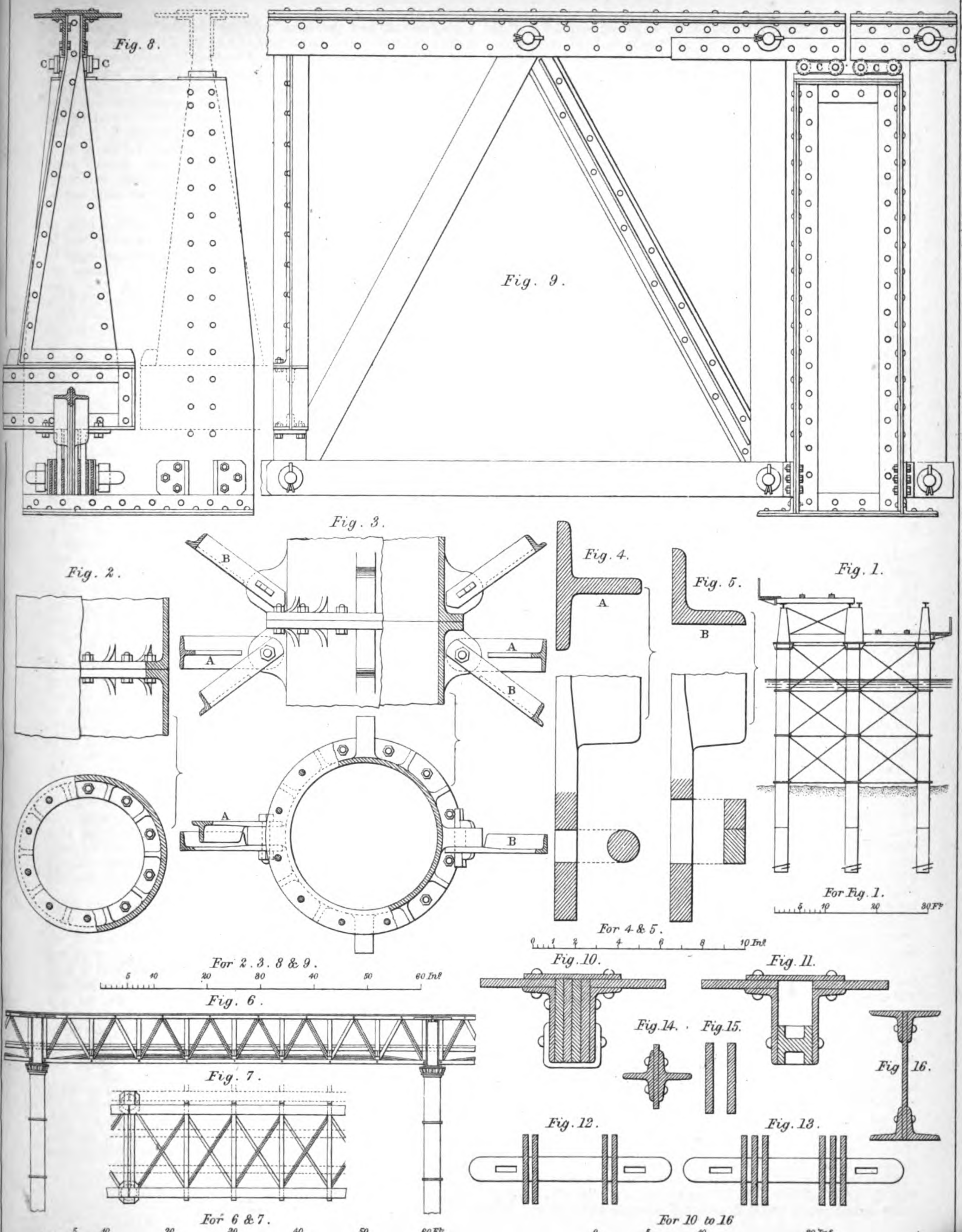
The piers are composed of hollow cylindrical cast-iron piles, of 1 inch thickness of metal and 2 ft. 6 in. outside diameter, cast in 9 feet lengths weighing about 1½ tons each, as shown enlarged in elevations and plans in Figs. 2 to 5, Plate 19; these are of two principal patterns, for the portions of the piles above and below the ground. That above the ground, Fig. 3, has flanges outside for bolting the lengths together by twelve 1 inch bolts; while that underground, Fig. 2, has the flanges inside bolted together by ten 1 inch bolts, and is flush on the outside so as to offer no resistance in penetrating the ground; they are large enough inside to leave room for a man getting in to bolt the several lengths together properly in the process of erecting. The foundation is obtained by one of Mitchell's screws at the bottom of each pile, of 4 ft. 6 in. diameter, which finds its own foundation without the expense of cofferdams or any other artificial preparation of the ground. The upright piles are placed 14 feet apart centre to centre, and are sunk to a depth of about 20 feet in the ground; but where the ground is softer than usual they are carried down deeper, to obtain the requisite s2rength of foundation. The greatest length of pile used has been 45 feet below the ground and 72 feet above. The oblique piles forming the struts are inclined at an angle of about 30° to the upright piles, they are precisely the same in construction as the upright piles, and are joined to the latter at about the ordinary flood level by a cap cast at the proper angle, which clips the body of the upright pile. The piles are all connected together above ground by horizontal and diagonal wrought-iron bracing, attached to lugs cast on the piles by a pin at one end and a gib and cotter at the other, as shown in Fig. 3. Figs. 4 and 5 show sections of the horizontal T iron bracings A, and the diagonal angle iron bracings B. The several parts of the bracing act alternately as struts and ties according to the direction of the current, and in consequence of this alternate strain an accurate fit of the bracing is required; to ensure this the joints at one end of each are therefore left to be done in India from measurement on the site, this being the only forging required in India. A party of submarine fitters is employed for attaching the bracings to the pilings and other work under water. These men are furnished with Heinke's helmets and dresses. The outside piles are faced with a double row of timber as a fender to protect them against shocks from anything floating in the water and brought down by the current. The weight of a single complete pier of five piles for two lines of rails, 63 feet high from the foundations, is 75½ tons, and the cost £624 delivered in London.

Fig. 6 is a side elevation of one of the spans of the bridge, showing the construction of the superstructure, which is that known as Warren's triangular system. Fig. 7 is a plan of one roadway, and Figs. 8 and 9 are an enlarged elevation of the double standard carrying the ends of the girders, and a side elevation of the girder and standard. Figs. 10 to 16 are sections of the bars composing the girders and tie bars. Fig. 10 is a section of the top compression beam at end; and Fig. 11 section of the same at middle. Fig. 12 shows bottom tie bars, section at end. Fig. 13, the same, shows section at middle. Fig. 14, section of the diagonal struts. Fig. 15, section of vertical and diagonal tie bars; and Fig. 16, section of roadway girder.

This form of girder, when manufactured and accurately fitted in England, requires the smallest amount of skilled labour for its erection abroad on reaching its destination; only a few pins and bolts have to be put in for completing the girders, and the skilled labour required for riveting box girders or lattice girders is avoided.

(To be continued.)

BOMBAY & BARODA RAILWAY = IRON BRIDGES.



PAPERS ON HYDRAULIC ENGINEERING.*

By Samuel McElroy, C.E.

No. 1.—Reservoir Construction.

The principle of collecting water for public or personal use is directly connected with the introduction of water works; and, preliminary to examination of the several theories or systems of construction and use which have been followed, a brief historical summary of ancient and modern practice is important, which is taken from Cresy's Encyclopædia and other works for the former, and principally from local reports for the latter.

Egypt.—In two of the prominent cities, Carthage and Alexandria, the former containing upwards of 700,000 inhabitants and the latter over 300,000, the first received its supply of water through a large aqueduct, which emptied itself into a great number of reservoirs or cisterns in different parts of the city, about 100 feet long by 30 feet wide, through earthen pipes laid for the purpose, said to be still visible; while the second was supplied from the river Nile, covered stone conduits lined with cement being carried to each private dwelling, discharging into small cisterns built for the purpose, of the same material and lining, also covered. In the wars between Rome and Alexandria, when the Roman army had obtained possession of a portion of the city, they were much surprised and annoyed by the Alexandrian general, who cut off their supply of fresh water, turning into their conduits salt water in its stead; but by their united exertions in a single night, they dug wells sufficient to supply their wants. The fact, taken in connexion with the enormous cost of this system of distribution, goes to show very clearly their care to provide the wholesome water of a river, in preference to the unwholesome water of wells, where used by a large population. While, in the case of Carthage, these numerous reservoirs would seem to have been used for direct private supply, without introduction to each house, as is now the case in some European cities. Recent visits to the remains of Utica, by H. B. M. ship Harpy, describe the main subterranean reservoir of about 320 feet diameter, with six cisterns 86 feet from it, 135 feet long, 19 ft. 7 in. wide, not less then 17 feet deep, built with arched roofs, connected with each other, and in good preservation.

Greece.—On the island of Samos, a canal was cut through a mountain to obtain a supply of water from a copious and celebrated spring; and at a point near the aqueduct several caverns were cut to receive its supply, whence the water was probably drawn by hand for use. On the island of Tenedos there still remains an ancient stone building, in which the water used by the inhabitants was collected, after it was brought from distant springs in earthen pipes. Among other remains of the city of Cnidus are several slabs of marble, channelled out for water conduits. On the island of Cos, an aqueduct three miles in length is built, which supplies the inhabitants, the cover being removed to enable them to get at its contents. In the city of Syracuse, one of the reservoirs is described as being cut out of the solid rock, as was the aqueduct which supplied it, being 57 feet long, 23 feet wide, and 10 feet deep. In other Grecian cities conduits of stone masonry are found leading to subterranean reservoirs, arranged on a similar system of distribution.

Italy.—In the arrangements for distribution made by the engineers of Rome, the water brought to the city by the several aqueducts was received at the walls of the city in reservoirs specially adapted to each supply. The levels of the several sources at these reservoirs differed materially, that of the Anio Novus being 158·8 feet above the level of the Tiber; while of the six other aqueducts, three were above a level of 125 feet, and the other three standing at 82·5, 34·2, and 27·4 feet above this river, which at the city was 91·5 feet above the Mediterranean. Each reservoir, or *castellum*, had a triple cistern attached to it to receive the water. Three conduits, of equal dimensions, were connected in such a manner, that when the water was more than necessary for the supply of the outer, it was discharged into that of the middle, which served all the pipes of the public fountains; one of the mains supplied the baths, the other the private houses. The object of this contrivance was to provide first for the public wants, then the baths, and afterwards private individuals. "At the end of each of these three conduits was a receptacle whence the general distribution was made; at the sides were two others, to take off any superabundant quantity. By such an arrangement the various supplies were regulated with the greatest nicety. The total width of the *castellum* (of the Aqua Julia) is 115 feet. No expense was spared in the construction of these stupendous edifices, which, attached to the numerous aqueducts of Rome, must have resembled palaces. Built of squared stone, and lined with brick coated with a fine cement, every precaution was taken to prevent leakage or infiltration. The several conduits and pipes were provided with valves and cocks, for shutting off or turning on a supply to any direction." (Cresy's Encyclopædia, page 172.) Ample provision was also made for cleansing the several chambers by flushing ports, built in the centre, and secured by a plug or a cut stone. Every house in Rome was supplied with water, a portion of the expenses being met by private tax on each house. In many cases fountains were placed in the courts, and in others cisterns were used, either open or covered. These were supplied from the *castellum*, principally by earthern pipes, although lead pipes were much in use in Italy. Wooden pipes were sometimes used for economy; pipes of terra-cotta were also used, and iron pipes were not unknown. In some of the baths copper pipes were used, but seem to have been limited in number. The Romans seem to have preferred the earthen pipes for distribution, as they did earthen vessels for drinking, on account of their superior coolness and purity. The tubes were made not less than two inches thick, the end of one fitting into that of the other. The joints were coated with a mixture of quicklime and oil, the pipes resting on stone blocks, to keep them in line, and in some cases they were entirely coated with cement. In the city of Venice, all the springs met with in constructing the foundations of the houses were led into wells built to receive them. In the absence of a spring the wells were supplied by rain water from the roof, and these supplies failing, as they sometimes do, recourse is had to the main shore for supplies brought in boats. These subterranean reservoirs are very carefully built, lined with a peculiar clay of the locality, and preserve the water in coolness and purity. In other cities of Italy the population is supplied by public reservoirs, placed at different points throughout the city, at a level below the ground.

Turkey.—In the city of Constantinople, one of the covered reservoirs, or *cisternæ*, connected with the distribution system, still remains. It is constructed of brick covered with cement. It has a vaulted roof supported by marble columns, the cistern being 336 feet long, about 200 feet broad, and containing when filled to about 40 feet depth 25,000,000 gallons of water. Remains of these *cisternæ* are found in Rome, independent of the *castellæ*, which received the aqueduct supply. They are also to be found in Spain.

Judea.—The city of Jerusalem is still supplied in part from the pools of Solomon, which were cisterns or reservoirs of masonry, receiving an aqueduct discharge, and works of this kind characterise that country. The countries of Assyria and Persia, Babylon and other great cities, contained extensive provisions for water supply.

Peru.—In this country reservoirs were constructed by the Incas on the Andes, from which aqueducts were built hundreds of miles in length, exceeding in character those of Rome. One, in the valley of Condesuyu, is 400 miles long, and is still in partial use.

Mexico is also famous for the aqueduct of Chapultepec, and the line over Lake Tezcuso. It would appear from these statements that with the ancients the system of distribution, to each private house was not universally in use, the inhabitants being obliged to go to the *cisternæ* for their more immediate supply: and as in those cases on record of house distribution, the open fountains, open *limariæ*, or covered *piscinæ*, were at or below the level of the ground, and fully connected by waste pipes with the system of sewerage, it is evident that the system of distribution under pressure was not in general use, so far as an available head within the house was concerned.

Modern Europe.—In a large number of European cities, as has been also the custom in Canadian cities, and as was the practice for many years in New York, the population is supplied from the public fountains or other sources by water carriers. The supply of the Canal de l'Ourcq in Paris, was distributed in this way. In other cities, as in London and Hamburg, the supply is carried to the consumers by distributing pipes, under the pressure of stand pipes connected with pumping engines, reservoirs being used rather as reserves for fire purposes than for house service.

* From the Journal of the Franklin Institute.

London previous to the year 1582 derived its supply by individual resort to the Thames, to wells, and to suburban streams. About that time a tide-wheel was erected at London-bridge, which forced the water of the Thames into a cistern on a wooden building 120 feet high, from which leaden pipes carried its supply to several districts of the city, pipes of wood and stone being in occasional use at a later date. With this distribution service, under additional pumping power, which was mainly of wood up to 1810 and 1815, as also in other cities of England, the greatest head in the houses was limited to 6 feet above ground.

The character of the supply furnished the citizens of London by the nine water companies in operation previous to 1852, has this remarkable peculiarity, that it was carried on under what is called the *intermittent* system, or in other words, that each company subdivided its distribution district into convenient sections, but one of which was supplied at a time, and in no case more than once a day, sometimes not more than three times a week; and that the supply of water under the standpipe head at the engine-house was kept on each section for a daily interval varying from three-quarters of an hour to three hours, but very rarely as long as three hours. Notwithstanding the use of cast-iron distribution pipes, the elevation of this intermittent supply to the upper stories of dwellings was confined to the more expensive houses, and as a general rule, all the supplies were received in cisterns or other receptacles very near or quite below the street grade. In most cases the mains were supplied direct from the engines through the engine house standpipes, a process for which these standpipes were specially adapted. To receive and retain for use this alternate supply, all the better class of houses were provided with cisterns, or water butts of sufficient capacity for this purpose. No such provision, however, seems to have been made for the poorer classes, who were obliged to draw their supply from short standpipes placed in the several courts, one pipe of this kind serving for from 50 to 100 houses, the water being kept in the pails, jars, buckets, &c., in which it was caught. From the Parliamentary Reports on this subject of 1850, it appears that of 288,037 houses in the city district of supply, 17,456 houses, or about 6 per cent., were unsupplied by any direct means; in special districts the ratio sometimes being as high as 18 per cent. In the several Reports of 1850, 1851, and 1852, on the disadvantages of the present London supply, the objections to this peculiarity, which also prevails in many other cities of Great Britain, are clearly and strongly urged.

The New River Company has six subsiding reservoirs within the city limits, and uses six engine stations. Two are lined with brickwork, the others being excavated in clay bottom, with side slopes of 2·5 to 1, faced with broken stone for protection from wash. Two being 86 feet above Trinity datum, supply by gravitation. The highest surface is 430 feet. Their joint area is 50 acres; level, 82, 86, 112, 154, and 400 feet; contents, about 8·5 days supply, as an average, the highest holding one day's supply; joint contents, 120,268,176 gallons. Daily distribution in 1849, 14,149,315 gallons.

The East London Company has five subsiding reservoirs, at datum level, 30½ acres area jointly. Contents, 32,500,000 gallons. Lined in part with Kentish ragstone, brickwork and gravel. The sixth, lined with brickwork, on Stamford Hill, is 86 feet above, and contains 2,500,000 gallons. Daily distribution in 1850, 8,829,462 gallons; highest service, 120 feet.

The Southwark and Vauxhall Company has no reservoirs, except for subsidence and filtration from the Thames. Highest service, 185 feet.

The West Middlesex Company has two subsiding reservoirs from the Thames, of 16 acres area; a reservoir on Camden Hill, less than 1 acre in area, lined with brickwork, at 111·5 feet level, containing 3,456,000 gallons; and another on Barrow Hill, lined with brick, 1·5 acres area, contents 4,572,000 gallons, level 167·5 feet. Daily distribution in 1849, 3,334,054 gallons; highest service, 207·5 feet.

The Lambeth Company has a reservoir on Brixton Hill, lined with brickwork with paved bottom, level 105 feet, area 3 acres, contents 12,150,000 gallons, depth 20 feet; and another on Streatham Hill, with brick walls and clay bottom, level 185 feet, area 1·25 acres, contents 3,750,000 gallons. Daily distribution in 1849, 3,077,260 gallons; highest service, 350 feet.

The Chelsea Company pumps into a subsiding reservoir at low grade, 3·5 acresarea, 15 feet deep. It has a reservoir* at Green Park, with brick walls and paved bottom, 10 feet deep, area 1·5 acres, contents 3,000,000 gallons; and one at Hyde Park, with brick walls on concrete, area 0·75 acre, 7 feet deep, contents 1,021,000 gallons. Daily distribution in 1849, 3,940,730 gallons; highest service 157 feet.

* This reservoir has lately been removed.

The Grand Junction Company has one reservoir at Camden-hill, with slopes lined with concrete and brick paved bottom; area 1·75 acres, contents 6,000,000 gallons, level 123 feet. Daily distribution in 1849, 3,523,013 gallons; highest service 150 feet.

The Kent Company has three reservoirs, lined with concrete or Kentish ragstone: one at Greenwich Park, level 140 feet; one at Deptford, level 100 feet; and one at Woolwich Common, level 200 feet; joint capacity, 3,865,344 gallons. Daily distribution in 1849, 1,079,311 gallons; highest service, 220 feet.

The Hampstead Company has a joint reservoir surface of 35 acres. Daily distribution, 427,468 gallons; highest service, 215 feet.

The metropolitan district supplied by these nine companies is about 10·5 miles long by 8 miles wide; total average daily distribution in 1849, 44,383,332 gallons; population supplied, 2,156,417; joint elevated reservoir contents, 206,000,000 gallons. From these statements may be inferred the relation borne by the London reservoirs to the distribution service, as to elevation and capacity, and the general plan of arrangement adopted.

The new supply of the Chelsea Company at Thames Ditton embraces a supply and summit reservoir on Putney Heath, 6 miles from the engines and 165 feet level. It combines a double covered and a small open reservoir, the former for domestic use, the latter for park and street purposes. The former is in two divisions, 20 feet deep, each 310 by 160 feet surface; contents of both, 10,150,000 gallons. The inside slopes are 1 to 1, faced with concrete, with which the bottom is covered 1 foot thick. The roofing is of 8-inch brick arches on piers, with concrete filling in the branches, and covered with puddling. This supply inaugurates the *constant* system, or system of constant pressure for London.

Liverpool and *Glasgow* are examples of this system as in use in the United States. The Rivington Pike Reservoir is capable of supplying the former with 13,000,000 gallons daily; and for the latter the Ryat Linn, added to the Waulkmill Glen Reservoir, the one at 298·3 feet and the other at 283 feet level, 50 feet deep, hold 50,000,000 cubic feet of water, at a point 5 miles from the city. A filtering apartment is in use here, passing over 3,000,000 gallons per day. In cases of this kind, where flat bank slopes 3 to 1 are used, they are generally protected by rip-rap walls, or a mixture of furnace cinders and small stones with clay.

Notices of a few reservoirs in the *United States* will serve to illustrate the subjects of discussion.

The Beacon Hill Reservoir, Boston, is the most elaborate structure of its class. It is a rectangle, built above the street grades, the walls being from 41 to 58 feet high. The outside walls are built in solid cut granite masonry, with a heavy ornamental coping, the inner walls being of the same material, 5 feet thick at the base, on a concrete bed, and 3 feet at the top; the floor is paved with concrete 3 feet deep, and covered with two courses of brickwork. The level is 121·53 feet, depth of water way 13·5 feet, contents 2,678,961 gallons. The average depth in 1861, in consequence of extraordinary city consumption, was 9 feet.

The Murray Hill Reservoir, New York, is built in two distinct divisions, with retaining walls of heavy stone masonry, arched cells being constructed around the entire structure, behind the face walls; its coping grade is about 49 feet above the street. Its division wall is of concrete faced with rubble masonry, 18 feet wide at base, 7 feet at flow line, built on a concrete bed, and carried up to coping level. Its inner slopes, 1 to 1, are laid in stone masonry 15 inches thick, to 4 feet above bottom, whence they are covered with 12 inches of concrete, also continued over the whole floor. Its level is 112 feet; contents, 38 feet deep, 21,000,000 gallons; its inner size is 386 feet square. Its flow line is 4 feet below inner coping. Its ordinary depth is about one-third of its full depth.

Prospect Hill Reservoir, Brooklyn, is built in earthwork. The inner slopes, 1·5 to 1, are puddled 2 feet thick, covered with 3 inches of concrete, and 8 inches of brickwork to the top angle, which has a coping 3 feet wide, on masonry bed. The floor is puddled 2 feet deep, covered with 4-inch brickwork grouted. Its contents are 20,000,000 gallons, depth 20 feet, level 197 feet.

The Cleveland Reservoir is an embankment, with a base 21 feet above grade. Earth retaining banks are constructed 25 feet high, inner slopes 1·75 to 1, outer 1·5 to 1. The slopes and floor are covered with 2 feet of puddling, with a facing of brick masonry. Its depth is 20 feet, level 150 feet, contents 6,000,000 gallons.

The New Reservoir, Fairmount, completed in 1852, is of earthwork, with inside slopes of 1·5 to 1, lined with puddled brick-clay 12 to 15 inches deep, covered with a layer of concrete, on which 4-inch brick masonry is laid; at the foot of the slope the brickwork abutment is 8 inches thick; the bottom is puddled, covered with brick laid flat and grouted. Its water surface is over 4 acres, contents 20,321,392 galls., depth 16 feet, level 98·14 feet. This completes the group of five divisions for this district, which are used for subsidence and supply, and aggregate 47,218,028 gallons capacity.

The Belleville Reservoir, Jersey City, N.J., is of earthwork, with puddled slopes and floor, inside slopes 1·5 to 1, covered with concrete mortar and 4-inch brickwork, which is backed with rubble masonry for 5 feet below top angle, 18 inches thick. Level 158·83, contents 14,000,000 gallons, inner size 323 by 396 feet; level of force tube discharge 160·79.

The Louisville Reservoir is built in two connected divisions, in earthwork, the banks being carefully worked down; inside slopes 1·5 to 1, covered with 4-inch brick masonry, which is 8 inches thick to a point 6 ft. above bottom, the floor being puddled, and covered with two dry flat courses of bricks. Its level is 150 ft., depth of water 20 ft., division banks 12 ft. high, and 12 ft. wide at top; contents 7,000,000 gallons; height of standpipe 180 ft.

The Detroit Reservoir is built in two distinct divisions, with embankments of soluble clay, carefully made, with interior puddle walls. The inner slopes are 1·5 to 1, faced with 4-inch brickwork, commenced with the intended use of 3-in. concrete backing, which does not appear to have been completed. The upper wall was laid in a temporary manner. Its level is 77·5 ft., contents 7,592,704 gallons, depth 25·5 ft., flow line 3 ft. below top angle; division wall 10 ft. wide at top.

The Manhattan Reservoir, New York, is built in two distinct divisions of different areas and depths, which can be connected by a pipe 15 feet below flow line. It has earth embankments, with outer retaining walls of heavy masonry, laid dry and pointed with cement. Its interior slopes are 1·5 to 1, paved with heavy dry wall from the rock blasted from its bottom. The banks have interior puddled walls. Its depths are 20 and 25 ft., water suface 31 acres, contents 150,000,000 gallons, level 115 feet. The floor is partly on rock, and is not puddled.

The new Croton Reservoir, under the specifications of 1857, is built of earthwork, in two connected divisions, the top of division wall being 3 ft. below flow line. The banks, which are 15 ft. wide at top, and 4 ft. above flow line, have interior puddle walls; the inside slopes are 1·5 to 1, covered with an 18-in. dry wall laid on 8 ins. of small stones. The head of the division bank is protected by 18 ins. of rubble masonry on 8 ins. of concrete, carried with 10 ft. face down the slopes. The puddle walls are commenced on concrete beds, or the rock-face, the floors not being puddled. Its depth is 38 ft., water area 96 acres, contents 1,029,880,145 galls. (N.Y.), level 115 feet. In 1859, the plan of slope lining was changed for a wall of solid rubble masonry.

The Hartford Reservoir is small and irregular in form, built in earthwork, of compact material. Its inner slopes vary from 1·5 and 2 to 1, on different sides, and are faced with two courses of dry stone, each 9 inches thick. Puddle walls are built in the banks. Its depth is 30 ft., greatest inner length 395 ft., and width 187 ft.; contents 7,830,000 gallons, level 120·94 ft.

Ridgewood Reservoir, Brooklyn, is of earthwork, in two distinct divisions. The puddling is made 2 feet thick on all slopes excavated, and in walls in all embankments, being carefully connected with the floor puddling, which is 18 to 24 inches thick. The inside slopes, 1·5 to 1, were covered with a dry wall of 16 ins., and had a 6-in. backing of small stones for a depth of 8 ft. below flow line. This being injured by the action of surface waves in 1859, was carefully relaid where necessary, and pointed for a depth of several inches in cement. Its depth is 20 ft., water surface 25·61 acres, contents 153,956,402 gallons, level 170 ft.

The Brookline Reservoir, Boston, which is chiefly a natural basin, has its inner slope lined with dry stone 18 ins. thick, for a belt of 14 ft. in width. This width was increased on account of the action of surface waves and ice. Its depth varies from 14 ft. to 24 ft.; contents 89,909,730 gallons, water surface 6 ft. below top bank 22·31 acres, level of this surface 120·6 ft.

All the reservoirs of this country are arranged upon the constant service system, although instances occur of the use of standpipes, which are made to act as reservoirs under this principle, as in the Twenty-fourth Ward works at Philadelphia.

THEORIES OF CONSTRUCTION.

The object in presenting this rapid sketch of ancient and modern practice, is not for the purpose of describing the several details of arrangement, but rather to illustrate certain general and important principles which have been seriously neglected, and need to be specially recalled.

As to the use of reservoirs, it is obvious for many reasons (which we need not pause to discuss, although involving interesting questions) that between the practice of the ancients and many moderns, in the resort to street fountains or small house cisterns at low levels, and the system of intermittent supply, as in London—and the service with adequate distribution, under constant pressure, as with us—safety, convenience, and method strongly favour the latter. All the losses which it may involve in supply are fully compensated by attendant benefits, and these may themselves be guarded with proper care.

But the principles of arrangement which we may derive from and add to the practice of the ancients, may properly demand our first attention.

There is a general, and perhaps natural, popular impression that water, from our familiarity with its flow in large and small quantities, its common use, its value as a beverage, and its cleansing properties, is easily controlled and confined, and essentially clean and pure; but the engineer who has had to struggle with its enormous weight, its insidious and incessant or its abrupt and overwhelming energy, its exquisite mobility, and its wonderful solvent power, and who has studied the constituents of its natural state and the laws of its purity and impurity, understands the fallacy of this popular idea.

It is evident also, that nothing new has been learned on this subject in hydraulic theory, and not much improvement has been made in practice, since the Jewish monarch Hezekiah distributed, under pressure, the supply of Gihon into the city of David. New combinations of old things characterise present professional practice, much of which, as we propose to show, is degenerate.

All hydraulic constructions of the ancients were exceedingly substantial in character, many of them yet remaining in use. Their *castellæ* and *cisternæ*, as their aqueducts, testify to-day of the care exercised in stone and brick, in cement mortar and lining, and in proportions of construction. This may be defined as one prominent characteristic, which illustrates their knowledge of the element they intended to subdue and confine. As a second point, it may be noticed that their aqueducts and reservoirs of all classes were carefully covered; that distinctions in use were made in the qualities of water supplied; and that provisions were made for depuration.

We also observe that the scale of reservoir capacity has been greatly enlarged in modern times, involving a necessary change in materials; and that in the European school, and a few instances with us, reservoirs in earthwork, with artificial slopes, at less than the angle of repose, are protected by substantial water-tight lining. But these instances are rare, being the exceptions to a rule which cannot be approved, and which in practice has universally condemned itself.

The principle of constant service in itself involves the use of reservoirs of great capacity, since the consumers are not prepared for any loss of supply; the use of earth embankments for such reservoirs is in several respects advantageous, and a regard for economy in space and cost favours the use of artificial slopes. As constant service also requires elevated reservoir location, where losses and accidents are enhanced in importance, the question of propriety in construction with us is national. This question has two divisions—proper stability and proper depuration.

Stability.—All earthwork of artificial slopes in contact with water is exposed to absorption and solution under static pressure, a condition increased by relative head, and is readily disturbed when exposed to water in motion. Either action is injurious, and should be prevented. The solvent and penetrating power of water on an embankment is liable to produce threads and eventual streams of leakage, against which provision must be made. For this purpose puddling is applied. But puddling being in part or wholly composed of clay, is itself peculiarly liable to destruction from water in motion, and hence requires protection; and a very common practice is, to place heavy pyramid walls of it in the centre of embankments, by which the preserver of the earth is to be preserved by earth. This involves an error in principle, since the earth embankment, from its peculiar properties of resistance, is what is relied upon to sustain the enormous thrust of the water prism, and its figure ought not to be thus divided into three distinct bodies and states of body with two distinct kinds of material, of which the face of the centre body is so formed as to thrust the inner embankment towards the foot of the slope, in case it has any tendency to motion from saturation or otherwise. There is no propriety then in placing puddle walls within an embankment, for the protection of the embankment, nor is there any propriety in building the base of a puddle wall on the materials it is intended to protect, if such base is not extended over the water floor of the reservoir, so as to prevent leakage precisely where the greatest pressure makes it most apt to occur. Especially is it erroneous to build the foot of a puddle wall on a rock face, along which water readily finds it way, as water joints cannot be made between smooth rock faces, or wood or iron, and clay, with any degree of certainty.

Evidently, then, the stability of a reservoir of this kind depends as to this point on the integrity of its embankments, and these cannot be protected except by absolutely water-tight facing as to the inner slopes, and flooring as to the bottom, and for such facing puddling is not in itself sufficient.

The stability of a reservoir is affected by the relative force and volume of its inlet and outlet currents; by the saturation of its inner slopes, which exposes them to the action of the frost, to diminish solidity, to slides and to leakage: by the action of surface waves, which act as breakers, and are created and affected chiefly by the force and direction of winds, by area or length of travel, by relative shallowness of depth, and to which broken ice at times adds abrasive power; and by the action of muskrats and other animals of the kind. These several actions apply to the bottom, the slopes, and the top angles, as also to the embankment prisms.

The use of dry slope walls is, therefore, defective in principle, since they freely admit the passage of water into the banks, with all the effects of saturation, solvency, currents or waves, which such an open structure cannot but transmit, either to puddling or earthwork, to a greater or less extent. It is only in modification of effect that they are beneficial, and these benefits depend on their thickness and tightness, and the relative power of injury the water may have, under ordinary or extraordinary contact and agitation.

Puddling carefully made, from proper materials, and worked dry is in itself, as a compact homogeneous body, admirably adapted for transmitting to the prism slope of an earth embankment on the planes of its surface, when itself properly built or filled, the thrust of the water prism; and when thus laid on the slope it can be very conveniently and certainly united with the floor covering; hence the eminent propriety of its use in this way, and for this purpose. And from the obvious necessity of its protection from the water, follows the use of cement masonry, of solid and durable character, over its entire exposure.

The instances which abound in illustration of this theory of absolute protection, based on the best ancient and modern practice, ought perhaps to be discussed at length, but will be grouped here for the present. Of the list of United States reservoirs presented, only the first four are free from grave objections on this point in construction. When it was attempted in 1854 to draw down the Brookline reservoir, the saturated banks followed the water; when the Hartford reservoir was filled in part, the east bank slid out, forming a new slope, which was in part retained; when Ridgewood reservoir, in 1859, was filled less than 7 ft. deep, the surface waves, under March winds, washed out the puddled and earth backing, so as to require the entire rebuilding of a wide belt before the wall could be subsequently pointed, an event which changed the lining of the new Croton reservoir; in the Manhattan reservoir, as to its walls, a glance reveals the effect on the banks, although changes of water level are rare, and for the system of puddling, occasional rivulets of leakage on the ends, and the necessity of a large sewer on Fifth Avenue, are sufficiently argumentative; the Detroit reservoir, in 1859, which had embankment puddle walls, with a light and imperfect brick face, being drawn down because the upper bank was weakened, brought down the entire embankment face with it, and after considerable consultation, a massive stone abutment was built at the foot of the slope, and a dry stone wall, 6 ft. thick at the base and 2·5 ft. at the top, carried up, for the ostensible purpose of holding the slope in its place!

From these and other facts, which might be much more fully collated, and which are comments on a simple theory, it may be taken for granted, that no reservoir is properly constructed which is not water-tight in every direction subjected to pressure, and which is not fully protected as to its puddling and earthwork by substantial cement masonry; nor does the fact that such light covering as that of the Belleville, the new Fairmount, and other reservoirs, serves its purpose so far well, justify the hazard which is incurred in its use.

As in slope puddling it is necessary to use thickness enough to make a convenient working width, and as it is advisable in hydraulic work to avoid prolonged bed joints, and as 8 inches of brick masonry can be made much tighter than several times its thickness of stone, while the same thickness does not double the cost, I have preferred to use for reservoir slopes, 2 feet of puddling, faced with a layer of concrete, and covered with 8-inch brickwork, carefully coped, and adopted this plan for the contract of the Brooklyn Water Works in 1856, covering the bottom with the same thickness of puddling, with 4-in. brick paving, grouted. And with hard-burned paving brick, properly selected and laid in close joints, such lining must prove very satisfactory. The same principle may, however, be fully sustained with carefully built rubble masonry.

Depuration.—Not only does the ancient and the best modern practice use substantial cement masonry in reservoir lining, but with the former, as shown at Rome, Constantinople, Utica, &c., and to an important extent with the latter, as in the new Chelsea Company reservoir, and others which might be adduced in the European school, the water is carefully protected from the sun, and provisions are made for purification by filtration or otherwise.

In all natural water there are three classes of impurities, which differ in different localities only in degree, and these are the *mechanical*, the *organic*, or vegetable and animal, and the *mineral*. Chemical science, which has devoted much attention to this subject, and the abundant results of experience, have shown, that subsidence corrects the first class of impurities, that æration and fermentation correct the second, while the third may be modified by æration and filtration. From these leading principles we understand at once, that while all reservoirs are depurative by subsidence, as well as by filtration if used, and therefore tend to collect these heavier constituents, none properly fulfil their office in this respect which do not furnish for consumption a surface supply, and their value for subsidence depends on their relative storage and method of use. We also understand that heat, light, and air are the prominent agents on organic matter in water, which is also collected in reservoirs on account of its specific gravity, and that it is therefore advisable to prevent so noxious a condition as direct fermentation to a sensible degree. The third class is not so easily affected, but may be moderated in degree by the remedies for the others.

We see then that subsidence, filtration, circulation or æration, and exclusion of light and heat, are the correct processes for water depuration and preservation, and that the surface currents are of necessity the most pure, while the lower strata are of necessity the most impure. And we therefore comprehend the philosophy of the expensive provisions to these ends adopted in ancient and modern hydraulic practice. It is a question of great moment to determine how far, in our own school of economical engineering, these provisions are or may be observed.

For the extensive scale of many of our works, the use of covering, which ought never to be cheap and temporary, is almost beyond attainment, on the ground of cost; while we know that it would maintain coolness in temperature and freedom from storm waves. It is also plain that filtration by artificial means is in itself an expensive and unsatisfactory process on any large scale, from the necessity of constant renewals, if the process is at all complete in action; although filter beds like those in action at Glasgow and other places are simple in construction, are easily renewed, and do not add over one half-penny cost per thousand gallons for annual operation and interest of capital. The reliance, then, of our own school is confined to subsidence and circulation.

Examining the systems of reservoir construction and use, with us, we have by no means a gratifying series of evidence that due precautions have been exercised in this respect. The use of distinct divisions is the exception rather than the rule, and very rarely does it occur that consumers are supplied with surface

CONVENTIONALISM IN ORNAMENT.

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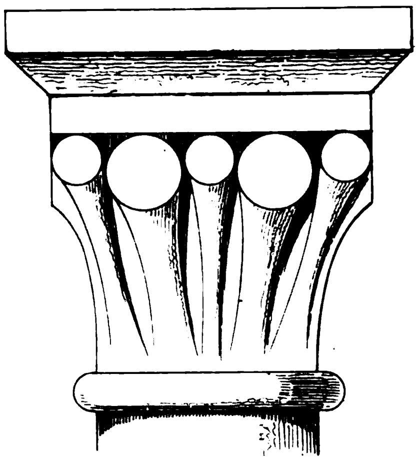

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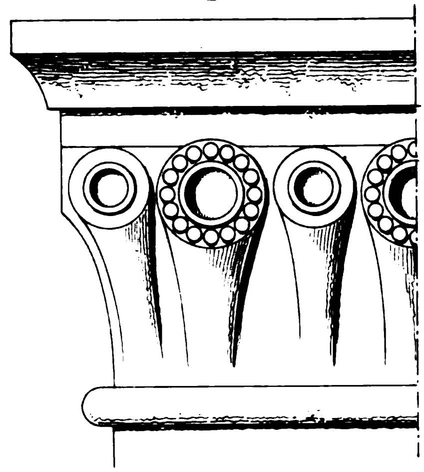
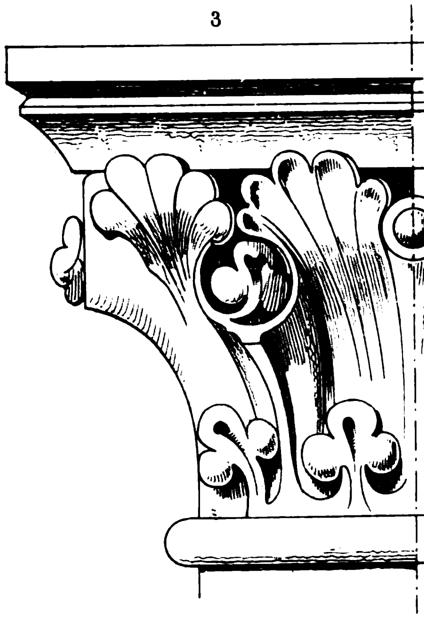


1. 2. 3. *Transitional Capitals from St. Davids*

3



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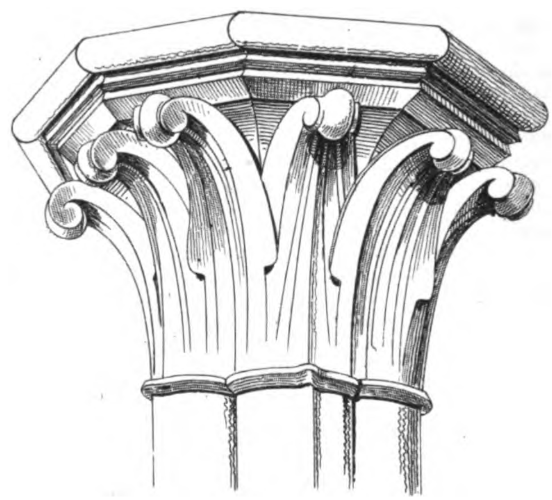

4. *Early English Capital from Llandaff*

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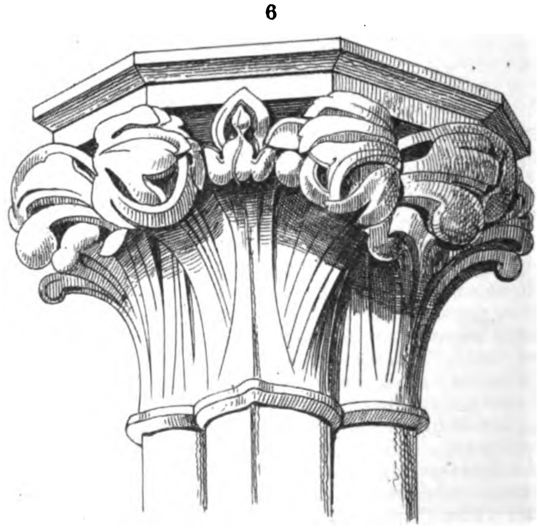


5 & 6 *Fully developed Early English Capitals from Llandaff*

water, which is the purest, but as a general rule, the reverse is the case, and the very process of subsidence carries into the pipes water much more impure than that of the fountain-head. In every such case, as to mechanical and other impurities, analysis will show, and has repeatedly shown, this improper effect. Hence the universal necessity of blowing off at the hydrants, the collections at dead-ends, the complaints common to all supplies, of causes independent of oxidation or other difficulties pertaining to distributing mains, and the knowledge in our houses of storms on the works by our drinking glasses.

But if this neglect is important as to mechanical impurities, it becomes still more so as to those which are organic. These are at all times objectionable, as infusoria, fungoids, fibrous matter, animalcules, and the like, for human imbibing, but become specially so when advanced by heat and light to a state of sensible fermentation, which is an effort of nature for self-depuration, and which is probably always at work in insensible degrees in all organic solutions.

If it be answered to this statement, that in warm latitudes the water and the sun have greater tendency to this action than with us, the question of degree may be admitted, but the facts in this case, derived from abundant English testimony, and from that of the supplies of our own country, are formidable in their warnings in this respect. At Boston, New Britain, New York, Brooklyn, Albany, Cincinnati, Pittsburgh, Chicago, Cleveland, Savannah, and other places, the records are unmistakable, and by no means of rare occurrence, and they are witnesses of well known chemical laws, which declare, that as all natural water contains organic matter, it needs watchful protection from its incident affections.

From this process of fermentation, which is frequently observed to be at work far below an inoffensive water surface, and from the plain advantages of aeration and surface supply, it is sufficiently evident as to the principle of use, that divisions are of great service in all reservoirs, and should be so arranged as to decant surface currents from one to another in succession, and that the use of a bottom supply is a direct violation of correct principle.

We also learn from evident considerations, that shallow reservoirs, and those of disproportionate storage to supply, are objectionable the moment a reasonable capacity for subsidence is passed. The propriety of covering the floors of reservoirs to prevent vegetation is also affirmed by numerous examples.

If, then, we do not cover our reservoirs, or use filtering chambers, or if we do, it is essential that their contents should be kept from contact with their earth embankments and flooring, that they should be deep and full, that circulation should be promoted by the use of several divisions, and that their supply should never be taken from the bottom; and no supply is, or can be, independent of great need of these simple and plain precautions, under any temperature.

CONVENTIONALISM IN ORNAMENT.*

By JOHN P. SEDDON, M.R.I.B.A.

(*With an Engraving.*)

THE rise, the maturity, and the fall of the Gothic style is strikingly marked by the energy, the luxuriance, and the languor successively observable in the ornament of those several stages, and it is an extremely curious fact that the plants copied in its sculptured foliage were in the same succession, the opening bud, the developed leaf and flower, and the flaccid seaweed or languid thistle tumbling into decay. The progress of Gothic architecture was itself one homogeneous growth, which ran its course from youth to age evenly and without marked breaks, although for convenience we have arbitrarily divided it into "Early, Middle, and Late Gothic;" and while we use the same nomenclature in describing its ornament, it must be borne in mind that they all insensibly arose out of each other, as the successive stages in the life of the plants themselves whence they drew their inspiration. This is very observable by merely turning over the admirable plates in the 5th vol. of Viollet le Duc's 'Dictionnaire raisonné de l'Architecture,' under the head of the article "Flore," which I heartily commend to the careful perusal of those desirous of following out this subject, as all who have to do with designing or executing ornament should do. He there gives in succession a sturdy capital of the date 1130 A.D., still half Romanesque, with its square abacus and lingering Corinthian arrangement, but with, instead of volutes, crisp stiffly-curled fronds of the fern, as the young plant pushes itself out of the ground with the full sap-vigour of the spring, and opposite to it he shows the natural type from which it was evidently conventionalised. Next you have the simple plantain leaves as gathered by their streams, and as orderly arranged round and closely clasping the bell of a capital, showing the method in which the peculiar treatment of the stems of the developed Gothic capital arose, and of which I shall have occasion to speak again; as also of the planting of the leaves on the extremities of the same, and later upon the horns which project from the capitals, and which were derived hence: these, by the way, while much copied at the present day, seem to be little understood. We next see the lily type, besides some of the glorious conventional ornament of the Early French style taken from it, and note the splendid character of the curves, strength in the stems, and the temperance throughout. We find as we proceed onwards to the complete Gothic, the full-fledged oak, ivy, maple, and vine; and lastly the nerveless seaweed, emulated in the florid extravagance of the Flamboyant, wreathed with all the grace and lack of self-restraint of its type, as flung hither and thither at the list of the waves. You may see the same for yourselves in the valuable collection of casts at the Architectural Museum, which possesses fine examples of all this same French ornament, and of course a still larger number of English examples, starting from our Norman or Romanesque, and thence onward to our insular Early English style, as at Lincoln and Ely, Stone Church &c., and the far finer work in my opinion of Wells and Llandaff, which are almost identical; the naturally treated foliage of the Decorated, and the crumpled nondescript work of the Perpendicular.

In point of conventionalism the Early Gothic is in all respects the finest, as indeed I believe it to be in comparison with every other class of ornament. I should give the palm, if it were necessary to choose between the several local developments, to the Early French, which indeed seems to be the favourite style of work among our Mediæval architects and carvers at this time: it is, *par eminence*, stone foliage. One would expect, if the Middle Gothic carved foliage of Rheims west frontal, or English Decorated work, were painted green, that an epidemic would soon appear among the cattle, which would assuredly browse upon it; but I suspect verdigris would be wasted upon the knobby branches at West Walton, or the stiff scrollwork upon stately Laon. All Early Gothic ornament is properly and sufficiently conventionalised, but there is a very great variety in its local developments. I have noticed a very broad distinction between that in the west and east of England, this is in its modelling and arrangement, for both are evidently from the same type—what it may have been I cannot say: many conjectures have been made, but I do not think it is a matter of importance, for whatever it may have been, it has not been followed into minutiæ. To the foliage of Wells Cathedral, being well-known, I may refer you, to show what I mean; although I consider that of Llandaff far finer, and I do not think I shall claim too much if I say that it is unsurpassed; but the whole of this western work is well worthy study; I found a most interesting series at St. David's in every gradation, from the Norman cushion capital to the enriched Early English of this particular class.* Curiously a great many capitals are left unfinished, and only boasted out, as if their carver had died, and no inferior hand had been allowed to complete his work.

The leaves of the Early Gothic foliage are mostly trefoils upon broad succulent stems, with occasional bosses of berries or buds; the external edges or boundary lines are as it were too small to allow of the space of the leaf to lie flatly between them, and the centre rib line is too long, so that the surface of the leaf is obliged to double itself up transversely and longitudinally. This peculiarity is much more marked in the centre than in the side divisions of the leaf, so that it is obliged to get into a regular dent in the middle, and the centre rib has to dive into it like a snake, and rise out again into a complete hump, before it can get to the end of the leaf as it ought to do; and if you can imagine the leaf to be one you could gather and press under a weight, it must be crumpled into folds: yet with all this complication, it is a perfectly symmetrical leaf, at least it is evident that its rib is central, with similar halves on either side. It is true that there are often more

* Concluded from page 221.

* But at Llandaff are the purest and most graceful specimens I have seen, the bell of the capitals is unusually long; there are none of the transition specimens such as at St. David's, but there are some simple examples which seem to be conventionalised from the hart's-tongue fern with as consummate art as the richer and more elaborate ones.

leaflets on one side than the other, and constant variety in the forms; yet not more than you will find in the leaves of every ivy-bush, not two of which are alike, yet all of which point to a certain typal form and law of symmetry, and each leaflet has its centre rib and halves, and room to expand from its stalk. Now it may seem that I am pointing out very simple and self-evident matters, which all can see for themselves, yet I assure you I do not think that I have ever seen a single modern copy of this class of work in which all these essentials are not more or less neglected. Just the general effect has been attempted, with a certain degree of success; but examine any single leaf, and ten to one it has no symmetry, or its rib is carried down the stem all on one side, leaving too much room for the leaflet on one side, which therefore looks bloated, while the opposite one is altogether starved, and has no room, and looks stuck on afterwards as an after-thought, and the depression in the middle leaf is a mere gash, as if the chisel had been thrown at it; and the usual bulge on the side leaflets does not rise with the central fibre as it ought, but having got all into the wrong place, gives them the appearance of having the mumps. But when the group is a complicated one, take the trouble to look for the stems, and you will surely find that half the leaves have none at all; and whereas in old work you might unravel the whole group, the modern cap turns out to be a mere imposture, made to look like an old one at a considerable distance, but it will bear no close inspection. What, then, when you come to the late class of Flamboyant or Perpendicular leaves of the most complicated description, and which used to be the favorite class of work until the modern fashion for the Early Gothic came in. Look at an old poppy-head; among the thousand knobs and knots, rivalling its seaweed type in crumpled texture, all have their true meaning and form, and the leaves are symmetrical ones, that you seem as if you could gather and spread out if you took the same pains that is required to do the same with the natural specimens. But a modern poppy-head generally looks as if it were a structure of tape afflicted with a rash: try to unravel that, and you have a task which would have puzzled Penelope.

I remember seeing at Norrey, near Caen, a capital (an Early one, by the way) decorated with foliage evidently taken from a crinkled cabbage, in which all its marvellous modelling was rightly conventionalised and thoroughly worked out; nor need this seem astonishing, because a carver who can thoroughly draw and model a single leaf, can with more time and patience do the other also. Why then can, or rather, do not our carvers do the like (for I am sure they might easily do it)? For this reason, that they never take the trouble thoroughly to work out and conventionalise one of the simplest leaves. They will do you to order whole arbours of oak or ivy, or whatever you like. "Crinkled cabbage would be nothing to them; oh! they know it all by heart,—have they not learned their trade?"—though, by the bye, I cannot conceive where, for I never see in their studios any appearance of even the apprentices being set to draw or model from nature; occasionally one finds a cast of a natural leaf or two, and some casts from old work, and not too many of these either. There is not time now-a-days to study rightly anything; so the masters carve foliage, nay even figures, with angels and archangels to boot, like the German professor, from their innate consciousness of what they ought to be; and the apprentices carve from their masters' work, without so much as the wing of a goose being put before them to improve their ideal conception of the "mighty pens" of St. Michael; until they also have learned their profession, and become themselves masters in Israel. I will allow, indeed, that of late a school has arisen which gives us a very fair imitation of Early French Gothic conventional foliage, and one does rejoice much that so manly and vigorous a type should have been selected; but then it is not carried out as the old designers would have done, by seeking and developing for themselves fresh types from nature. So that it has already degenerated into mannerism; and in the search for piquancy, the leaves have begun to look like ornamental glove-stretchers; and I am sorry that in many otherwise fine works in the International Exhibition I notice there is a great admixture of an element that seems to me to be like the rococo of Louis XV., with its shells and knucklebones, over again. This is conventionality indeed, but that of a class that is "at variance with the strict canons of taste and propriety."

But I have been pointing out rather what is not proper conventionalism than what is, while I anxiously desire to give some satisfactory explanation of what is the "artificial treatment" which at the outset of this paper it was stated is "requisite to maintain consistency with regard to the material purpose and position of ornament," and having referred mainly to carving in stone, I will for the sake of simplicity confine myself to that. I think it consists principally of *knowing when to stop*, for I find that our own carvers understand conventional and natural ornament as two distinct irreconcilable things. If you ask them (as the committee of the Architectural Museum asked of those who competed for their prize for a capital from the hawthorn type) for conventionalised nature, they are utterly in the dark. They will reply, they can give you Early English or Early French, Decorated or Perpendicular, conventional ornament or natural—as you please; in which case you get either the ordinary copies of old work, or thin metal-like looking stuff, that provincial papers go into fits about, assuring their readers that the enlightened carvers in fine frenzy roamed all the woods and hedges in the neighbourhood, and immortalised every weed. But in the case of the hawthorn, for which the puzzling addition of conventionality was requested, in this instance, it was evident by the results of the competition that this was understood to mean that it was to be as unlike the real thing as possible, and the getting a spray of the plant to look at was deemed to be perfectly unnecessary.

Now to make in stone a good conventional copy of a leaf requires no search into innate consciousness, but simply to have a leaf before you, to select such features of it as can be well represented in the material, and to omit those that cannot be so. You can give the outline and form, then let us have it accurately and truly—but the thinness, leave that to the metal-worker. You can give the general modelling; be careful to give this truly—but not the minutiæ, which in the position your work is to occupy would be lost, or look finicking. We do not care for the jagged edges and veining on the surface,—give us the heart and spirit of the thing, the flow and the grace of the curvature. Do not let your leaves loll about, but be planted firmly on their stalks; and let the stalks be well rooted at their base, and spring as if they would go straight upwards until dragged down by the weight of the leaf, like a piece of whalebone with a stone at the end; then you will get a line like those in the draperies of the early painters of Italy. Attend to this, particularly in the stemming of the horns of foliage in the bells of your capitals, which are always right in old work, and always wrong in modern. And last, and not least, get gradation everywhere; for if you take sections through different parts of either leaf or stems of good class, you will find it never in two places alike, and always to have a clear, definite, and beautiful curvature; while you may cut across a modern stem in a dozen places, and hardly find the section vary, and one taken through the leaf generally resembles that through a dilapidated batter-pudding. The true and somewhat fair excuse for this hurry and want of precision in modern work is the competition, which forces a large amount of work to be done in a very limited time and for a very small price. Now architects have the remedy in their own hands: let them be content with a very little ornament, if necessary, and seek quality instead of quantity,—there is plenty of talent among our carvers, they only want to be shown what is wanted, and fairly paid for doing it, and they will soon be able to do it. But then architects must be able to show them what they really do require, and must learn to design and model themselves before they can teach others.

Better however than the best of foliage, is art that tells a tale, and expresses something more than dumb nature, however well it may be conventionalised; let us therefore determine to get as much as we can of sculpture and painting of a higher class into our buildings, then we can spare some of the foliage; but whatever we have, let us take care that it be of the best.

THE ECONOMIC CONSTRUCTION OF GIRDERS.

(*Continued from page* 233.)

GIRDERS OF GREAT SPANS.

In our last paper we arrived at the formula for the weight of a double girder,

$$G = \frac{Sk(W_2 + F)}{1 - Sk} \quad \dots \quad \dots \quad \dots \quad (3)$$

and from this we drew some general conclusions as to the ultimate spans.

We have now in the first place to determine the values to be assigned to F for given spans; F being the total dead weight of the portion of the complete structure required for one line of railway, exclusive of G, the weight of the bare girder.

The most anomalous part of the structure is that addition to the girders rendered necessary by their having to act in the secondary capacity of booms to the fabric, when engaged in resisting the lateral pressure of the wind; the webs in this action being represented by the strata of horizontal bracings.

Misled by the minuteness of this addition when the span is short and a considerable width is given to an openwork structure, we spoke of it as of such moderate amount that it might generally be treated as covered by the value 3·5 taken for the factor of safety; in extreme or peculiar cases alone a separate provision becoming necessary. Actual calculation has however pointed out to us that this addition becomes so very considerable as the spans increase that, although doing so mars the simplicity of the investigation, we must make an independent allowance for it.

Notwithstanding this modification in our views, we still consider that the general factor of safety should be taken of a uniform value (3·5) for cases in which the dead weight amounts to more than a certain percentage (71·4) of the movable loading. Any apparent excess of strength that this may give for the girders of the longer spans will probably be required to counteract the greater destructive effect of the wind, arising from the virtually increased suddenness of application, and the increased chance of the wind impulses corresponding with the oscillations of the structure.

The metal added to the girder, to resist the longitudinal stresses resulting from the lateral action of the wind, may for one double girder be represented by the letter E. This is generally, but not necessarily, incorporated with the booms of the girder. It is to be remembered that E is to be treated as part of F, not of G; G must be taken for the weight of those parts alone which are directly employed in supporting the whole weight and loading acting vertically.

The amount of E will vary so much with the nature of the structure that any formula for it must be of limited applicability, and employed with caution; we shall endeavour however to arrive at one which will be suited to the general arrangement we have chosen for bringing out the comparisons—viz., two double openwork girders placed 27 feet apart from centre to centre, prepared for the support of a double line of railway at the lower level.

The resistances to the wind will consist of that offered by the structure itself, and that by the trains; estimating these by their amount per foot run of span, the latter will be constant, but the former will increase somewhat with the span, the sum of these resistances, which we may denote by the letter r, will be pretty accurately represented by this formula:—

$$\left.\begin{array}{r}\text{Resistance to wind in}\\ \text{tons per foot run...}\end{array}\right\} = r = \frac{1}{100}\sqrt{S} + \frac{1}{10} \qquad \dots \qquad (4)$$

The whole side pressure on the structure will be $= Sr$, therefore the sum of the stresses induced in each girder at the midspan will be—

$$= Sr\,\frac{S}{8\times 27} = \frac{1}{216}S^2r \qquad \dots \qquad \dots \qquad (5)$$

This is to be distributed between the two booms of each girder, and as it may be either a tension or a compression, according to the direction of the wind, we must estimate the portion taken by the lower boom as a tension, and the portion taken by the upper boom as a compression. If the roadway be at the lower level, considerably more than the half will be brought upon the lower boom; but for our present purpose we do not need to determine the proportions in which it is dealt out to the booms, since to cover the expense of material for joint-plates, loss by rivet holes, &c., we may take the same allowance of metal for the resistance of compressive and tensive stresses—say one inch for every four tons. The whole stress then divided by 4 gives us $S^2r \div 864$ as the sum of the additions to be made to the sections of the booms of each girder at the midspan. Now the booms being otherwise strong at the extremities, we may calculate the additions made to the sections at other parts of the span as in exact proportion to the stresses; therefore the total increase of weight in the booms will be given by this formula, E being the increase of weight in tons for the whole of the double girder—

$$E = \frac{2}{3}S\times 0{\cdot}0015\times\frac{1}{864}S^2r = \frac{S^3r}{864000} \qquad \dots \qquad (6)$$

The following table will give an idea of the importance of these additions:—

TABLE I.

Span, in feet.	r, in tons.	Increase of section at the midspan in sq. inches.	Increase of weight or E, in tons.
100	·200	2·31	0·23
200	·241	11·11	2·22
300	·273	28·11	8·40
400	·300	55·55	22·22
500	·324	93·72	46·86
600	·345	143·7	86·22
700	·365	207·0	144·90
800	·383	283·6	226·88

THE HORIZONTAL AND TRANSVERSE BRACINGS.

We have now to calculate the weight of these. The horizontal bracings may be arranged in two or more strata. When the number is more than two, that is when, besides the bracing at the top and bottom of the girder, one or more bracings at intermediate heights are introduced, part of the metal E treated of above as generally incorporated with the booms must be detached therefrom, and affixed where the horizontal bracings join the web. The existence of intermediate strata will strengthen the struts of the web, but may occasion the consumption of some more material in the horizontal bracings themselves; which however will be compensated by a saving in the transverse bracings.

In the principal stratum of horizontal bracing, or that at the level of the roadway, some saving may be effected by making use of the transverse girders as struts.

In very many cases a considerable saving of material will arise from making the parts of a horizontal bracing *double-acting*, so that every part will be of use, on whichever side the wind may blow. This saving will become more significant the greater the stress to be conveyed, since the efficiency of the parts to act as struts becomes thereby greatly augmented. The saving on this account in large structures (the lengths of the parts being nearly constant) is so important that it may be looked upon as fully counterbalancing the increase in the value of r, as exhibited in Table I. We consequently find that a very simple formula will express with sufficient accuracy the weight of the horizontal and transverse bracings, taken together and estimated very liberally.

$$\left.\begin{array}{r}\text{Weight of horizontal and transverse}\\ \text{bracings for each line of railway...}\end{array}\right\} = S^2 \div 8000 \qquad (7)$$

The results for various spans will be found in col. 3 of Table II.

THE TRANSVERSE GIRDERS OF THE ROADWAY PLATFORM.

If these are made pretty deep, and placed, say 6 feet apart, we may take them with fastenings complete at 1·8 ton each; this is equivalent to 0·15 ton per foot run for each line of railway.

THE PLANKING, LONGITUDINAL BEARERS, &c. OF TIMBER.

We may take the united sectional area of these at 12 feet for the whole bridge, which with an allowance for fastenings, and a protecting coating of sand &c., may be estimated as amounting to 0·15 ton per foot run for half the width of the bridge, or for one line of railway. The total roadway platform, &c. which constitutes the constant portion of F, may then be estimated as follows, for one line of railway, or per double girder.

Transverse girders	0·15	per foot run
Planking, balks, &c.	0·15	,,
Permanent way	0·06	,,
Handrail	0·01	,,
Total	0·37	

Weight of roadway platform, permanent way, including safety rails, &c., and all other dead weight excepting G, E, and the horizontal and transverse bracings,

$$= S\times 0{\cdot}37 \qquad \dots \qquad \dots \qquad \dots \qquad (8)$$

And therefore

$$F = E + \frac{S^2}{8000} + 0{\cdot}37S \qquad \dots \qquad \dots \qquad (9)$$

The following table exhibits some of the values in tons of F and its components:—

TABLE II.

Span.		E.		H and T bracings.		Platform, &c.		F.
100	....	0·23	+	1·25	+	37	=	38·48
200	......	2·22	+	5·00	+	74	=	81·22
300	......	8·40	+	11·25	+	111	=	130·65
400	......	22·22	+	20·00	+	148	=	190·22
500	......	46·86	+	31·25	+	185	=	263·11
600	......	86·22	+	45·00	+	222	=	353·22
700	......	144·90	+	61·25	+	259	=	465·15
800	......	226·88	+	80·00	+	296	=	602·88

We now proceed to ascertain the values of k for various structures, treated with different values of the factor of safety.

Formula (2) gives us $k=\frac{G}{WS}$, wherein W represents the whole load supported, and supposed to be uniformly distributed over the span.

Let us first take, as perhaps the simplest possible example, a solid rectangular bar of wrought-iron; and let us assume that a bar one inch square placed on supports one foot asunder becomes destroyed, for all practical purposes, by a central load equal to one ton, or two tons spread uniformly over its length. Then calculating our elements for such a bar we have, G = ·0015 ton, W=2·0015 ton, S=1. And therefore

$$k_1=\frac{\cdot 0015}{2\cdot 0015}=\cdot 000749$$

$$\text{And } k_{3\cdot 5}=3\tfrac{1}{2}\,k_1=\cdot 002622.$$

The ultimate span to which such a bar could be extended without breaking down under its own weight, supposing no lateral disturbing cause such as the wind to exist, would be $=1\div\cdot 000749=1335$ feet. And the utmost span to which under similar circumstances such a bar could be extended, so that the factor of safety should not descend below 3·5, would be

$$=1\div\cdot 002622=381 \text{ feet.}$$

If the effects of the wind were introduced, these ultimate spans would undergo reductions, according to the narrowness of the bars.

In the above example the span is twelve times the depth. To show, in a simple manner, the influence of the ratio of the depth to the span upon the value of k, let us take the rectangular bar of double the above depth. For a bar 2 inches deep, say 2 inches wide, and 1 foot span, we have G=·006, W or the distributed breaking weight = 2 tons × breadth × square of depth=16 tons, S=1. Therefore

$$k_1=\frac{\cdot 006}{16\cdot 006}=\cdot 000375, \text{ and ult. span}=2667.$$

This latter bar has therefore double the economic merit of the other.

As another example, let us take the Conway tube The calculation of the value of k for this is rendered a great deal more complicated by having to consider the amount E, of the material abstracted to resist the wind-induced stresses. We shall, in the first instance, assume that no wind will act upon it. Taking then W_1 or the total dead weight=1112 tons (this is the same as in our calculation at page 194, but must be an under-estimate), and W_2=400 tons, we found T to be equal to 7·18 tons, and C=5·05 tons; so that the factor of safety, as measured from the tension, is$=19\div 7\cdot 18=2\cdot 65$ nearly. G may here be taken equal to 1050 tons, no value for E, but only keelsons, &c., which are not directly concerned in the girder action, having to be deducted. We have then F=62, W=1512. And therefore

$$k_{2\cdot 65}=\frac{1050}{1512\times 400}=\cdot 001736,$$

$$k_1=\cdot 000655, \text{ and } k_{3\cdot 5}=\cdot 002293.$$

And the ultimate spans (the proportion of depth to span=1:18·35, page 234, being maintained) would be as follows:—

With factor of safety=1,	Ultimate span=1527 feet
,, ,, 2·65,	,, 576
,, ,, 3·5,	,, 436·2

We see then that even were no such antagonistic force as the wind to exist, it would be almost impossible to construct the Conway tube with a sufficiently high factor of safety, the economic merit of the structure being so low; with a value of $k_{3\cdot 5}=\cdot 0022925$, S=400, W_2=400, and F=62, we find by formula (3) the weight of G alone to be$=\frac{\cdot 00917}{\cdot 00083}\times 462=5152\tfrac{1}{2}$ tons.

We offer the following as an approximate calculation when the effect of the wind is to be allowed for. At page 196 it was shown that the wind estimated at 30 lb. per superficial foot causes, at the edges of the booms, a stress of tension T equal to 1·875 tons, or eT=1·4 tons. Now here occurs the principal difficulty in the calculation; we require to fix upon a certain factor in computing the amount of E to be abstracted to resist the wind-induced stresses, but this factor should evidently bear some relation to the factor applied to the stresses produced by the vertical pressure of the total weight supported. If we demand for E, 1 inch of sectional area for every 4 tons of stress, although this is reasonable in itself, it would be out of all proportion to the stress to which the remaining material would be subjected by the vertical pressures; this great discrepancy being caused by the excessive weakness of the structure. We shall, therefore, give the results for different ratios of section to stress.

1st. When E is calculated at the rate of 4 tons per inch (that is for C and eT, but not to cover joint-plates), the wind stresses appropriate the $\frac{1\cdot 4}{4}$ part of the whole section at the midspan, or 503 inches; and the weight of the iron thus taken from G will be $=\frac{2}{3}503\times 400\times\cdot 0015$ ton $=201$ tons, to which we may add 49 tons for the proportion of joint-plates; this makes E=250 tons; F will therefore be=62+250=312 tons, and G=1050−250=800 tons; W_2=400, and W_1=1112, as before. And to obtain the value of the factor of safety, since the metal left for girder action is only$=\left(1-\frac{1\cdot 4}{4}\right)=\frac{2\cdot 6}{4}$ of that which gave T=7·18 tons, the value of T will now be$=7\cdot 18\div\frac{2\cdot 6}{4}=11\cdot 05$. The excess of T here given over the value 9·053, obtained at page 196, arises from the discrepancy above referred to. From these data we readily deduce the following factor of safety$=\frac{19}{11\cdot 05}=1\cdot 72$.

$$k_{1\cdot 72}=\frac{800}{1512\times 400}=\cdot 001323$$

$$k_1 = \cdot 000769$$

$$k_{3\cdot 5} = \cdot 002692$$

The ultimate span with this latter value (which corresponds with the proper factors of safety) would be only$=1\div\cdot 002692=371\tfrac{1}{2}$ feet. Showing that it would be altogether impossible to construct a bridge on the system of the Conway tube—having an effective depth like it of less than 1-18th of the span, which with a movable loading at the rate of 1 ton per foot of span, and subjected to a windstorm equivalent to 30 lb. on the superficial foot, would still have a factor of safety equal to 3·5—*unless the span were under* $371\tfrac{1}{2}$ *feet.*

2nd. When E is calculated at the rate of 6 tons per inch, the part of the midspan section appropriated amounts to 335 inches; so that, T being now equal to $7\cdot 18\div\frac{6-1\cdot 4}{6}=9\cdot 365$, the factor of safety against gravitation will have a value equal to $19\div 9\cdot 365=2\cdot 03$ nearly; and E, taken with the same proportion for joint-plates as before, amounts to 167 tons; therefore G=883 tons, and

$$k_{2\cdot 03}=\frac{883}{1512\times 400}=\cdot 00146.$$

This is a very near approximation to the true state of the Conway as calculated at page 196; we there have the factor of safety$=19\div 9\cdot 053=2\cdot 1$ nearly. The corresponding value of k will be given with sufficient accuracy from the above—thus

$$k_{2\cdot 1}=\frac{2\cdot 1}{2\cdot 03}\times\cdot 00146=\cdot 00151, \text{ say }=\cdot 0015.$$

From this we obtain approximately the ultimate span for the Conway tubes under their present condition of stress, &c.,

$$=1\div\cdot 0015=667 \text{ feet.}$$

We might proceed to find still more exactly the value of $k_{2\cdot 1}$ for the Conway, but it is not of sufficient consequence, since such would not be applicable to other spans, without a separate estimate of the value of F for each.

We shall now endeavour to arrive at correct values of k for openwork girders, such as described at pages 150, 164, &c., having a depth equal to 1-8th of the span.

When the span is short, the factor E may be neglected; and therefore G becomes identical with the weight of the girder. Consequently we have, $G = \text{tabular number} \times \left(\frac{S}{8}\right)^2$

For these girders, W_1 is$=\frac{1}{2}$S tons, W_2=S tons, $W=1\frac{1}{2}$S tons, and the factor of safety calculated from the most severely stressed parts is as nearly as may be=4. Therefore

$$k_4 = \frac{G}{WS} = \text{Tab. number} \times \left(\frac{S}{8}\right)^2 \div 1\tfrac{1}{2} S^2 = \frac{1}{96} \text{ of Tab. number}$$

$$k_1 = \frac{1}{384} \text{ Tab. number, and } k_{3\cdot5} = \frac{1}{109\cdot7} \text{ Tab. number.}$$

For the 1st and 9th forms (page 164) with the load at the lower level, the tabular numbers are respectively ·1078 and ·1010. Consequently the values of k are as follow:—

First form	k_1=·000281	$k_{3\cdot5}$=·000983
Ninth form	k_1=·000263	$k_{3\cdot5}$=·000921

It has here been assumed that the allowances of metal in proportion to stress are the same for any span. The correctness of this will be apparent, when we consider that W, the total load supported, increases much more rapidly than the span; and if exactly the same pattern of girder were retained, would warrant an increase in the value of C for the bracing struts. As however it is necessary to provide a greater number of points of support to the roadway in long spans, it becomes necessary either to supply suspension rods, or to cut up the simple bracing into one or more series, the result being that, as stated in Prop. III., page 233, so long as the general character of the structure is retained, the weight G varies as S×W. Of course, we do not mean that this holds good with perfect exactness, but it is sufficiently accurate for the purposes of a general view of the subject. The value of k may then be obtained from any size of bridge, since it only expresses inversely the economic merit of any particular form of construction. As some readers, from not having sufficiently studied the previous articles, may not see very clearly how the above values of k have been obtained, we here offer a general approximate estimate of the weight of a double girder.

Estimate of the Weight of an Openwork Girder, having a Depth equal to 1-8th of the Span.

When the loading is assumed to be concentrated at the level of the upper or lower boom, the stresses produced in the corresponding bays of the two booms do not agree; thus, in Table X., page 149, the stresses in the central bays of the upper boom amount to only 22·5 units, while in the corresponding bays of the lower boom they amount to 24. Now in all such cases it is the greater stress which is given by the common formula—viz., stress in booms=WS÷8D; and the more numerous the series of bracings and the greater the number of triangles in each series, the more nearly will the stresses in the two booms correspond with one another; and it may be remarked that the stresses at the actual centre of the span are both really the same as given by the formula. This is a point of some importance when, as in Table XI., the lower boom has its central bay less strained than its central joint; in such a case the joint-plates must be of extra thickness compared with the plates. Let us assume, then, that the formula gives the central stresses with sufficient accuracy, the error will be on the safe side, and will most affect the shorter spans. The central sectional areas will be equal to WS÷8D.C for the upper, and WS÷8D.eT for the lower boom. Now if we could vary the sections in proportion to the stresses, the average sectional areas would be two-thirds of these central ones. We can, with some approach to accuracy, apportion the sections to the stresses to a considerable distance on either side of the midspan, but there are various practical objections to reducing the sections towards the extremities below a certain percentage of the central ones—we may take these limits at about 65 per cent. for the upper, and 35 per cent. for the lower boom. The resulting average sections are about 75 per cent. for the former, and 70 per cent. for the latter, and the amounts to be added for joints and rivets about 15 and 20 per cent. respectively; the top being understood to be built up of plates and angle-irons, and the bottom of bars without longitudinal lines of riveting. The weights of the booms will therefore be as follow, C and eT being taken equal to $3\frac{1}{4}$ and 4 tons respectively:—

Weight of upper boom,

$$= \frac{WS}{8D\,3\frac{1}{4}} \times \cdot75S \times 1\cdot15 \times \cdot0015 \text{ ton} = \frac{WS^2}{D} \cdot00004975 \quad \ldots \ldots (10)$$

Weight of lower boom,

$$= \frac{WS}{8\,D\,4} \times \cdot70S \times 1\cdot20 \times \cdot0015 \text{ ton} = \frac{WS^2}{D} \cdot0000394 \quad \ldots \ldots (11)$$

When $D=\frac{1}{8}$ S, these become respectively WS×·000398 and WS×·000315.

The Bracing.—When all the loading W is assumed to be transmitted through the bracing (this rather exaggerates the effect of the loading), then the braces at one end of the structure are altogether conveying a stress$=\frac{1}{2}$ W sec θ, and the length of each series of braces is=S sec ϕ. We may assume one-half of the braces to be struts, and the other ties; and if all the struts were retained of the same sectional area throughout the span, their total weight would be$=\frac{1}{4}$ WS sec θ sec ϕ ×·0015÷C, and similarly the weight of the ties would be equal to the same with eT substituted for C; and when $\theta=45°$, these weights would become,—

$$\text{Struts} = \frac{WS}{C} \times \cdot00075 \qquad \text{Ties} = \frac{WS}{eT} \times \cdot00075.$$

Now if all the loading were fixed or constant, and the sections everywhere made in proportion to the stresses, the average sections would be equal to half of the sections at the extremities of the girder, and consequently the weights equal to only half of the above. Practically, we may take the average section of the struts at 70, and that of the ties at 60 per cent. of the strongest, and allow for rivets and extra lengths 10 per cent. for the former, and 5 for the latter; so that, taking $C=2\frac{1}{2}$ and $eT=3\frac{1}{2}$, we have

Weight of bracing struts,

$$= \cdot7\,\frac{WS}{2\cdot5} \times \cdot00075 \times 1\cdot10 = WS \times \cdot000231 \text{ ton} \ldots \ldots (12)$$

Weight of bracing ties,

$$= \cdot6\,\frac{WS}{3\cdot5} \times \cdot00075 \times 1\cdot05 = WS \times \cdot000135 \text{ ton} \ldots \ldots (13)$$

Total Bracing ... ... =WS×·000366 ton.

And for the total weight of the girder we therefore have

Upper boom	= WS×·000398
Lower boom...	= WS×·000315
Bracing	= WS×·000366
Total of girder taken=S long, and without end pillars	= WS×·001079=G

Now since $k=\frac{G}{WS}$, we simply have k_4=·00108, k_1=·00027, and $k_{3\cdot5}$=·000945. Which results are sufficiently confirmatory of those obtained from the tabular numbers.

Let us now inquire what reduction can be made upon the values of k, by employing superior materials, greater depth, &c. From the foregoing investigation, we find the relative weights of struts to ties as follows:—

Struts of bracing	= ·000231	Ties of bracing	= ·000135
Top of girder	= ·000398	Bottom of girder	= ·000315
	·000629		·000450

Now, if we adopt steel for the ties, we may reduce the sections to one-half; and by selecting a suitable variety of hard wrought-iron for the struts, we may reduce their sections by, say 15 per cent. The changes are as follow:—

Proportional Weight of Girder when ordinary wrought-iron is used.		Proportional Weight of Girder when steel is used for the ties, and selected wrought-iron for the struts.	
Struts... ...	629	Struts	535
Ties	450	Ties	225
Total	1079		760

A corresponding reduction will take place in the values of k. Assuming the somewhat exaggerated value ·001 for $k_{3\cdot5}$ in ordinary wrought-iron girders, with a depth equal to 1-8th of the span, we have the following changes:—

Ordinary wrought-iron.	Steel and selected iron.
$k_{3\cdot5}$ = ·001000	$k_{3\cdot5}$ = ·000705
$k_{1\cdot0}$ = ·000286	$k_{1\cdot0}$ = ·000202
$k_{3\cdot0}$ = ·000857	$k_{3\cdot0}$ = ·000604
$k_{2\cdot1}$ = ·000600	$k_{2\cdot1}$ = ·000423

By increasing the depth of the structure, we may obtain still lower values of k: there are however objections to carrying this source of economy too far.

We have seen that the weight of the booms, compared with that of the bracing, is nearly as 2 to 1; if we increase the depth from 1-8th to 1-6th of the span, we reduce the stresses in the booms in the proportion of 2 to 1½, while the weight of the bracing, if we can retain the same values of C, is not affected, the whole weight of the girder is therefore reduced in the proportion of 3 to 2½, assuming the values of C and sT to remain unaltered; this would give us, when steel and selected wrought-iron are employed, the values of k as follows, k_1=·00017, $k_{2\cdot1}$=·00035, k_3=·00050, and $k_{3\cdot5}$=·00059.

For short spans it might be far from economical to make use of expensive steel and selected iron, but when we have to deal with very long spans, the ultimate saving of expense from their adoption will be very great indeed: this will be evident from an inspection of the values of G, in Table IV.

When, on the other hand, we diminish the depth of the girder, we increase in very nearly the same proportion the weight of the booms, without affecting very materially that of the bracing. Taking, for girders having a depth equal to 1-8th of the span, $k_{3\cdot5}$=·001000 as a standard, and estimating in this manner the weights for other proportions, we get the following values of k for openwork girders of good ordinary wrought-ironwork.

TABLE III.

Ratio of span to depth.	k_1	$k_{2\cdot1}$	$k_{3\cdot0}$	$k_{3\cdot5}$
6	·000238	·000500	·000714	·000833
8	·000286	·000600	·000857	·001000
10	·000334	·000700	·001000	·001167
12	·000381	·000800	·001143	·001333
14	·000429	·000900	·001286	·001500
16	·000476	·001000	·001428	·001667
18	·000524	·001100	·001571	·001834
20	·000571	·001200	·001714	·002000

From defects of this method of deriving the weights, the values in the table for the shallower girders must be considered somewhat exaggerated.

We may now offer an example of the complete calculation of the weight G, of the whole of one double girder, and of the half of the complete viaduct for two lines of railway. Let S be taken equal to 400 feet as in the Conway tube, then W_2=400 tons, and by Table II., E=22 tons, and F=190 tons; therefore, when $k_{3\cdot5}$ is taken=·001, we have

$$G=\frac{Sk}{1-Sk}(W_2+F)=\frac{\cdot4}{\cdot6}\,590=393 \text{ tons;}$$

Complete girder or G+E=415 tons.

Share of complete structure due to one line of railway, including timber, &c. .... } = G+F = 583 tons.

This is a very satisfactory result to contrast with the 1112 tons of the Conway, when we bear in mind that the factors of safety are respectively 3·5 and 2·1.

A fairer comparison will be given by adopting a factor of safety equal to that of the Conway—viz., 2·1; although this will still be unjust towards the deep openwork structure, in so far as the value of F is unduly high when such a factor is employed.

With a factor=2·1, and ordinary good iron, we have seen that $k_{2\cdot1}$=·0006; so that $G=\frac{\cdot24}{\cdot76}\,590$=186 tons only, showing the great influence which the value of k has upon the weight of very long girders. G+E=208 tons, and G+F=376 tons instead of 1112 tons. By the employment of steel and selected iron, and a depth equal to 1-6th of the span, we have shown that $k_{2\cdot1}$ might be reduced to about ·00035. This gives us

$$G=\frac{\cdot14}{\cdot86}\,590=95 \text{ tons, } G+E=117, \text{ and } G+F=285 \text{ tons.}$$

The adoption of such a structure as this, though showing the same general factor of safety as the Conway tube, would not of course be advisable. Let us see what is the lightest that might be recommended. Many engineers believe that a factor=3 gives ample surplus strength in large structures. Now the value of k_3, when steel and selected iron are used, along with a depth equal to 1-8th of the span, is=·000604. Consequently, for a span of 400 feet, we have

$$G=\frac{400\times\cdot000604}{1-400\times\cdot000604}(W_2+F)=\frac{\cdot2416}{\cdot7584}\,590=188 \text{ tons.}$$

Complete double girder ... = G+E = 210 tons.

Half of complete structure, fitted for two lines of railway, including timber, permanent way, &c. } = G+F = 378 tons.

With ordinary iron, k_3=·000857, and hence G=308, or 120 tons more than when superior materials are employed.

It then appears that, by employing an openwork structure having a depth equal to 1-8th of the span, the Conway tube, with a factor of safety equal to only 2·1 and weighing more than 1112 tons, could have been replaced by any of the following:—

1. A structure composed wholly of wrought-iron except the planking and other timbers of the roadway, which including timber, permanent way, &c., would, with a factor of safety also equal to 2·1, have weighed only 376 tons.

2. A structure as above, but with a factor of safety equal to 3, which would have weighed only 498 tons.

3. A structure as above, but with a factor of safety equal to 3·5, which would have weighed only 583 tons.

4. A structure composed of steel and selected iron for the girders, and ordinary iron and timber for the other parts, which with a factor=2·1 would have weighed only 310 tons.

5. A structure as above, but with a factor equal to 3, which would have weighed only 378 tons; or

6. A structure as above, but with a general factor of safety equal to 3·5, which would have weighed only 422 tons.

These facts have to some considerable extent been long known to a few; yet the public has been led to regard such structures as the Conway, Britannia, and Victoria Bridges with pride. Another generation may, with more reason, classify them—at least in so far as the *superstructures* are concerned—as perhaps the most expensive engineering blunders of the century. In the case of the Victoria Bridge however, all must admire the boldness, skill, and success attendant upon the founding and rearing of its piers of masonry in the rushing stream of the St. Lawrence.

TABLE IV.—*Containing the Values of G in Tons, corresponding with given values of k and S, and with the values of F given in Table II.*

Span in feet=	100	200	300	400	500	600	700	800	Ultimate spans in feet.
Value in tons of W_2+F, being whole load supported less G =	138	281	431	590	763	953	1165	1403	
Values of k.	Values of G.								
·0005	7·3	31·2	79·6	147·5	254	408	627	935	2000
·0006	8·8	38·3	94·6	186	327	536	843	1295	1667
·0007	10·4	41·0	115	230	411	690	1119	1786	1429
·0008	12·0	53·5	136	278	509	880	1483	2294	1250
·0009	13·6	61·7	159	332	624	1119	1930	3608	1111
·0010	15·3	70·3	185	393	763	1430	2718	5612	1000
·0012	18 8	88·7	242	545	1144	2451	...	...	833
·0015	24 4	120·	353	885	2289	8577	...	...	667
·0020	34·5	187·	647	2360	∞	...	...	...	500

Having obtained the values of G, as in Table IV., we can readily ascertain the weight of the complete girder, or that of half of the complete structure for two lines of railway, by simply adding the values of E or F contained in Table II. We give the following examples, in which k=·001.

TABLE V.

Span in feet ... =	100	200	300	400	500	600	700	800
G in tons	15·3	70·3	185	393	763	1430	2718	5612
Girder complete, or G+E ...	15·5	72·5	190	415	810	1516	2863	5839
Bridge complete per line, including timber, &c. = G+F =	53·8	151·5	316	583	1026	1783	3183	6215
Total load supported by the girder = W = W_2+F+G =	154	252	616	983	1526	2383	3883	7015

Edinburgh. R. H. B

ON THE ESTABLISHMENT AND MANAGEMENT OF COTTAGE IMPROVEMENT SOCIETIES

By W. A. Greenhill, M.D.

At the recent meeting in London of the National Association for the Promotion of Social Science, some very interesting and useful remarks were made upon the improvement of the dwellings of the labouring classes, by Dr. Greenhill, who, from his personal experience in connection with societies having this object, is especially qualified to convey information respecting the best means of establishing and conducting them. The importance of this subject induces us to make the following extracts:—

"It is unnecessary to urge the importance of attending to a poor man's house, if his social, physical, moral, and (it may even be added) spiritual welfare is aimed at—for this you have often heard before; neither is it advisable on the present occasion to speak on the actual construction of the dwellings—for this subject also has been largely treated of by persons better qualified than myself. We will therefore go on to the next stage of inquiry, and consider in what manner the requisite amount of suitable accommodation for the poor in this country can best be provided.

It should be stated that the following observations relate only to town populations. I have had no experience of agricultural districts myself; but from what others have said and written on the subject it would appear that there are so many important differences between town and country cottages that the same remarks will hardly apply to both. These remarks, therefore, are intended to relate to towns only; and first of all it may be better to mention (but in a very rough and general way) what amount of money may be considered necessary in order to effect the object mentioned above. Probably about £5000 for each 1000 inhabitants would be wanted. This calculation would, of course, require to be modified very considerably in different towns, and also in different parts of the same town; but perhaps it may serve for the basis of our discussion on the present occasion. It will also be borne in mind—first, that this money will not all be wanted at once; and secondly, that it is not meant to be sunk, but to be profitably invested. Nevertheless, this calculation, if adopted, would require in each town a large amount of capital: in Manchester, Liverpool, and Glasgow, upwards of £2,000,000 would be wanted; in London about £15,000,000 would do all that is absolutely necessary. The next question is, How is this enormous amount of money, required for the whole country, to be raised? for, though the greater part of it is already invested in small tenements, yet it will be necessary for almost all this class of property to change hands: and who are to be the purchasers? In this country little or no assistance must be expected from the Government. Large manufacturers may do (and in some cases have done) a good deal by providing suitable accommodation for their own workmen without any pecuniary loss to themselves, and with much indirect advantage in several ways. Private benevolence may do a little, for, according to the above calculation, even £150,000 would thoroughly renovate only one small town of 30,000 inhabitants. And upon the whole, it seems very doubtful, however much the habit of saving money deserves encouragement amongst the poorer classes, whether any great sanitary and moral advantages are obtained by enabling them to become the purchasers of the houses in which they live. Neither can we depend on being able to persuade many of the present owners of cottage property to carry out the necessary repairs, when the doing so will in most cases involve a pecuniary loss. So that altogether it would seem that joint-stock companies afford the best means of raising the necessary capital, besides possessing various other advantages which need not now be more particularly mentioned. It will not, therefore, be out of place if a few observations are offered 'On the Establishment and Management of Cottage Improvement Societies;' for certainly, if if we may judge from the numerous failures that have taken place, the subject must be considered to be still imperfectly understood; and, on the other hand, it is these very failures that have been one of the chief discouragements to the cause of house-improvement throughout the kingdom. There seems to have been a sort of revolution in public opinion on this subject. At first it was thought to be very easy both for philanthropic individuals and for societies to improve the dwellings of the poor without loss to themselves. After a time this was found not to be the case—so much so, that a few years ago it was by most persons believed to be impossible for a society to pay the shareholders a fair dividend; and those who consented to advance money for the purpose of estalishing such a society, said candidly that they looked upon it as so much given away in charity, or (commercially speaking) as money lost. But we may profit by the experience of the last few years, as well as by that of the earlier period alluded to, and the general result may perhaps be stated as follows—viz., that those who think it an easy thing to establish and manage a successful Cottage Improvement Society will probably still find themselves mistaken; but that, on the other hand, this, like other difficult things, is quite possible if it be done properly. And in order to do the thing properly, what is wanted? The answer is brief, but comprehensive:—1. Sufficient money; and, 2. Competent managers—on both of which points it is necessaay to say a few words.

First,— as to money, we may here safely follow the advice in Horace,

> ————'Rem facias, rem;
> Si possis, recte; si non, quocunque modo rem.'

Which may be freely translated as follows: 'First, get your capital; if you can, get it *recte, i.e.*, by a small number of shares of large amount, all fully paid up; if you can't manage this, then get it *quocunque modo, i.e.*, by debentures, or preference shares, or mortgage, or loan, or gift (for humble followers of Mr. Peabody may occasionally be found in the provinces as well as in the metropolis), or however you can; only be sure you get the greater part of your capital paid (or promised) before you seriously commence operations. You need not necessarily have much to begin with, and in fact it is better not to have at first more than is absolutely necessary, for you will then be more likely to manage it economically, and the temptations to extravagance in the establishment of a new company are manifold. No general rule can be laid down as to the best mode of raising the required capital.

Sometimes the money can be got in sums varying from £100 to £1000; sometimes it is easier to get it from a larger number of much smaller shareholders. In short, whatever appears to be the easiest and cheapest mode of raising the capital in any particular town, may be considered the best; for economy in such a society is a great virtue, and, even if everything goes on well the management is sure to require so much attention that it will be advisable to spare the promoter (or whatever his title may be) all the trouble that you can. There is one advantage connected with small shares that deserves to be mentioned, and that may in certain cases be considered to be more than an equivalent to the great increase of trouble in working the machinery of the society. The company (if successful) will serve as a sort of savings' bank for a poor man's earnings, which will not only pay him a better interest than the ordinary savings' banks, but also enable him to enjoy the satisfaction of making his capital useful to his brethren without loss to himself. (It will be noticed that it was said that the society, if successful, would afford the poor man this advantage; for it must be confessed that hitherto Cottage Improvement Societies have generally been supported only by persons to whom a slight pecuniary loss was no object.) However, if people have confidence in the promoter of the society, there will generally be no difficulty in getting together money enough to enable you to begin; and after that, if people see that the society is properly managed, there will generally be no difficulty in increasing your capital to almost any extent you please.

Second,—But now comes the second question. What *is* the proper management of such a society? A Cottage Improvement Society, if strictly private, may be said to be properly managed when the directors are able to fulfil, at least to a considerable degree, the duties they owe both to the shareholders and to the tenants; if the society goes a step further, and ceases to be a mere private partnership, there will be certain additional duties required by the public. In both cases it may be safely affirmed that it is generally far easier to get together the money required to establish the society than to find competent persons to manage it. The whole secret of the success or failure of the society will depend mainly on its management; so that, if you cannot find at least three or four persons fit to undertake this office, you had better not attempt to establish the society at all.

It is generally found easier by the directors to do their duty to the tenants than to the shareholders; at least, there has probably been no instance in which the tenants of a Cottage Improvement Society have not been much better off than those of an ordinary landlord. Indeed, the common temptation of the directors of such a society is to do for the tenants too much rather than too little, and to give them expensive comforts and conveniences which they are as yet quite unable to appreciate. The work of elevating the tastes and habits of the poorer classes must be attempted very gradually, or the landlord will be liable to constant disappointments, which might have been avoided by a different course of proceeding.

But besides the more obvious duties of the directors towards their tenants, which need not be here specified, as they are the very objects for which the society has been established, there are others which are not always equally practicable, and which are sometimes entirely overlooked. The tenants should not be regarded merely as persons who pay you a fair rent for a well-built or renovated house, but rather as your poor friends, almost as your parishioners, to whom it is both a pleasure and a duty to do all the good in your power. Here, again, there will be great need of judgment and common sense; but still there can hardly be a doubt but that frequent friendly intercourse between the directors and their tenants is a very important means of promoting the welfare of the society. The directors will also have an opportunity of encouraging the tenants to put their money in the savings' bank, or to belong to some friendly society, and to send their children to school; they can to a certain extent repress vice and immorality, and they can relieve cases of sickness or distress as they occur. All this can be done in some towns much better than in others; but there is none in which it cannot be carried out to a certain extent, and probably no society which would not be benefited by it.

With respect to the duty of the directors towards the shareholders, it is mainly summed up in the paying them a half-yearly dividend at the rate of not less than 4 per cent. per annum, and this (as you all know very well) it has not generally been found an easy thing to do. If the result is attained, the actual kind of machinery used is of comparatively little consequence, and all mere matters of detail may be allowed to vary indefinitely in different localities. In one town, where the society is looked upon chiefly as a charity, it will be thought very important to obtain the co-operation of the clergy; in another, where it is considered chiefly as a commercial company, their names among the directors will appear out of place. The matter of most importance is to take care that the utmost possible economy is practised both in the establishment and in the subsequent management of the society; for it is the neglect of this caution that has been the chief reason why so many societies have failed to make their operations remunerative, while private builders have had no difficulty in doing so.

Some societies limit their operations to one particular court or lane; others are always ready to purchase any suitable property that is offered in any part of the town. The latter mode of proceeding seems to be preferable in most cases, and will in general be found much the more economical. If you have determined to get possession of one particular row of houses, you will probably have to purchase some of them at an exorbitant rate; whereas, if you are not tied to any one locality, you will purchase only those properties which suit in price as well as in other respects. Another advantage that an extending society possesses over one that has in a manner finished its work, is this—viz., the greater life and activity and interest connected with its operations, when there is always fresh property to be purchased or repaired, or new houses to be built. In the one case, after the first novelty of establishing the society has gone off, its proceedings are apt to flag, and lose something of their vigour, from want of constant care and attention. In the other case it may be said of the society, that

'Mobilitate viget, viresque acquirit eundo.'

As it is important to pay the shareholders a dividend as soon as possible, in order to prove that the new society is worthy of some degree of public confidence, it is better to begin by purchasing old houses that require improvement, but are nevertheless inhabited, rather than by building new ones. In the former case, the revenue begins to come in as soon as the purchase is completed, and the first dividend may be paid within six or nine months after the capital has been contributed. In the latter case, much time is spent in the erection of the new houses, and the getting them fully occupied, so that it is generally not till the end of the second year after the establishment of the society that the first dividend is paid. Whether in the end it is more economical to renovate old houses or to build new ones may be doubtful, seeing that the expenses for current repairs have been reckoned in the former case at about double what they are in the latter; but, for the reason above given, whenever suitable property can be procured, it is certainly advisable to commence in this way, and indeed to continue the same plan, until the society is sufficiently firmly established to be able to bear without inconvenience the smaller immediate profits that generally come from new houses.

It is also generally advisable for a new society to begin with a small amount of capital, which may be increased from time to time as it is wanted, rather than to get together at first a larger sum of money than is needed for immediate use. The surplus, even if it be not swallowed up by unnecessary 'preliminary expenses,' is a loss to the society, as being so much unproductive capital, on which a dividend is being paid. In the same way it will be better to let the first purchase of property be small, or of moderate size; if blunders are made, they will be less expensive to the society, and when you have learned to manage thoroughly a small property, you will be better fitted to undertake a large one. Again, if you determine to begin by renovating old property, it will be better not to increase your difficulties (which will always at the outset, even under the most favourable circumstances, be quite enough) by making your first experiment with a block of houses so ruinous as to require an unusual amount of expensive repairs, or situate in such a neighbourhood that you cannot get respectable people to take them, while you will not suffer the existing tenants to remain. This advice may at first appear to be not only selfish, but almost unintelligible; for 'is not the physical and moral purification of such a block of houses the very object for which the society has been established?' Certainly it is, but not of this block only; and it is in order that the society may have the opportunity of doing away with the physical and moral filth of many such blocks of houses hereafter, that the above advice has been given. If you cannot pay your shareholders a fair dividend, you will find it difficult to increase your capital; and if you are not able to increase your capital, your sphere of usefulness will be limited to one single block of houses, instead of spreading over the whole district.

There are some other points of good management, which are too obvious to need more than a passing allusion, and which would not have been mentioned at all, but that they have been too often neglected; such are—the punctual payment of rents; the establishment of an adequate sinking fund in the case of leasehold property, and also of a reserve fund to meet unforeseen losses or extraordinary expenses; also the keeping an exact and accurate account both of the tenants and of the property of the society.

There is another point of especial consequence, though not especially applicable to Cottage Improvement Societies—viz., extreme care and exactness in keeping the accounts; but on this point also it is unnecessary to enlarge further than to recommend (particularly in the case of societies whose capital and property is constantly increasing) more frequent audits than are generally held.

It has been stated above that something is due from the society to the public, by which it is meant that the example of each Cottage Improvement Society is at the present time so important for good or for evil, that an additional responsibility is cast upon the founders, and an additional motive is supplied for using every endeavour to ensure success.

The above remarks contain only a very slight sketch of the different points to be attended to in order to manage the society properly. It could easily have been expanded; but perhaps it will be better if those persons who are thinking of establishing such a society will examine and criticise these observations for themselves, testing them especially by the experience of existing societies, as given in their published reports.

It may fairly be expected that a few words should be added on the results which might be anticipated from the large adoption of the course recommended in the preceding remarks. The general consequence would be, that in every town in the kingdom containing (say) 5000 inhabitants and upwards, all the cottage-property in the place would gradually fall into the hands of a society formed for the very purpose of promoting the moral and physical welfare of the poorer classes. In large towns the proposed society must (in order that the supervision of the houses and the tenants may be properly carried out) have branches situated in different districts, each managed by a sub-committee in connection with the general body of directors—thus combining the advantages of local knowledge and experience with the vigour and economy of a central organisation. The size of these branches may be allowed to vary according to circumstances, but probably the property purchased by about £50,000 would be quite as much as could be properly attended to by a single sub-committee. In cities of the largest size, it might possibly be advisable to have two or more societies, each with its own confederate branches. And lastly, with respect to this great metropolis, 'this enormous city' as Arnold calls it), 'grand beyond all other earthly grandeur, sublime with the sublimity of the sea or of mountains' from its very vastness—to this great metropolis the same machinery will equally apply, and in it the same principles of management may be carried out with an equal probability of success."

INTERNATIONAL EXHIBITION, 1862.

Machinery in General.

LABOUR-SAVING machinery and tools actuated by steam, water, air, electricity, and other motors, are special developments of our time, and are numerously represented in the present Exhibition. That mechanical arrangement which utilises the greatest amount of the applied force, and produces a complete required result, approaches most nearly to our notions of perfection. There are very few mechanical contrivances so complete that there is left no room for improvement. However from time to time machines and contrivances more and more complete are being introduced: so that ultimately we shall arrive at what may be termed engine *classification.*

The watch and chronometer furnish good examples of this gradual advance towards perfection; the steam-engine, and other machines, are even yet far from having attained this much to be desired completeness; yet the open road is still trodden by many skilful competitors, and ultimately the desired result will be achieved. The International Exhibition for 1862 presents but few contrivances of extremely novel character connected with mechanical engineering, but it offers to our notice what is far more useful, tools and machines more complete than those exhibited ten years since. When the steam-engine is as perfect in its way as the chronometer, then it will take its stand as a fixed machine, and will become what may be termed *classified.* The same may be said of other machines and tools. Then the nation that manufactures such tools and machines in the greatest number, while thus standing first in manufacturing industry, will thence acquire and exert an immense political and social influence for the common benefit of our race, and will themselves have attained at the same time the most advanced stage of civilisation.

In reviewing the machinery and engineering tools in the exhibition, it is not very material in what order we take them, as each mechanical contrivance must stand on its own merits, or fall by its defects.

MESSRS. MAUDSLAY, SONS, and FIELD exhibit (1926, Class 8) the splendid machinery constructed for H. M. armour-plated iron ship Valiant, consisting of a pair of *Horizontal Double Piston-rod Engines* of 800 H.P. (nominal). The cylinders are 82 inches diameter, with a stroke of 4 feet, and at full speed the screw will make about sixty revolutions per minute; the cylinders are completely encased in steam jackets, but the steam on its passage from the boilers to the slide-valves does not pass through the jackets, they are supplied from the main steam pipe by means of a separate system of pipes provided for the purpose. The glands of the piston-rods are fitted with an apparatus specially constructed for tightening the packing when the engines are in motion; it has been applied to the machinery of several of H. M. ships by Messrs. Maudslay, Sons, and Field, and has proved of great service: it is so arranged that without any care on the part of the person using it the gland must move perfectly parallel with the piston-rod, thus obviating all danger of a break down from its becoming jammed by being tightened more on one side than the other. The relief valves of the cylinders are so constructed that the engineer on watch can instantly ease them by hand without moving from his place on the starting platform: this arrangement is found to be very effective for large engines. Whenever water is present in the cylinders from priming or other causes, it frequently happens with engines not fitted with the above improvement, but which rely upon springs or weights on the relief valves, that the latter do not act quickly enough to allow a free passage for the water, and the cylinder ends have in several instances been fractured in consequence. The slide-valves of these engines are worked by the ordinary link motion, and they are double-ported, a method of construction which requires much less travel than the common slide, thus reducing the length of the links and consequently enabling the engines to be more quickly reversed.

The expansion gear, which is of a peculiar and very efficient description, consists of a revolving valve driven by means of gear work at the same velocity as the crank shaft, and with a perfectly smooth and uniform motion. The steam can be cut off at any requisite part of the stroke without easing the engines. This mode of working expansively was designed some years since by Mr. Field, to obviate the difficulties so frequently occurring in screw engines, with the usual arrangement of cams and reciprocating throttle valves or the more complicated system of expansion slides. The connecting rods and cranks are balanced by a weight attached to a wheel, which is fitted upon the after end of the crank shaft for the purpose of turning round the engines by hand when necessary.

All the important parts of these engines are visible from the platform, and are easy of access when under steam. Especial attention has been paid to the construction of the feed and bilge pump valve-boxes, so as to ensure all the valves being quickly and easily removed and cleaned, without stopping the engines; the safety of many vessels has been imperilled by neglecting these precautions. The boilers are of the ordinary tubular construction: they are arranged on each side of the ship, with the stoke hole in the centre.

Messrs. Maudslay and Co. also exhibit a model showing the arrangement of a three-cylinder Horizontal Double Piston-rod Engine (Mr. Charles Sells, chief draughtsman to Messrs. Maudslay, patentee), fitted on board H. M. frigate Octavia, of 500 H.P. and 51 guns. These engines were designed for attaining great economy of fuel, combined with uniformity of motion; they are fitted with surface condensers, an improved superheating apparatus (Mr. Field's patent), and complete steam jackets on the cylinders. The crank shaft is forged in one piece, the cranks forming an angle of 120° with each other; this construction places all the moving parts in perfect equilibrium, without the addition of weights for that purpose. The cylinders are 66 inches diameter, with a stroke of 3 ft. 6 in. The slide-valves are so constructed that the steam is cut off at one quarter of the stroke, without the use of a special valve for the purpose. They are worked by eccentrics fixed upon a revolving weigh-shaft, which is driven by a peculiar and novel arrangement of spur wheels, which enables the degree of expansion to be altered so as to cut off the steam at one-sixth of the stroke, and is also considered to furnish a safe and rapid mode of reversing the engines.

Messrs. Maudslay have received a medal for marine engines and models, "for general excellence of the engines, also of the collection of working models."

The Patent Double Cylinder, and Patent Annular Cylinder arrangement, invented by Messrs. Maudslay, Sons, and Field, were exhibited in 1851, and are well known to engineers generally, which accounts for their absence in this Exhibition. The extensive character of the operations of this firm may be gathered from the fact that they have fitted 414 paddle wheel and screw vessels, of an aggregate power of 87,000 horses.

Among the principal exhibitors of Marine Engines, presenting features of interest, are Messrs. Penn and Sons, Greenwich (1955); Messrs. Ravenhill, Salkeld and Co., London (1962); Messrs. G. Rennie and Sons, Blackfriars (1964); Messrs. R. Napier and Sons, Glasgow (1939); Messrs. Randolph Elder and Co., Glasgow (1939); Mr. T. W. Cowan, Greenwich (1830); Messrs. Humphreys and Tennant, Deptford (1891); Messrs. A. and I. Inglis, Glasgow (1896); and Messrs. R. Morrison and Co., Newcastle-on-Tyne (1936).

MESSRS. WILLIAMSON BROTHERS, Canal Iron Works, Kendal, exhibit (2026, Class 8) Vortex Turbines, an Improved Centrifugal Pump, and Blowing Fan. The *Vortex Turbine* is the invention of Prof. James Thomson, and has been very extensively applied. The large vortex exhibited is constructed to give 60 horse power on a fall of 45 feet, and is for a cotton mill in Yorkshire. There is a small vortex shown in motion, which is designed to use 50 cubic feet of water per minute on a fall of 8 feet, and serves to illustrate the position and action of the wheel when at work. The water is supplied to it by a centrifugal pump. In this turbine the moving wheel is placed within a chamber of a nearly circular form. The water is injected into the chamber tangentially at the circumference, and thus receives a rapid motion of rotation. Retaining this motion it passes onward towards the centre, where alone it is free to make its exit. The wheel, which is placed within the chamber, and which almost entirely fills it, is divided by thin partitions into a great number of radiating passages. Through these passages the water must flow on its course towards the centre, and in doing so it imparts its own rotary motion to the wheel. The whirlpool of water acting within the wheel chamber being one principal feature of this turbine, leads to the name "Vortex" as a suitable designation for the machine as a whole. The guide blades by which the required direction is given to the water previous to its entrance into the wheel chamber are usually four in number, and they are made movable on gudgeons near their points, so that the orifices may be contracted at pleasure to adapt them to any quantity of water less than the full supply.

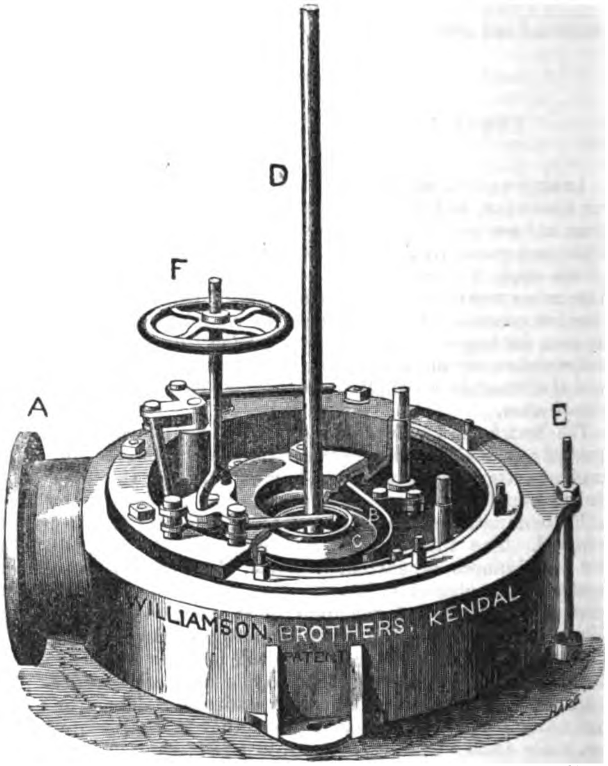
In relation to the action of turbines generally, the chief and most commonly recognised conditions of which the accomplishment is to be aimed at are, that the water should flow through the whole machine with the least possible resistance, and that it should enter the moving wheel without shock, and be discharged from it only at a very inconsiderate velocity. The vortex is in a remarkable degree adapted to fulfil these conditions. The water moving centripetally (instead of centrifugally, which is more usual in turbines) enters at the period of its greatest velocity (that is, just after passing the injection orifices) into the most rapid moving part of the wheel, the circumference; and at the period when it ought to be as far as possible deprived of velocity, it passes away by the central part of the wheel, the part where it has the least motion: thus in each case, that of the entrance and that of the discharge, there is an accordance between the velocities of the moving mechanism and the proper velocities of the water. The principle of injection from without inwards, adopted in the vortex, is considered by the inventors to afford another important advantage in comparison with turbines having the contrary motion of the water; as it allows ample room in the space outside of the wheel for large and well formed injection channels, in which the water can be made very gradually and regularly to converge to the most contracted parts, where it is to have its greatest velocity. It is as a concomitant also of the same principle, that the very simple and advantageous mode of regulating the power of the wheel by the movable guide blades already described can be introduced. This mode, it is to be observed, while giving great variation to the areas of the entrance orifices, retains at all times a very suitable form for the converging water channels.

Another adaptation in the vortex is claimed as being highly beneficial; by the balancing of the contrary fluid pressures due to half the head of water and to the centrifugal force of the water in the wheel, combined with the pressure due to the ejection of the water backwards from the inner ends of the curved vanes of the wheel, only one half of the work due to the fall is spent in communicating *vis viva* to the water, to be afterwards taken from it during its passage through the wheel, the remainder of the work being communicated through the fluid pressure to the wheel without any intermediate generation of *vis viva*. Thus the velocity of the water where it moves fastest in the machine is kept comparatively low, not exceeding that due to half the height of the fall. The inventor states that in many turbines the water attains at two successive times the velocity due to the whole fall. The much smaller amount of action or agitation with which the water in the vortex is said to perform its work effects a saving of power, by diminishing the loss necessarily occasioned by fluid friction. Further, the velocity of the circumference of the wheel is made the same as the velocity of the entering water, and thus there is no impact between the water and the wheel, but on the contrary the water enters the radiating conduits of the wheel gently, that is to say, with scarcely any motion in relation to their mouths. In the vortex a very favourable influence on the regularity of the motion proceeds from the centrifugal force of the water, which on any increase of the velocity of the wheel increases, and so checks the water supply; and on any diminution of the velocity of the wheel, diminishes, and so admits the water more freely; thus counteracting in a great degree the irregularities of speed arising from variations in the work to be performed.

When the work is subject to too great variations, as for instance in saw-mills, bleaching works, or in forges, great inconvenience often arises with the ordinary bucket water-wheel, and with other turbines, from their running too quickly when any considerable diminution occurs in the resistance to their motion.

The vortex represented in the engraving (Fig. 1) is shown with a portion of the cover broken away, in order that the internal arrangement may be seen. (A) is the supply pipe, by which the water is conveyed to the case. (B) one of the guide blades, of which there are four, for directing the water into the revolving-wheel (C); these guide blades are regulated by cranks and spindles from the hand-wheel (F), placed in any convenient position within the building. The revolving-wheel is keyed upon the

Fig. 1.



upright shaft (D), at the lower end of which is the pivot. From the upper end of the shaft, the motion is communicated to the horizontal shaft by bevel wheels. (E) is a lever for raising the pivot when necessary in consequence of wear.

When circumstances render it desirable, the vortex may be placed at any height less than about 30 feet above the tail race, the fall below the wheel being rendered available by suction-pipes descending from the central discharge orifices.

The vortex of 60-horse power is intended to be thus arranged, at a height of 30 feet above tail water:—The water is admitted from the head-race by a 30-inch pipe; and after passing through the wheel is conveyed by two suction-pipes into the tail-race. There is a sluice at the entrance to the supply pipe for shutting off the water, and the guide blades are regulated by a small hand-wheel above the vortex case. This arrangement is often very convenient, and in many situations it admits of the vortex being placed in such a position that the power can be taken direct from its own shaft, without any intermediate gearing.

Among the exhibitors of this description of motor are the North Moor Foundry Company, Oldham (1948); Messrs. Easton, Amos & Sons, Southwark (1844); Messrs. Donkin & Co., Bermondsey (1840); and Messrs. R. Roberts & Co., Adelphi, London (1968).

Messrs. Williamson also exhibit (2026) an "Improved Centrifugal Pump," with exterior whirlpool chamber. The machine consists of a sort of wheel, with an exterior case. The wheel is constructed with a middle plate, having a boss in the centre for fixing it upon the shaft, and two outer discs or covers with circular orifices, for admitting the water. Between the middle plate and the covers are fixed curved vanes, extending from the central orifices to the outer circumference of the wheel. The wheel being caused to revolve, the water entering at the central orifices is discharged into the exterior casing, and thence through a delivery pipe, placed tangentially to this case.

The essential improvement which the inventors claim to have introduced into these machines, consists in the addition of an exterior chamber round the circumference of the revolving-wheel, which is termed the "whirlpool chamber," and it is usually made about the diameter of the wheel. The water revolving in the chamber assumes the condition of a "vortex or whirlpool of free mobility," the principles of motion in which are said to have been first noticed by Professor Thomson, as described by him in a paper read before the British Association. The following is a brief explanation of its application in this pump:—It will be understood that the water, on leaving the circumference of the wheel, has unavoidably a high rotary velocity. This velocity is in all cases so great that the water carries away, in its energy of motion, a large part of the work applied by the steam-engine or other motor, which is wasted in friction, and adds to the quantity ejected through the discharge pipe.

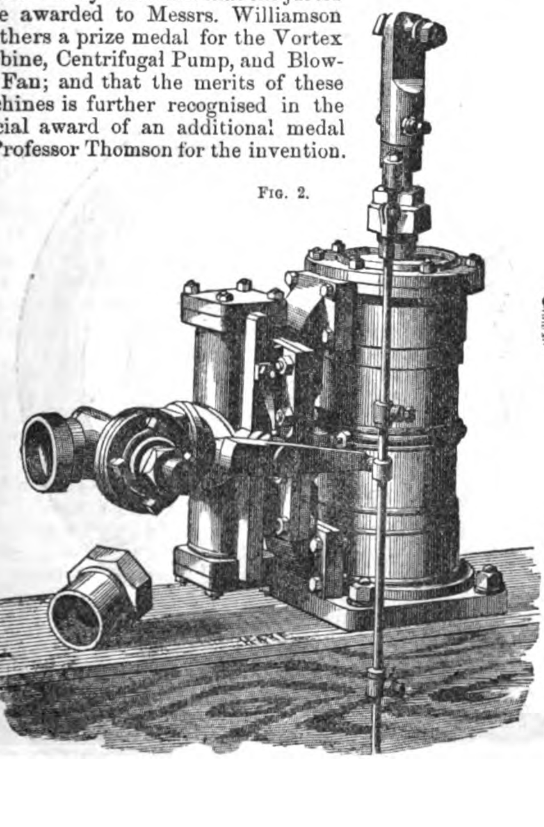
The object of the whirlpool, as applied in the pump under notice, is to utilise the work contained in the rapid motion of the water on leaving the wheel, or to employ it in increasing the efficiency of the machine. This is effected, in accordance with the principle of motion, in the "whirlpool of free mobility," by which each particle of the fluid forming it, as it passes from the centre of rotation outwards, gives up its velocity, and becomes subject to a pressure capable of causing it to ascend to a height corresponding to the energy deducted from its motion. This pressure necessarily adds itself to the outward force generated within the wheel. In this pump there is also provided an outlet chamber, arranged to receive the water from all parts of the circumference of the whirlpool, the outlet chamber is separated from the whirlpool by discs, which prevent any slowly moving or eddying water from breaking into and disturbing the whirlpool. The vanes are curved backwards, at such an angle as to admit the water freely and without shock, and all the parts are arranged so as to attain the highest efficiency in the working of the pumps.

The same firm also exhibit (2026) a *Blowing Fan* with exterior whirlpool. This fan is constructed on the same principle as the centrifugal pump previously described, the efficiency being in like manner greatly increased by the application of the exterior whirlpool. It is suited for foundries, smiths' fires, and other purposes where a powerful blast is required, and in all cases an important saving of power is effected by its use.

A *Vertical Column Steam Engine* exhibited by Messrs. Williamson, is simple in its arrangement; all the working parts are inclosed in one iron column, which gives great strength and steadiness, whilst all the parts are of very easy access. It was selected for description in the 'Encyclopædia Britannica.'

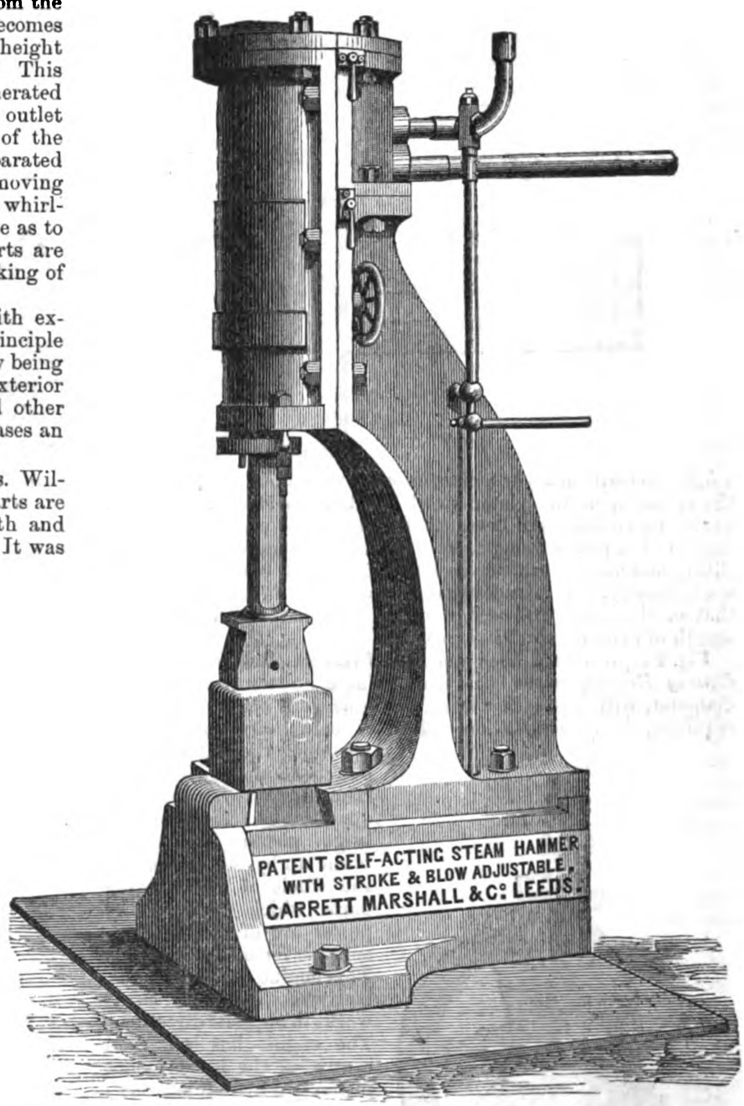
It is worthy of remark that the jurors have awarded to Messrs. Williamson Brothers a prize medal for the Vortex Turbine, Centrifugal Pump, and Blowing Fan; and that the merits of these machines is further recognised in the special award of an additional medal to Professor Thomson for the invention.

Fig. 2.



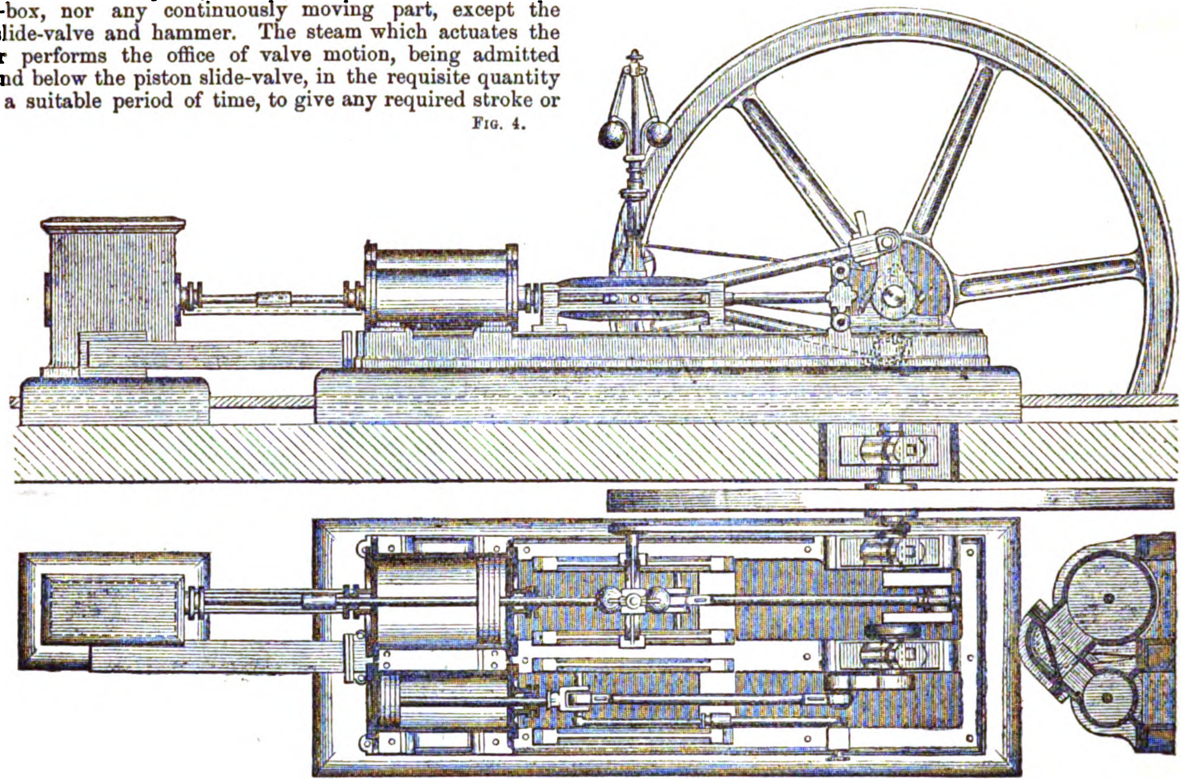
Carrett, Marshall & Co., Leeds (1813, Class 8), exhibit *Joy's Patent Organ Blower*, Fig. 2, applicable also as an Hydraulic Reciprocating Engine, for pumping, intensifying water pressure, working presses, as well as sawing, rubbing, grinding, polishing, ventilating, and working punkahs in hot climates. As organ-blowers they have been applied in numerous cases, both horizontally and vertically, self-regulating to all sizes of feeders, and working at any required water pressure; the wind-chest, being connected to the admission cock, regulates the speed of the blower. The sizes generally used for this purpose vary from 2 inches diameter, 10 inches stroke, to 9½ inches diameter, 10 inches stroke. The cylinders are all brass lined, and pistons, valves, faces, &c. are of brass; or the whole may be of brass. The length of stroke is adjustable. These engines can be constructed of considerable power, and to work at a speed of from 1 to 110 feet per minute of piston. They are applied, with modifications, to be worked by compressed air, for mining, coal getting, and tunnelling operations; and, by steam, for direct-acting sawing, pumping, boring, and percussive operations, where any required speed under 500 strokes per minute may be attained. The hydraulic reciprocating engines, worked by the pressure of the water of towns, may also be employed in connection with a compound hydraulic pump, to work presses in warehouses without hand labour, and for raising and lowering goods, and for 1, 2, and 3-powered water cranes. The Rotative power Hydraulic Engines consist of two or more actuating cylinders, and not a single one, as in the organ-blower, or hydraulic reciprocating engine.

Fig. 3.



The *Steam Hammer*, Fig. 3, is double-acting, thereby giving a powerful blow in a short space of time. The force of such blow can be regulated at pleasure; and the length of stroke can also be varied by adjusting the hand-wheel. This hammer appears to possess extreme simplicity, having no valve-motion, levers, or stuffing-box, nor any continuously moving part, except the piston slide-valve and hammer. The steam which actuates the hammer performs the office of valve motion, being admitted above and below the piston slide-valve, in the requisite quantity and for a suitable period of time, to give any required stroke or

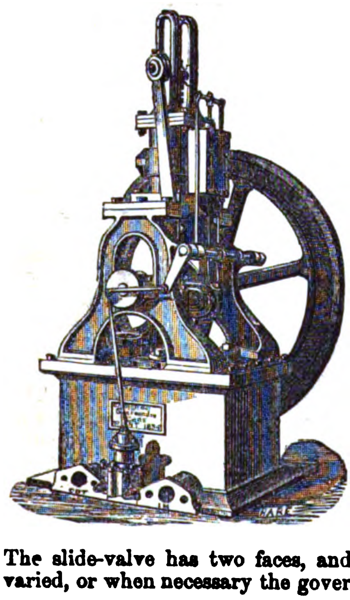
FIG. 4.



a *light blow* with lead, or a *clear heavy blow* without lead, retaining the steam upon the piston until the blow is struck. In these hammers, an increased bearance is given to the piston-rod by the depth of the piston being more than its own diameter. For steel tilting and other work, when some 400 to 500 blows per minute are necessary, this hammer has its parts even further reduced to that of the piston-rod and hammer-head, only with additional length of cylinder and guidance.

Fig. 4 represents a *High and Low Pressure Direct-action Condensing Engine*, by the same firm. The cylinders are 12½ inches diameter, with 2 ft. 3 in. stroke. The whole is on one base-plate requiring little foundation. Besides being direct-acting and portable, the air-pump is double-acting, and also combines the hot-well and condenser; the weight of the large piston is entirely borne up by the slides, and the whole of the working parts which transmit the power are of wrought-iron suitable for 60 lbs. pressure. This engine is strong, light, and well balanced, as it works in opposite directions. The engine has no dead centre, as the low-pressure piston is a little in advance, and in a position to receive the exhaust steam from the high-pressure cylinder at the time it ought to be set free. The cylinders are close together, and have but one slide to work them both with a short length of steam passage from the end of one cylinder direct to the other. The slide-valve has two faces, and its lead and stroke can be varied, or when necessary the governor is caused to regulate the

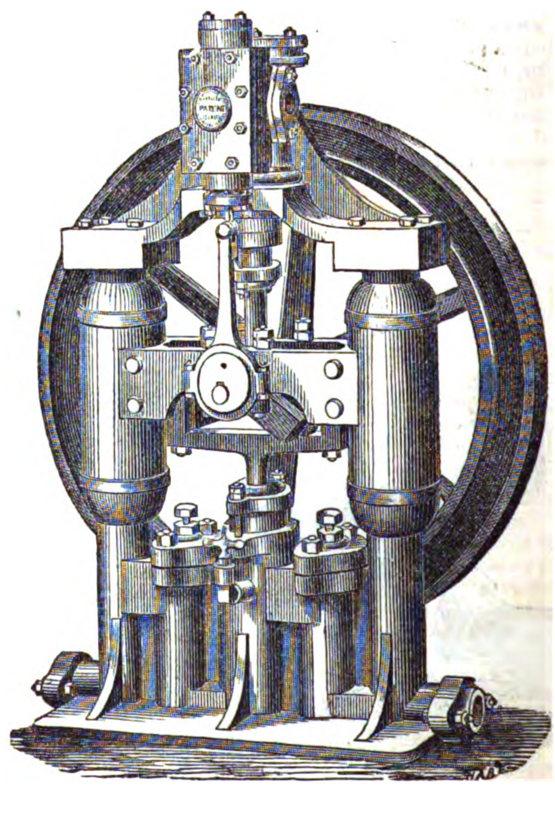
FIG. 5.



quantity of steam admitted into the cylinder at full pressure instead of its being throttled in the usual manner.

Fig. 5 is a *Stationary Fire Engine* to force 10,000 gallons, 125 feet high per hour; to be set to work at any moment, by steam from the ordinary boilers of a manufactory. The pump for this purpose, besides its air-vessels, is constructed double-acting, with 8½-inch working barrel and piston, and 6-inch ram, with valves of brass. The steam cylinder is 13 inches diameter,

FIG. 6.



and the engine is complete in itself, to which the pump forms the base of foundation. The former can be disconnected from the pump, and used as a motive-power for driving machinery, feeding boilers, and a variety of purposes, the pump being ready at any moment to be attached, in case of fire, and equal in power to two or three common fire-engines. *Steam Pump*, Fig. 6, is constructed for feeding locomotive and marine boilers. *Steam Pump*,

FIG. 7.

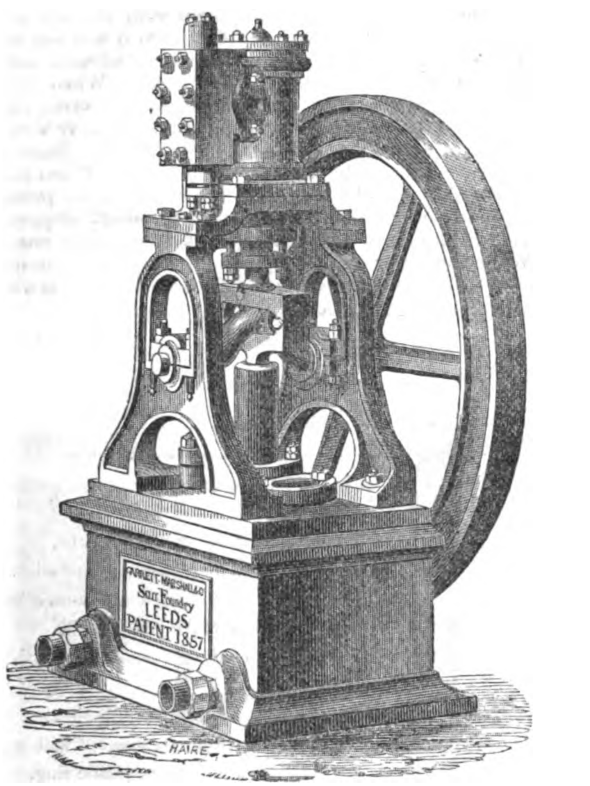
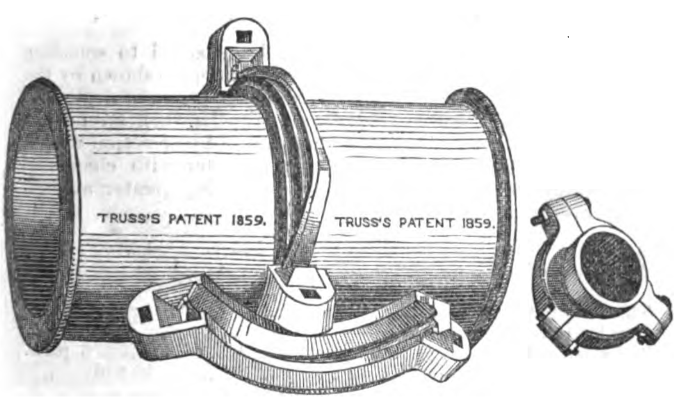


Fig. 7, is constructed for feeding stationary boilers of 50 horse-power. One of the latest applications of Fig. 6, with double-acting pump, is at Saltburn, near Redcar, forcing some 5000 gallons of sea water per hour 220 feet high, and 220 yards distance.

A medal was awarded to Messrs. Carrett, Marshall and Co., for steam engines, steam pumps, hydraulic machinery—general good arrangement and good workmanship. Also, honourable mention for an improved steam hammer.

Mr. T. S. Truss, C.E., Gracechurch-st., exhibits (2011, Class 8) *Pipe Joints* (fig.8) for hot water apparatus, gas and water mains, &c. These joints are constructed to facilitate the making of water-tight joints without the tedious method of caulking, being easily

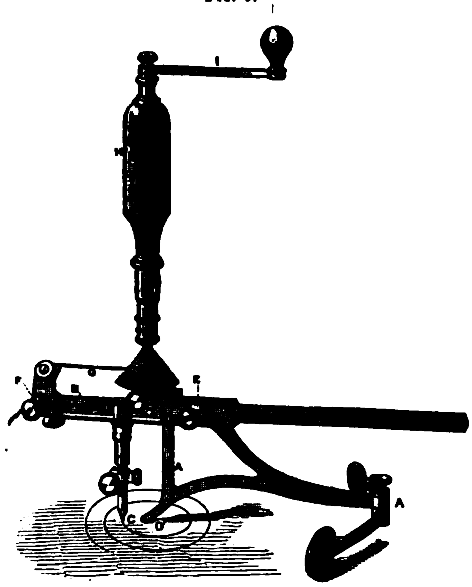
FIG. 8.



rendered capable of sustaining any required amount of pressure; and can also at any time be disconnected to allow of alteration or removal, and refitted, without injury to any of the parts. The pipes are cast with a bead at each end, upon which the ring of elastic packing (india-rubber or woollen felt) is placed, when the ends of the pipes are brought near together. The iron band, formed in three or more segments with two interior grooves corresponding with the beads on the pipes, is then placed around the packing and drawn together by means of screw-bolts and nuts, thus making the joint upon the tops of the beads. According to the width of the band and the interior grooves the joint is more or less elastic, resembling in action a ball-and-socket joint, and it is thus well suited to gas and water mains, which are liable to deflection; for which purpose it is in use for mains varying in diameter from 2 inches to 4 feet. The joint has been tested to a pressure of 1000 feet of water.

Mr. Henry Johnson, of Crutched Friars, exhibits (2920, Class 13) his *Volutor*, Fig. 8, for tracing spiral curves. This instrument has been contrived for the purpose of facilitating, by means of mechanical arrangements, the drawing of volutes, an operation that requires much time and care, and also the drawing of other spiral curves. During the action of the instrument a band is wound round its centre, which regulates the pencil, and thus a continuous curve is traced with a radius varying in length at every point. The radius of the curve is increased during each revolution by the circumference of the axis, and a circular cylinder will be found convenient as an axis for tracing spirals whose radii increase in arithmetical or other proportions. In drawing volutes a flat band may be used, wound round a cylinder, so that each coil incloses the preceding one, and increases the diameter of the axis; but a grooved cone appears to be more convenient, as the proportions of a cone and the distances between the grooves may be more readily adapted to the curves required. A stand with

FIG. 9.



wheels, A, moved round the central point O, supports a horizontal arm or bar B, and which moves through a horizontal tube D, on the stand. To the horizontal arm is fixed the tracing pencil C, pressed down by a vertical spiral spring. A steel rod rises through a perforated grooved cone (or other axis) and its handle H, and is furnished with a small winch handle I, by which the stand is made to revolve, while the cone is held still by its handle H; and a band G, one end of which is attached to the cone and the other to one end of the horizontal arm, is wound round the cone, and the end of the arm is gradually drawn towards the centre, and the curve is traced by the pencil. In volutes commenced at the extremity of the radius vector the band is attached to the base, and adjusted to the groove selected for the first curve, and is wound round the cone, approaching the apex as the instrument revolves. When tracing volutes commencing at the centre and receding from it, a movable set of pulleys F, should be fixed with a screw on to the outer end of the horizontal arm. One end of the band being fastened to the pulleys, and the other attached to the apex of the cone, it will be wound round the cone approaching the base, and the pencil will recede from its position in the centre, tracing the curve as the outer end of the arm is drawn by the band towards the centre. When variations of radius less than the circumference of the axis at each revolution are required, the effect of the band wound round the centre may be modified by passing it over some of the pulleys, one set of which, E, is fixed on the stand, and the other set, F, is movable, and may be screwed on to either end of the arm. The effect varies according to the number of lines of band over which it is distributed; as, for instance, when the band is passed over one pulley the effect is distributed over two lines, and the radius varies in a revolution one-half of the circumference of the axis; when the band is passed over two pulleys the effect is distributed over three lines, and the radius varies in a revolution one-third of the circumference of the axis, &c. When tracing the fillet of a volute, the cone should be turned round until the band is tightened, after the pencil has been placed in its proper position. The size of the axis is thus slightly altered, and a proportionate distance maintained between the curves. In drawing a parallel curve, as the size of the centres must coincide, it will be necessary to alter the length of the band to suit the position of the pencil.

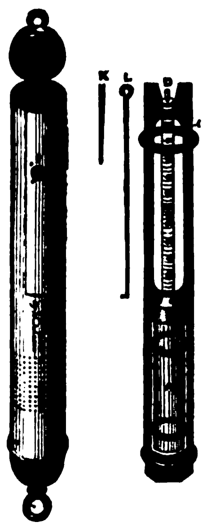
Mr. Henry Johnson shows also (2920) his *Deep Sea Pressure Gauge*, Fig. 10. It is well known that in deep sea soundings the pressure of water is too great to admit of accurate measurement by the compression of any highly elastic fluid confined in a small portable instrument. For a long period water was considered incompressible, but it has been found to possess a slight degree of elasticity, sufficient to render its compression in a vessel available as an indication of the compression or density of the water into which it is lowered. In the year 1762, December the 16th, Mr. Canton communicated to the Royal Society the results of his experiments on the compressibility of water—'Philosophical Transactions,' vol. lii., page 640. He took a small glass tube of about 2 feet in length, with a ball at one end of it of $1\frac{1}{4}$ inch in diameter, and filled the ball and part of the tube with water exhausted of air, and left the tube open, that the ball, whether in rarefied or condensed air, might always be equally pressed within and without. He placed the ball and tube under the receiver of an air-pump, and could see the degree of expansion of the water answering to any degree of the rarefaction of the air; and also placed the ball and tube into the glass receiver of a condensing engine, in which he could see the degree of compression answering to any degree of condensation of the air. In this way he found by repeated trials, when the temperature was about 50° Fahrenheit, and the barometer about a mean height, that the water expanded and rose in the tube, by removing the weight of the atmosphere, one part in 21,740, and that it was as much compressed under the weight of an additional atmosphere. More recently, Mr. Perkins found, when subjecting water to great pressure, a diminution in volume of $\frac{6}{100}$th parts under a pressure of 1120 atmospheres, equal to one part in 18,666 per atmosphere. The experiments of Mr. Perkins, exhibited at the Adelaide Gallery, appeared to be intended as a demonstration of the fact of progressive compression, rather than a basis for minute calculation.

The effect of pressure of water at great depths is illustrated by a very interesting experiment made by Rear-Admiral Sir James Clarke Ross, who, after lowering several bottles which returned to the surface with the corks reversed, lowered a bottle fitted with a tube; a cork being suspended in the bottle so as to enter the tube in the event of the water in the bottle being condensed under heavy pressure, and expanding upon the raising of the bottle and the diminution of the pressure. Upon the return of the bottle to the surface it was found that the cork had been forced some distance along the tube, and the compression of the water in the bottle, and its subsequent expansion, were thus demonstrated.

In experiments conducted with a pressure-gauge made of metal, it was found that air-bubbles adhered to the inner surface of the pressure-gauge, and materially affected the results. This difficulty is avoided in the instrument now exhibited, which is composed of glass, so that the absence of air-bubbles may be ascertained by inspection before any experiment is made. The instrument consists of a cylindrical glass vessel with a long neck or stem finely graduated; within which are placed a flat elastic ring to act as an index, and an elastic stopper.

When used, the pressure-gauge should be well rinsed with warm water, to prevent the adhesion of air to its inner surface, and then filled to the top of the stem with sea-water boiled to free it from air. In the event of this water being poured in while warm, it will be necessary to fill up the stem after the water has cooled down to the temperature of the atmosphere, so that the stopper may be inserted without confining any air beneath it. A small vent, or grooved needle, affording a passage for the escape of superfluous water, should be pushed in with the stopper, which should be slightly lubricated to prevent excessive friction, until the lower end of the stopper is coincident with the zero or top line of the graduated scale, marked 2000, when it will also touch the flat elastic ring. The vent should then be withdrawn, and the stem will remain tightly closed by the stopper. When lowered into water of greater density, the water in the pressure-gauge is compressed by external pressure until of equal density with the surrounding water, and the elastic stopper and the elastic ring are pressed along the tube towards the cylinder. When raised, as the external pressure diminishes, the water in the pressure-gauge expands, and gradually presses back the elastic stopper, the elastic ring remaining as an index to mark the extreme compression. When the water attains the temperature of the atmosphere the stopper will have returned to its original position, less a small difference arising from friction.

Fig. 10.



A. Cylinder.
B. Stem with graduated scale.
C. Flat elastic ring or index.
D. Elastic stopper.
E. Metal frame lined with caoutchouc.
F. Caoutchouc rings preventing concussion.
G. Caoutchouc rings at top and bottom of the case, securing the frame in position.
H. Metal hook on door fastening down the top of case.
I. Clasp to door, let in to avoid projection.
K. Vent or grooved needle inserted with stopper.
L. Hook used to draw up the elastic ring.

The volume of water in the cylinder and stem is considered as consisting of 2000 parts, of which the cylinder contains nine-tenths, or 1800 parts or degrees, and the stem one-tenth or 200 degrees, and which are numbered 1801 to 2000. The graduated scale on the stem may easily be read to one tenth of a degree, or $\frac{1}{20000}$th part of the whole volume of water. For the compression of one part in 20,000 of boiled seawater a pressure is required of 15·8 lbs. avoirdupois per square inch, equal to the pressure of a depth of 35·446 feet, or nearly six fathoms. This amount of pressure, which is the result of several experiments, and which is confirmed by the observations of Mr. Canton, appears to be a fair basis for the compilation of tables of comparison of depth and pressure.

The instruments should, however, be attached to sounding lines, and the indications compared with the depths shown by the lead. The results would form a table of comparison of depth and pressure of practical use in determining depths when strong currents render the use of the lead uncertain. A correction will be required for the variation in volume of water with change of temperature, and which is not uniform, being greater at high temperatures, as for instance—

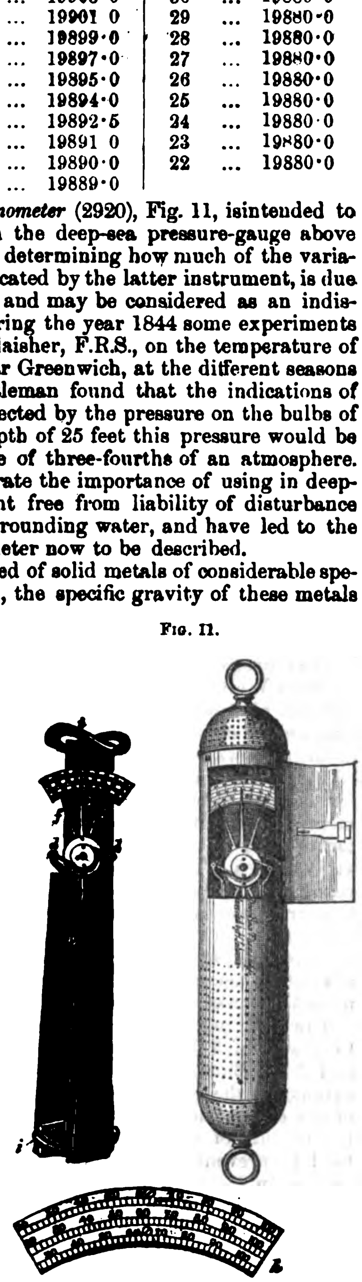
At 86° the volume is for this object estimated at ...	20,000	parts.
At 65° the volume is contracted to	19,932·5	„
The difference for 21° being	67·5	parts.
or for 1 degree 3·21 parts.		
The volume at 65° of	19,932·5	parts.
is contracted at 31° to	19,880	„
The difference being for 34°	52·5	parts.
or for 1 degree 1·55		

TABLE showing the variation in the volume of sea water, boiled to free it from air, with change of temperature. Thermometer 67·5° Fahr. Barometer 29·92. The volume at 80° being considered as unity, and divided into 20,000 parts. A gentle motion kept up to equalise the temperature of the sea water has prevented its freezing at 28·5°.

Deg. Fahr.	No. of Parts.	Deg. Fahr.	No. of Parts.	Deg. Fahr.	No. of Parts.
86°	20000·0	64°	19930·0	42	19888·0
85	19996·0	63	19927·5	41	19886·7
84	19992·5	62	19925·0	40	19885·5
83	19989·0	61	19922·5	39	19884·5
82	19985·5	60	19920·0	38	19883·5
81	19982·0	59	19917·5	37	19883·0
80	19978·5	58	19915·0	36	19882·5
79	19975·0	57	19913·0	35	19882·0
78	19971·5	56	19911·0	34	19881·5
77	19968·0	55	19909·0	33	19881·0
76	19964·7	54	19907·0	32	19880·5
75	19961·5	53	19905·0	31	19880·0
74	19958·25	52	19903·0	30	19880·0
73	19955·0	51	19901 0	29	19880·0
72	19951·5	50	19899·0	28	19880·0
71	19948·0	49	19897·0	27	19880·0
70	19945·0	48	19895·0	26	19880·0
69	19942·5	47	19894·0	25	19880·0
68	19940·0	46	19892·5	24	19880·0
67	19937·5	45	19891 0	23	19880·0
66	19935·0	44	19890·0	22	19880·0
65	19932·5	43	19889·0		

Johnson's *Deep-Sea Thermometer* (2920), Fig. 11, isintended to be used simultaneously with the deep-sea pressure-gauge above described, for the purpose of determining how much of the variation in volume of water, indicated by the latter instrument, is due to variation of temperature, and may be considered as an indispensable adjunct to it. During the year 1844 some experiments were made by Mr. James Glaisher, F.R.S., on the temperature of the water of the Thames near Greenwich, at the different seasons of the year; when that gentleman found that the indications of temperature were greatly affected by the pressure on the bulbs of the thermometers. At a depth of 25 feet this pressure would be nearly equal to the pressure of three-fourths of an atmosphere. These observations demonstrate the importance of using in deep-sea soundings an instrument free from liability of disturbance from compression by the surrounding water, and have led to the construction of the thermometer now to be described.

FIG. 11.



The instrument is composed of solid metals of considerable specific gravity, brass and steel, the specific gravity of these metals being 8·39 and 7·81 respectively. These metals are therefore not liable to any apparent compression by the water, which under a pressure of 1120 atmospheres, or at a depth of 5000 fathoms in round numbers, acquires a density or specific gravity of 1·06. In the construction of this instrument, advantage has been taken of the well-known difference in the ratios of expansion and contraction by heat and cold of brass and steel, to form compound bars of thin bars of these metals riveted together, and which will be found to assume a slight curve in one direction when heat has expanded the brass more than the steel, and a slight one in the contrary direction when cold has contracted the brass more than the steel. The indications of the instrument record the motions under changes of temperature of such compound bars; in which the proportion of brass, the more dilatable metal, is two-thirds, and of steel one-third. Upon one end of a narrow plate of metal about a foot long, *a* (Fig. 11), are fixed three scales of temperature *h*, which ascend from 25° to 100° Fahr., and which are shown more clearly in the diagram detached from the instrument. Upon one of these scales the present temperature is shown by the pointer E, which turns upon a pivot in its centre. The register index *g* to the maximum temperature, and the index *f* to the minimum temperature, are moved along the other scales by the pin upon the moving pointer at *e*, where they are retained by stiff friction. At equal distances from the centre of the pointer are two connecting pieces *d d*, by which it is attached to the free ends of two compound bars *b b*, and its movements correspond with the movements of the compound bars under variations of temperature. The other ends of the bars are fastened by the plate *c*, to the plate *a*, on which the scales of temperature are fixed. The connection of the bars with both sides of the centre of the pointer prevents disturbance of indication by lateral concussion. The case of the instrument has been improved at the suggestion of Rear-Admiral Fitzroy, and now presents to the water a smooth cylindrical surface, with rounded ends and without projection of fastenings. In surveying expeditions this instrument would be found useful in giving notice of variation of depth of water, and of the necessity for taking soundings. A diminution of the temperature of water has been observed to accompany diminution of depth, as on nearing land or approaching rocks or shoals. Attention would also thus be attracted to the vicinity of icebergs. One of the deep-sea thermometers was suspended by Mr. Glaisher on a thermometer-stand for six months, and read daily in connection with standard meteorological instruments. During this period the readings approximated to those of the best instruments.

Mr. Johnson has received an award of "honourable mention" for his volutor and deep-sea thermometer; "for novelty of construction."

(To be continued.)

REVIEWS.

Manual of Hydrology. By NATHANIEL BEARDMORE, C.E. London: Waterlow & Sons. 1862.

This is a comprehensive and truly valuable practical work, on a subject of which the importance is increasingly felt, and on which reliable data and well-arranged tables are an essential requisite to successful practice. We give, in the author's own words, some account of the circumstances that have led to the present production:—

"The work now laid before the public has arisen out of a small treatise called "Hydraulic Tables," published in May, 1850; of which a second edition, in a very much extended form, was issued in September, 1851. The prevailing idea of these works is described in the following extracts.

First Edition, May, 1850.—'In the computation of hydraulic questions daily required by an engineer, much labour is saved by the systematic use of tables; the means of detecting errors are far greater than in isolated calculations; and the results, when tabulated, are more useful than any mere formula: the one shows the object attained—the other gives the means only. In the following treatise the author has endeavoured to extend the basis of hydraulic calculations on which there should not be much difference of opinion, to systematic results; the tables are reduced to uniform measurements throughout, and the range of computations for slopes, velocities, &c., is such as will be required in practice; the whole being expressed in decimal measures. To these are added the general qualities of materials, with computations for the strength of iron beams of approved proportions, concluding with tables of numbers, &c., generally required in a treatise intended for ordinary use of the practical engineer. The powers, roots, and logarithms of numbers are appended in a simple and legible form, to save the labour of searching them from different works in the numerous requirements of the profession. The computations of all the principal tables are original, and have taken much time and labour. It would be scarcely possible to enumerate all the authorities; among others consulted are—Du Buât, Robison, Leslie, Bossut, D'Aubuisson, Rennie, &c.; without previous researches, it would be useless to attempt a treatise of this kind, and therefore, probably, the suggestions of many have been useful, although not specifically acknowledged. The leading object has been to induce a more general and systematic application of hydraulic formulæ to practice: for the principles, being subject to the laws of gravity, must be uniform; therefore, however varying the means and circumstances, the results should be consistent. The remarks upon rainfall and the produce of springs have been made rather to give examples than to propound any particular theory.'

From Preface to Second Edition, September, 1851.—'The first edition of this work was received with much greater favour than the author had at all expected; and, by the kindness of his friends, the sale was large for so technical a work. This will be the best excuse for the new form in which this book is offered. To extend the use of this edition as a handbook for the engineer, in matters relating to hydraulics and hydrodynamics, many new tables have been constructed, and the table of constants for time and height of high water and mean spring range has been inscribed from the Admiralty tables and various other sources. The introductory remarks on the use of the tables have been amended, and more information is interwoven, chiefly on our English rivers. The original remarks on tides and rivers are limited, or otherwise we should have been traveling out of the scope of this treatise; experience and practice are the great guide; and, therefore, to obtain the best data for practical results, we have carefully collated all the well authenticated data within our reach or personal experience, and had them condensed into tabular forms. The author has to thank several professional friends—Messrs. Cubitt, Rendel, Rennie, Simpson, &c.—for their kind assistance in permitting the use of, and communicating original papers. He has also to acknowledge accessible information at the disposal of Admiral Sir F. Beaufort, F.R.S. Captain Drinkwater Bethune, and Captain Vetch, of the Admiralty Harbour department, whose published reports contain good data—not omitting to mention Captain Beechey's very valuable published papers: others to whom we are indebted are named especially when the information is due to them. Considering the small extent of engineering literature, and the immense stores of knowledge constantly accumulating in the office of an engineer, it is to be wished that more of these data were placed at the public disposal, for it is on such alone that any true theories can be constructed. The work here referred to was soon out of print. During the long interval which has elapsed it would have been easy to reprint, but the author was anxious to improve the work, and extend matter which was compiled originally rather in the form of notes than as an exact treatise, and with considerable hesitation whether such dry figures would secure a reader. The practice of engineering has now become so wide, that the projection and advising in London on works situated in every part of the globe is a matter of daily occurrence; it has therefore been apparent, during the eleven years occupied more or less in collecting the data for this work, that it would be impossible to take too wide a range for the information to be contained in a Manual of Hydrology.' "

The work is in four divisions: 1. Hydraulic and other tables, 2. Rivers, flow of water, springs, wells, and percolation. 3. Tides. estuaries, and tidal rivers. 4. Rainfall and evaporation.

In Division 2 much interesting information is given regarding the Rhine, the Po, and other European rivers; the Nile, and the Ganges. Plates are inserted, giving sections of some of these rivers, variations of volume and height, comparative rainfall and temperature, &c. In Division 3, the Seine, the Gironde, and also the Hoogly are treated of, as well as the tidal streams of Britain. Division 4 deals with the rainfall, not merely of different parts of the United Kingdom, but also of India, the British colonies, France and its colonies, Belgium, Germany, Denmark, Switzerland, Austria, Italy, and other principal localities.

We think we need not say more in recommendation of a book that takes a place hitherto unoccupied in the English language with regard to the branch of engineering of which it treats, and takes it worthily. No one who stands in need of data, or general information relating to hydrography, can well fail to consult the Manual with interest and profit.

EMBANKMENT OF THE SURREY SIDE OF THE THAMES.

The report of the commission appointed to inquire into the above-named subject has been printed, and is as follows:—

"We the undersigned members of your Majesty's Commission appointed to examine plans for embanking the Surrey side of the river Thames, within the metropolis, and to report which of the said plans of embankment will, in our opinion, conduce with the greatest efficiency and economy to the improvement, embellishment, and convenience of that part of the metropolis, improve the navigation of the river, and provide a public thoroughfare without stopping such trade as must be carried on upon the bank of the river, and also upon the cost and means of carrying the same into execution, beg to submit the following remarks:—

The nature of the inquiry entrusted to us was made known by advertisements in the newspapers, and twenty designs were submitted for consideration. A short description of each is appended. The authors have attended, giving full explanations, and stated their respective views, as will be seen in the evidence hereto annexed.

We must here express our opinion of the excellence of many of the plans submitted to us; and although we cannot recommend any one plan for adoption in its entirety as meeting all the requirements of the case, yet the principal features of some of them are embodied in the plan we have the honour to suggest.

Some of the plans comprise the whole length of the Surrey shore, from Deptford to Battersea Park; and we have accordingly directed our inquiries to that extent.

We propose to divide this district into three sections; the first extending from Deptford to Westminster Bridge, the second from Westminster Bridge to Vauxhall Bridge, and the third from Vauxhall Bridge to Battersea Park.

With respect to the first section; as the existing thoroughfares, with the new street now being made between Southwark and Blackfriars road will, in our opinion, afford sufficiently convenient and direct means of communication for the traffic; and, as the flooding of the low-lying districts could be obviated by a more efficient system of drainage, there does not appear to us any public necessity for an embankment and roadway between Deptford and Westminster Bridge. The formation of such a roadway would involve a vast expenditure of money, and cause a great disturbance of the trade and commerce of that part of the metropolis. If, however, the owners and occupiers of such wharf property should be desirous at any time of constructing an embankment which, while increasing their own accommodation, would insure uniformity of design, and improve the navigation of the river, we are of opinion that every facility should be afforded them for so doing, although we are unable to recommend that the cost should be defrayed by the public.

With respect to the second section, namely, from Westminster Bridge to Vauxhall, we are of opinion that a new and improved communication is necessary, and this, we think, may be effected by constructing an embankment and roadway between those points. The property adjacent to the river between Lambeth Church and Vauxhall Bridge is of an inferior character. The wharf walls are insufficient to keep out the water at high tides, hence many of the streets are at times flooded, causing distress and sickness to the inhabitants, who are for the most part of the poorer classes.

Between Vauxhall Bridge and Battersea Park, which comprises the third section of our inquiry, an embanked roadway would afford access to the Battersea station of the South Coast Railway, and to the goods station of the South-Western and Chatham and Dover Railways, would improve and embellish that part of the metropolis, and afford a convenient and agreeable approach to Battersea Park from the densely populated districts of Lambeth and Southwark.

We, therefore, humbly submit to your Majesty that an embanked roadway of about two miles in length should be formed between Westminster Bridge and Battersea Park, commencing at the east abutment of Westminster Bridge, on a viaduct of an ornamental character opposite the Houses of Parliament, as far as Bishop's-walk; thence on a solid embankment to the north side of the London Gasworks, continued under Vauxhall Bridge as far as Nine Elms on a viaduct, and thence upon a solid embankment, passing under the land arch of the railway bridge, and terminating at the approach road of the new Suspension Bridge at Battersea. The plan and section, which are appended to this report, show the direction and levels of the intended road, and the arrangements proposed for accomodating some of the occupiers of the most important of the waterside premises; and in suggesting viaducts we have endeavoured not to interfere, more than is absolutely necessary, with the trades which must be carried on upon the banks of the river.

The dredging of the foreshore in the front of the embankment to a level of 5 ft. below low-water will (particularly at Lambeth and Nine Elms) improve the navigation, compensate to a great extent for the loss of tidal water displaced by the solid portions of the embankment, and, as the foreshore will be formed under the viaduct of solid material, and on a suitable incline, it will tend to prevent accumulations of mud where the shores are flat or uneven.

Communications with the embankment would be made at Stangate, by prolonging Palace New-road, and widening Bishop's-walk on the western side, Church-street, Broad-street, Vauxhall-row, High-street, Battersea-road, near Nine Elms goods station, New Park-road, leading to Wandsworth, and the station of the London, Chatham. and Dover Railway Company.

The estimated cost of this work, including land and compensation, is £1,100,000; but it is important to observe, that if the present favourable opportunity for carrying out this great work be not at once embraced the cost will necessarily be much greater, by reason of the increasing demand for land and buildings for trade purposes in and near to the metropolis. This scheme would be a metropolitan improvement; and with reference to the means by which the cost is to be defrayed, we consider that the coal and wine dues should be appropriated for such a further period as may be necessary for the purpose.

All which we humbly report to your Majesty,

Witness our hands and seals this 29th day of July, 1862.

William Cubitt.	Edwd. Burstal.
Joshua Jebb.	Henry A. Hunt.
Douglas Galton.	John Robinson M'Clean.

Henry Kingscote, Secretary."

PRESERVATION OF STONE.

In our fourth article on this important subject, we proceed to give, as promised, a digest of the process of Messrs. Bartlett Brothers, Camden Town, for the induration and preservation of stone; first however giving an analysis of the latest patent that has passed the Great Seal having the same object in view. This patent has been taken out by Mr. Herbert Church, and is to a great extent based upon the late discovery of Professor Graham, that of obtaining an *aqueous* solution of silica. We pay all deference to the discovery of such an important chemical fact, and feel deeply interested in the results; but, so far as we are able to judge, the solution is wrongly applied in this particular instance. The materials proposed to be used by Mr. Church are an aqueous solution of silica, or an acid solution of silica, and caustic baryta. Beginning, then, with the aqueous solution of silica, let us mention a few of its peculiarities, and then leave our readers to judge how far it is available for such uses as that we are descanting upon, in a commercial point of view. The primary disqualifications are—1st. That it cannot be retained long in solution, but gelatinises in a comparatively short space of time. 2nd. Any agitation by transit or otherwise at once produces this thickening of the solution; so that in either case, from either cause, it is rendered inutile for any purpose where penetration is essentially necessary. None other than a comparatively limpid and true solution can enter the pores of a stone for any purpose whatever. As to the cost of the solution made by the agency of the dialyser, it must be considerable, and we cannot yet see how it can be produced at commercial prices, for surely no cost of induration should exceed the difference in price between a soft stone, and one that is hard and possessing the maximum degree of durability.

Before leaving the aqueous solution of silica, we would ask, wherefore should the potash be withdrawn, when in this alkali we have a valuable adjunct for all combinations with other bases? Let us illustrate our assertion by a well-known fact in nature's operations. Felspar is a compound of silica, potash, and alumina, and forms one of the constituents of our standard of durability, granite, and it requires the action of centuries to reduce this felspar to an inferior condition, yet is this at last accomplished by the removal, by atmospheric influence, of the potash. Hence, may we not infer that the presence of the potash is absolutely necessary? Of course, with that which is over and above the correct equivalent we have not been dealing; but even a slight excess is a matter that requires due consideration, before we could pronounce it in the least degree harmful to the stone. In some stones, indeed, we are prepared to say it certainly is not; and in our last article on this subject we find Messrs. Coombe and Wright providing, by the use of silicate of potash, for any deficiency in the stone of this material; and not only in felspar, but also in the mica of the plutonic rocks do we find a large percentage of potash, as the following analysis will show:—

Felspar.		*Mica.*	
Silica	63·74	Silica	53·75
Alumina	17·14	Alumina	24·62
Lime	3·00	Potash	21·35
Potash	13·06	Loss	00·28
Water and loss ...	3·06		
	100·00		100·00

Having thus proved the durability of these silicates of alumina to be dependent to a large extent upon the presence of potash, we naturally deduce that the total removal of the potash is a disqualification and hindrance to the combination of the silica with another base.

The second solution proposed is an acid solution of silica; in fact, the very solution from which the former one would be separated by the dialyser. This solution is made from a silicate of soda or potash neutralised by an acid—say hydrochloric—and is, as the inventor specifies, made decidedly acid. We cannot see any advantage in this solution over the fluo-silicic acid, except in price; plainly all the disadvantages of an acid action are there present, and these we have already enumerated when dealing with the fluo-silicic acid process of Messrs. Coombe and Wright. We then come to the baryta; this, says the patentee, must be caustic baryta, used by preference of a temperature as nearly as conveniently to boiling heat. We cannot attempt to remove the prejudices that will at once present themselves against such a caustic solution. Touching the commercial part of the matter, we must however say, that (as fairly acknowledged by the patentee) on the least exposure to the air, it becomes covered with a pellicule of carbonated material; and we might also ask, what substitute for brushes is to be found for manipulation, as all known kinds would, in a few hours, be reduced to a rotten pulp?

Here however we leave the materials: and now for their application and combination. The patentee purposes, by the application of two solutions separately applied, to produce a mutual decomposition in the pores of the stone of the materials so applied; thus silicate of baryta is said to be deposited. The insuperable objection to the use of two solutions has always been the uncertainty of the proportion in which the separate solutions shall be presented to each other in the stone, and the difficulties arising from the liquid passing that which is already decomposed on the face of the stone to the interior. These difficulties have, to our minds, been always insurmountable; and the patentee seems to have his doubts, when he speaks of the use of vacuo and atmospheric pressure to effect the entrance to a desirable degree of the solutions into the stone. We cannot but look on this patent as identical with that of Mr. F. Ransome; and this is another instance in which we have to advert to the difficulty of obtaining valid and secure patents under the existing state of the patent law, and the necessity that exists for patentees to be well advised in this matter. Were either of these patents worth litigation, we plainly foresee that litigation would take place, to the vexation and damage more or less of both inventors engaged.

Respecting the process of induration by silicate of alumina, referred to in the commencement of this notice, this substance appears to fulfil to an extraordinary extent the requirements that past experience in the matter have shown to be necessary. Silica has ever been known to possess a great affinity for alumina, especially in the presence of an alkali. Fuchs says, "alumina combines with silica to form an insoluble product; thus in the manufacture of water-glass, the quartz should not contain any alumina, and the *insoluble* residue left behind when the mass is dissolved in water is probably owing to the alumina which the glass has taken up from the glass pot." In the same pamphlet by Fuchs we read, "If for instance a burned plate of potters' clay, which possesses no particular hardness, and can be easily broken in pieces, is saturated with moderately concentrated water-glass; and if the soaking be repeated when it has become dry, it is rendered so hard that it resists both chemical and mechanical action which is made to bear upon it." Here, then, we have the highest and most uncontestible evidence of the affinity of alumina for silica and its enduring results, as far as insolubility is concerned; and looking at the constituents of granite, as given in the analysis of its mica and felspar, we find this enduring material to consist chiefly of silica and alumina, and almost wholly of silica, alumina, and potash; and by a parity of reasoning, a process that will secure the impregnation of stone by these substances, seems to leave little to be desired, so far as its materials are concerned. In the case of a siliceous stone, where lime is altogether absent, we should have an artificial mica deposited in the stone; and where lime is present it would be found entering into combination, and without doubt producing an artificial felspar. The completeness of this process has been already remarked upon; for if the before-mentioned elements did not admit of manipulation in a perfect manner, the whole system would prove but a beautiful theory, not reducible to practice. An extract from the 'Annales des Ponts et Chaussées' will show how far we are corroborated by M. Kuhlmann in our statement, who had already theorised in the matter. Failing in success with the silicate of potash or water-glass *seulement*, he tried hydro-fluo-silicic acid; and then advancing another step, the 'Annales' state, "lastly, he has obtained excellent results from the fixation of potash in the soft limestones by substituting aluminate of potash for the hydro-fluo-silicic acid, the employment of which he has advocated with a view of forming in the stone a compound *analogous* to mica. He thus replaces mica by felspar, which likewise fixes potash in a state of insolubility. From this also he concludes, that in calcareous stones the presence of alumina alone may explain the fixation of a certain proportion of potash, and ought to remove every fear of any alteration in silicified limestone by the slow action of time."

Now here we undoubtedly have the theory of forming an artificial mica or felspar in the stone by the use of successive applications of silicate of potash and aluminate of potash; but as M. Kuhlmann from that date (1858) to the present time has not carried this system into practice, we deduce, as well as from our own experience, that in practice the application of two solutions in a separate form failed in practical working. To Messrs. Bartlett Brothers, then, are we indebted for the completion of the theoretical systems of both Fuchs and Kuhlmann, inasmuch as they have discovered that in an alkaline menstruum the silica and alumina may be used (with proper limits as to time) as one solution; thus, wherever the one is conveyed the other is present in its due proportion, leaving nothing to chance either concerning the presence of the re-agent or its due proportion. If then saturation of a porous body with the elements of mica or felspar, for which element it has a great affinity, adds to it hardness, durability, and consequent resistance of the injurious effect of time and atmosphere, certainly that is effected in Messrs. Bartlett's process; and whilst we may look upon the "honourable mention" of the jury of Class II. as confirmatory of this opinion, we cannot see why their approbation should have stopped short of the award of a medal for the untiring perseverance and energy that has developed so satisfactory a solution of this important question.

FOREIGN ENGINEERING MODELS AT THE INTERNATIONAL EXHIBITION, 1862.

(*Continued from page* 244.)

A sectional model one-twentyfifth the full size is exhibited of the Artesian Well at Passy, together with models one-tenth the full size of the appliances used in sinking it. We still avail ourselves of the admirable descriptions given in the French work already referred to. The well was begun in September 1855, with a diameter of 1·10 metre for the first 53 metres, which traverse the clay. After this first portion was lined by tubing, the shaft was continued one metre in diameter through the chalk. After some accidents, such as breakage and loss of the tools at the bottom of the well, which caused but short interruption of the work, a depth of 528 metres was reached at the end of March, 1857, when the upper tube, which had been maintaining the pressure of the clay, collapsed. During a space of six months it was vainly sought to repair the damage by the usual modes of tubing artesian wells. It then became evident that more energetic means must be employed, and larger dimensions given to the shaft where the earth had fallen in and become soaked by land springs. The years 1858 and 1859 were occupied in sinking a cast-iron cylinder 0·035 metre (about $1\frac{3}{8}$ inch) thick, and 3 metres in diameter, with flange joints, as far as it would go; strengthening this cylinder (which had been cracked by the pressure of the clay) by iron stays; continuing the well to the chalk 53 metres below the ground level, by means of two other concentric cylinders of plate iron strengthened with angle-irons; and afterwards lining all the interior with masonry, thus reducing the diameter of the well-shaft to 1·60 metre. In 1860, the upper part of the well being thus repaired, the old sinking in the chalk, of which the sides had stood, was cleaned out, and the sinking continued to the depth of 535 metres. A wooden lining was then let down, and lowered as the work proceeded, but this lining could not be got lower than a depth of 550 metres.

In order to continue the shaft, an inner tube formed of iron plate 2 centimetres (about $\frac{13}{16}$-inch) in thickness was sunk, and thus a depth of 576·60 metres was reached. At this depth the borer met with a water-yielding bed (in May 1861); but the water rose only to within 3 or 4 metres of the ground level. The work of sinking was proceeded with, and in September following, after having gone through a bed of clay, a second bed of aquiferous sand was met with at a depth of 586·50 metres. The flow of water was plentiful and in variable volume.

The present yield of the well in the twenty-four hours is 6200 cubic metres, at a level of 77·15 metres above the sea, or 24 met. above the ground level;

7,400	metres	at	73·15 metres
9,800	„		65·25 „
12,800	„		59·32 „
16,300	„		53·32 „

(or at the ground level).

The instruments used were the sinking tool (a huge chisel armed with teeth), having a vertical motion, and breaking up and pulverising the earth, and a scoop with a valve for bringing up the stuff. The work was thus done by percussion, without any turning motion. The cost of the sinking amounted to about one million of francs, or £40,000.

Well worthy of inspection are the models of dams or weirs, formed of swivel floodgates (*hausses mobiles*), which open when the water reaches a certain head, and close again when the head is sufficiently reduced. The models exhibited are one-tenth full size, and represent works constructed or in course of construction on this system on the Upper Seine, the Yonne, and the Marne. The model which exhibits the arrangement adopted for ten of the dams on the Marne is particularly interesting, as showing an ingenious hydraulic method of raising or lowering the flood-gates. Each gate is made twice the depth of the movable dam, the pivot being level with the bottom of the dam, and the lower half swinging in a sunk chamber of the form of a quarter cylinder, formed of plate iron, into which the water is admitted on one side or the other, according as the upper portion is required to be raised or lowered. This modification is due to M. Louiche Desfontaines, a chief engineer of the Ponts et Chausséés.

The Brest Swing Bridge is exhibited in a model one-fiftieth the full size, and further illustrated by a model, one-tenth the full size, of one tower with its mechanism. This bridge forms the communication between the towns of Brest and Recouvrance, across the Penfeld, which separates them. The clear headway at high-water is 19·50 metres, and the distance between the faces of the abutments 174 metres. The width of roadway is 5 metres, and that of each footway 1·10 metres. The two halves of the swing-bridge rest each on a circular pier having a diameter of 10·60 metres at the top. These piers are 117 metres apart, from centre to centre, leaving a clear opening of about 106 metres. This is equal to the width of the channel forming the military port, so that the construction of the bridge, which is at the entrance of the port, caused no obstruction to the movements of the vessels of the navy.

Each half of the swing-bridge is 7·72 metres deep at the face of the piers, and 1·40 metre at the end, and is formed of two openwork iron girders, having T top and bottom flanges, and bracing formed of standards and St. Andrew's crosses. The lateral stiffness, so necessary to a swing-bridge, is secured partly by a complete network of bracing connecting the bottom flanges of the two girders, while above a platform of two layers of timber with the joints crossed contributes towards the same end. The tail-end has the form of a box, and contains the counterpoise weigh s to balance the fore-end. The spacing of the standards of the girders is so adjusted as to bring two standards of each girder right over the ring on which the bridge travels. Thus four principal points of support are obtained, which are strengthened in a special manner by means of columns. These columns are connected by four strong crosses of St. Andrew, and traversed by a circular tower of iron plate of strong construction, and provided with platforms at top and bottom. The whole arrangement thus forms a firm and compact structure, connected at once with the girders and with the travelling ring.

The arrangement of the rings has much in common with that of railway turntables. The details are, of course, on a considerable scale, the load to be dealt with being about 600 tons, and the diameter 9 metres. The number of rollers is 50; their mean diameter 0·50 metres, and their length 0·60. The rings were turned on their faces, upper and lower, with peculiar care; and for this purpose a special apparatus had to be made at Creusot, at a cost of 75,000 francs (£3,000). The fixed ring has teeth in its external circumference, in which works a pinion having its shaft fixed in the moving ring. The other end of this shaft carries a toothed wheel, which is worked by a second pinion horizontally fixed on the driving-shaft. The latter is vertical, and comes as high as the platform of the bridge, where it carries a cross-head furnished with capstan bars. By this arrangement the men who are working the bridge can see what they are doing: and there is also the advantage that the moving power can readily be increased in case of need. As soon as the bridge is in place the cross-head is lowered beneath the platform, which is thus left clear for the traffic.

In order to make the roadway as steady as possible while carrying the traffic, contrivances are added for levelling the bridge at the fore and tail-end of each of the swinging portions. At the fore-end there are iron screws, which are driven from the one-half of the bridge into the other when closed, so as to steady the junction. The tail end is furnished with levers, by which it is brought to the level when the bridge is in place. An ingenious mechanism is provided for raising each half of the bridge by hydraulic power, so as to enable the rings to be repaired when necessary.

The preceding notices have sufficed but to sketch a portion of the engineering models of our continental neighbours, and the works which they illustrate. The whole display, in the French department more especially, is highly honourable to the exhibitors. And acknowledgment is due not merely to the professional skill and ingenious resource everywhere manifest, but to the broad and liberal spirit, and the faithful and lucid exactness, with which every circumstance, detail, difficulty, or expedient is brought forward to contribute to the common stock of scientific experience.

NOTES OF THE MONTH.

Reports of the Juries of the International Exhibition, 1862.—The Council of the Society of Arts have undertaken, with the co-operation of H.M. Commissioners and of the Juries, the publication of the Reports of the Juries descriptive of the progress of industry since the Exhibition of 1851. The production of this work is intrusted to Dr. Lyon Playfair, the special commissioner of the juries.

Discovery of a Mediæval Tryptich.—In the recent clearance of pews, galleries, shrines, and antiquities in the choir of Hexham Abbey, the Ogle Shrine, which had been converted into a pew, was taken down as well as everything else. It stood on the south side of the choir, occupying one bay, from pillar to pillar, and was enclosed by open-panelled and carved oak screenwork of Perpendicular workmanship, the interior of which was snugly covered with green baize. When this covering was torn off, the altar-painting of the shrine was found to be *in situ*. This interesting relic, doubtless thus hidden since the Reformation, is a tryptich of the 15th century. It has a massive frame of oak, 4ft. 3in. by 6ft. 6in., of the same character of moulding and carving as the screenwork empaling the shrine. The three panels of the picture are of an uniform size—1ft. 10in. by 3ft. 8in., and the subjects in each are confined within an outline of a vesica form, and enriched with diapered backgrounds. The centre compartment represents Christ in the act of rising from the tomb, the lower half of the figure being concealed by the decorated side slab. The eyes are closed and head bowed down, an expression of inconceivable sorrow and compassion pervading the features. Blood streams from the crown of thorns and from the wounds. Above the crown of thorns, which is curiously raised in slight relief, is a gorgeous nimbus, which, it is evident, once blazed with gold. This ornament is in bold relief, as are two candlesticks placed on either side of the tomb. Below the tomb and behind the nimbus and in other interstices there is a diaper of gold stars. A wavy vesica of clouds confines the whole, which stands out thus cloud-encircled from a deep crimson background, diapered with hexagonal sombre-coloured rosettes, each rosette containing the letters I.H.C. painted in the same tint. The compartment to the left of this contains a full-length figure of the Virgin holding the Infant Christ on one arm, and a sceptre, announcing her sovereignty as queen of heaven, in the other hand. The nimbus of this figure is also in high relief, and is more elaborate in design than that upon the head of Christ. A raised nimbus surrounds the head of the Infant, and the sceptre is richly ornamented in relief. The robe of the Virgin is of a crimson colour, and has a small geometrical pattern upon it. It is fastened upon the breast with a row of embossed clasped ornaments. Over the arm on which she holds the Child and below her waist falls a piece of amber-toned drapery covered with fleurs-de-lys. This figure is surrounded by a double border of golden rays following the same vesica outline, behind which the background is diapered with starry circles. The third compartment is filled with a representation of St. John. He bears in one hand a chalice, in the other a palm branch. The edge of the chalice, its stem, and its base, together with the nimbus of the saint, are all rendered in the same character of ornament as that of the other subjects, but of different designs. The vesica outline of this painting is formed by a flowing scroll-like pattern. The diaper of the background is similar to that of the Virgin's panel. Portions of the curious raised ornament are lost, and the base of the centre panel has been used roughly; but, taking into consideration that the picture has, unknown, formed part of a pew for perhaps three centuries, it is in wonderful preservation. According to contract, as part of the "old materials," this rare relic became the property of the joiner, of whom it has been purchased by Mr. F. R. Wilson, architect, Alnwick.

Proposed new Building for the Patent Office.—The Commisioners of Patents have just communicated their report to the Lords of the Treasury, on the subject of building a new Patent Office Library and Museum, and they report favourably on the undertaking. The document recapitulates the report made on the same subject by the Commissioners of Patents in 1855, which recommended the provision of increased accommodation and facilities for the researches of persons interested in inventions and patents. The present commissioners state that in 1860 they suggested Fife House and gardens in Whitehall as a convenient site for the Patent Office buildings and museum, and one that would unite all the necessary requirements. The question of the embankment of the river stopped the way at that time, and hence negotiations were again suspended. The report states this difficulty is now removed, and it is consequently open to her Majesty's Government, if it should think fit to do so, forthwith to appropriate the site of Fife House for the erection of the Patent Office buildings.

An Underground Railway for Paris.—When the Prince Napoleon was in London lately, he went over the Metropolitan Railway, and, on his return to Paris, he reported so strongly in favour of it that the Emperor has already, it is said, ordered a subterranean line from Montmartre to the Louvre, to be commenced forthwith, and has appointed Mr. Fowler consulting engineer to the undertaking.

Kitchen Ranges in the International Exhibition 1862.—An inspection of the different arrangements of kitchen ranges displayed at the International Exhibition in Class 31, and an examination of the advantages claimed for them by their inventors, would well repay those interested in the subject, the opportunity for comparing so many varieties in one place being rarely afforded. The collection, although containing many examples which appear at first sight to embrace the necessary requisites to secure economy and efficiency, is yet, with very few exceptions, singularly deficient of examples exhibiting features of useful novelty. The number of exhibitors of cooking apparatuses is about forty, of whom only five or six adopt the old-fashioned form of open grate. In the majority of them an enclosed fire-place is substituted for an open one, a great improvement which, after having been long unavailingly urged upon public attention by scientific men, and one or two of the more skilful manufacturers, received a considerable impulse from the Exhibition of 1851. The course pursued by the exhibitors in most instances appears to have been to imitate one another, displaying but little earnest endeavour to remove even those defects in the generality of "close" ranges which the experience of the last ten years has rendered notorious. These may be briefly stated to consist in the absence of a satisfactory arrangement for roasting meat before the fire without interrupting the use of the oven, &c.; the inability to control the too great rise of temperature in the kitchen; and the annoyance occasioned by the odour of cooking being diffused over the house. In addition to these evils, in the majority of cases a faulty construction of both fire-place and flues has prevented that real economy of fuel which the close form of stove was intended to secure, and of which it is certainly capable. The kitchen range (No. 6002, class 31), manufactured by Messrs. Brown and Green of Bishopsgate Street Within, we have inspected in operation, and it appears to us completely to remedy the defects enumerated above; as yet it is the only one of which we can say so much. This range is 14 feet in length; contains four roasters or ovens, and three boilers. It is stated that it is capable of plain cooking for more than 2000 persons, with a consumption of less than one ounce of fuel a head, and that this result was proved by a trial of this particular range by the Inspector of Cookery for the army, by order of the War Department. Similar advantages are secured in the smaller ranges on the same principle, for family use. This firm was one of the first to manufacture close cooking-ranges in England, providing ovens properly heated and ventilated, and at the same time supplying a deliverance from the intolerable smoke nuisance. From that time to the present, nearly a quarter of a century, they have devoted their skill and experience to perfecting their invention. The apparatus exhibited is the largest and by far the handsomest kitchener in the building; and in addition to the special merits of its arrangement and simplicity of action, reflects great credit upon the firm for the excellence of its workmanship and finish. The award of a medal in this instance we heartily approve.

CLASSIFIED LIST OF PATENTS SEALED IN AUG. 1862.

264 Moncton, E. H. C.—Obtaining of ammonia by electricity from the products of combustion—January 31
Scheurweghs, P.—Treatment of fatty matters—January 31
1371 Gossage, W.—Manufacture of soap—May 7
451 Stoehr, E. M.—Combination of manganese with other metals (com.)—February 20
445 Paterson, J.—Reburning animal charcoal (com.)—February 19
532 Torr, J.—Reburning animal charcoal (com.)—February 27
455 „ Use of animal charcoal (com.)—February 20
456 „ Manufacture of sugar (com.)—February 20
471 Ross, W. H.—Manufacture of sugar (com.)—February 22
525 Miller, W.—Manufacture of sugar (com.)—February 26
643 Bennett, W. J.—Solution for use with Portland cement, &c.—March 10
1084 Newton, A. V.—Manufacture of blasting powder—April 15
1231 Cheavin, S. & G.—Filtering apparatus—April 26
479 White, D. B.—Air-tight vessels for containing liquids—February 22
424 Birdsdall, J.—Preparing hides for tanning—February 17
340 Dickson, J.—Production of voltaic electricity—February 10
378 Mennons, A. F. M.—Manufacture of manures (com.)—February 13
356 Wood, W.—Manufacture of liquorice cakes—February 11

339 Mennons, M. A. F.—Vapour baths (com.)—February 10
423 Hughes, E. I.—Collecting gas from furnaces, &c. (com.)—February 17
267 Schatten, Hermann—Gas meters—January 31
744 Meyers, T.—Gas meters—March 17
484 Mennons, A. F. M.—Heating by gas—February 22
444 Davis, Wm.—Increasing illuminating power of gas—February 19
485 Johnston, W.—Gas lamps or stoves—February 24
495 Davis, L., and Parkes, F. M.—Production of gas for lighting, &c.—February 24

1248 Gwynne, J. E. A.—Centrifugal pump—April 29
1738 Appold, J. G.—Regulating flow of air, gas, or water—June 10
523 King, T., Varrill, R.—Apparatus for regulating the flow of water, &c.—Feb. 26
542 Wood, W. S.—Apparatus for regulating the flow of steam—February 27
499 Carnaby, J.—Valves &c. of gas pipes—February 25
533 Adams, F.—Valves &c. of gas pipes—February 27
606 Hack, T., Carter, A. E.—Screw cocks—March 6

335 Tolhausen, F.—Tyre of railway wheels (com.)—February 7
393 McConnell, J. E.—Railway brakes—February 13
546 Makinson, A. W.—Locomotives—February 28

1020 Funnell, E. C.—Self-acting indicating signal—April 10
359 Johnson, R.—Welding wires for telegraphs, &c.—February 11
843 Haworth, J.—Telegraphic signals—March 27
413 Chatterton, J.—Telegraphic cables—February 15
538 Bright, Sir C. T.—Electric telegraphs—February 27
514 Cook, H. W.—New mode of propelling carriages by electricity—February 25

284 Lancaster, C. W.—Strengthening ordnance of cast-iron—February 3
289 Meakins, T. M.—Obtaining explosive force, and in projectiles—February 4
374 Horsley, Jun.—Breech loading arms—February 12
596 Sidebottom, J.—Fire-arms and projectiles—March 5
1653 Newton, W. E.—Shot-proof towers and their working—May 31
1798 Johnson, J. H.—Projectiles (com.)—June 18
488 Haddan, J. C.—Small arms, artillery and projectiles—February 24
362 Bolton, F. J.—Rifle stoppers and oil bottles—February 11
1334 Victor, J.—Manufacture of safety fuses for mining and other purposes—May 5
320 Tonkin, J.—Manufacture of gunpowder—February 6

363 Hetherington, J.—Spinning machines—February 11
419 Crawford, H. & J., Templeton, R.—Weaving looms—February 17
472 Kirkwood, J.—Weaving looms—February 22
1886 Lord, Josiah.—Weaving looms—June 27
463 Hamer, W.—Preparing cotton &c.—February 21
420 Hodgkinson, J.—Machinery for preparing cotton, &c.—February 17
450 Friedlander, J.—Scutching machines—February 20
506 Watson, T., Dracup, R.—Wool combing machines—February 25
1830 Taylor, J.—Doffer for carding engine—June 21
1189 Newton, W. E.—Manufacture of lace or open fabrics (com.)—April 23
541 Foster, J. R.—Manufacture of bullion fringe or cord—February 27
408 Turner, C.—Felted fabrics—February 15
476 Liebmann.—Felted fabrics—February 22
436 Pendlebury, J. T.—Machinery for folding or plaiting cloth—February 19
492 Kirkham, J. N.—Bleaching and dyeing yarn in the cops—February 24
360 Lindemann, G.—Dressing yarns by gas—February 11
1666 Newton, A. V.—Machinery for breaking and cleaning flax (com.)—June 2
345 Smith, G.—Shawls—February 10
298 Norton, J. L.—Beating, stretching, and dyeing fabrics—February 4
361 McConal, J. J.—Securing bales of cotton, and other goods—February 11

459 Spence, J.—Mode of transhipping grain (partly a com.)—February 21
464 Crease, E. S.—Boring machinery—February 21
269 Smith, Wm.—Bricks, tiles, &c.—February 1

311 Bamlett, A. C.—Reaping and mowing machines—February 6
1644 Newton, W. E.—Handles of shovels, dung forks, &c. (com.)—June 2
1690 Newton, A. V.—Grass harvesters—June 4
511 Cranston, W. M.—Reaping and mowing machines (partly a com.)—February 25
565 Reynolds, S. G.—Power-spading machines—March 1
904 McCranston, W.—Reaping machines (com.)—March 31
434 Firth, W.—Ploughing or digging machines—February 18
457 Wood, C.—Horse rakes—February 20
502 Piddington, J.—Machine for husking grain—February 25
531 Smith, J.—Machine for drying grain—February 26
482 Foster, R.—Horticultural buildings—February 22

512 Kingsford, C.—New composition for manufacture of bread—February 25
337 Carrington, J.—Stalls and horse-boxes—February 8
249 Davis, Wm.—Cork-cutting—January 30
288 Clark, Wm.—Preserving and colouring wood (com.)—February 3
228 Clark, Wm.—Preserving timber—February 7
539 Bray, T.—Ornamenting wood in imitation of inlay—February 27
392 Green E.—Buttons for dresses—February 13
369 Hinshaw, A.—Hooped skirts (com.)—February 12
364 Aman, G. J.—Envelopes or bags for post parcels—February 12
460 Skellern, R. H.—Self-inking hand-stamp or press—February 21
389 Burrows, G. C.—Lounging seats, chairs, &c.—February 13
351 Fyfe, J.—Knapsacks—February 11
322 Brooman, R. A.—Stereoscopic albums, &c. (com.)—February 7
280 Reisbeck, F., Becker, W.—Locks to bags, portmanteaus, &c.—February 1
347 Clark, W.—Reflectors (com.)—February 10
366 Robb, J.—Ventilation—February 12
866 Noualhier, E. T.—Ventilation—March 28
461 Ward, H.—Ladies' saddles—February 21
474 Millingham, J.—Hearses—February 22
745 Mennons, M. A. F.—Means of arresting runaway horses (com.)—March 18
415 Harrison, A. H.—Under garments—February 15
448 Wilcox.—Manufacture of frills or ruffles—February 19
430 Lees, J.—Rat and mice traps—February 18
505 Clark, W.—Tobacco pipes (com.)—February 25
536 Smith, W.—Cigarettes (com.)—February 27
1712 Hazeltine, G.—Photographic camera (com.)—June 7
443 Hinton, W.—Barometer—February 19
682 Sidie, L.—Aneroid barometer and steam gauges—March 13
527 Clark, W.—Clasps for jewellery (com.)—February 26
428 Watkins, R.—Lamps and materials for combustion—February 18
1651 Newton, W. E.—Manufacture of artificial leather (com.)—May 31
547 Ralliff, J. C.—Covers of blotting cases—February 28
480 Blakey, G. S. & J.—Leggings or gaiters—February 22
1650 Chanbart, L.—Method of raising water levels in canals, &c.—May 31
435 Marzetti, T. C., Watson, J.—Hoist—February 19
467 McAdam, W., Chrystal, W.—Pullies—February 21
751 Dunn, T.—Construction of roofs, bridges, &c.—March 18
465 Pickin, R. & W. E.—Carriage bodies—February 21
1182 Robertson, A.—Apparatus for projecting fluids—April 23
489 Waller.—Boots and shoes—February 24
404 Blin, E., and Lamplough, H.—Viewing microscopic photographs—February 25
1610 Critchley, J.—Parasols &c.—May 29

399 McFarlane, T. D.—Sewing machines—February 14
957 Lindley, L., Taylor, F.—Sewing machines—April 4
1124 Bousfield, G. T.—Sewing machines (com.)—April 17
554 Bradford, T.—Washing machines—March 1

601 Partington, E.—Preparing rags for paper—March 5
516 Green, A.—Manufacture of envelopes with black borders &c.—February 26

315 Astley, P. H.—Life boats, &c.—Feb. 6
373 Samuelson, A.—Building ships and vessels—February 12
517 Stephen, A.—Building ships and vessels—February 26

863 Ashe, W. A.—Mode of driving shafts of propellers (com.)—March 28
272 Spencer, T.—Propellers—February 12
410 Cork, J.—Propellers—February 12
552 Parker, J.—Propelling vessels by steam—February 28
545 Muntz, W. H.—Paddle-wheels—February 28
1618 Griffiths, R.—Propellers—May 29

330 Bartholomew, W. H.—Barges or vessels for canals—February 7
383 Abel, C. D.—Towing boats or other vessels—February 13
418 Russel, J.—Raising sunken vessels—February 15
530 Midhurst, J.—Reefing sails, &c.

994 Whitehouse, J.—Door knobs, metallic mountings for ditto—April 8
370 Brooman, R. A.—Cast-iron furniture ornaments (com.)—February 12
440 Adams, W. B.—Manufacture and arrangement of springs.
624 Bromhead, S. S.—Coal-box—March 8
469 Charasse, H.—Ornamentation of iron bedsteads—February 22
1473 Atwood, C.—Manufacture of iron and steel—May 15

585 Gjers, J.—Sand or material for moulding iron castings—March 4

543 Revell, J.—Oil cans—February 27
325 Silver, H. A.—Manufacture of ebonite, vulcanite, &c.—February 7
324 Shaw, P.—Lamps—February 7
550 Charcouchet, J. L.—Machines for breaking stone—February 28
497 Smith, F. G.—Crushing machines—February 24
526 Knott, C. L.—Pianofortes—February 26
379 Williams, W.—Pianofortes—February 13
358 Brinsmead, J.—Pianofortes—February 11
1233 Broadwood, H. F.—Pianofortes—April 30

390 Allen, E. E.—Construction of steam-engines—February 13
483 Johnson, W. B.—Construction of steam-engines—February 22

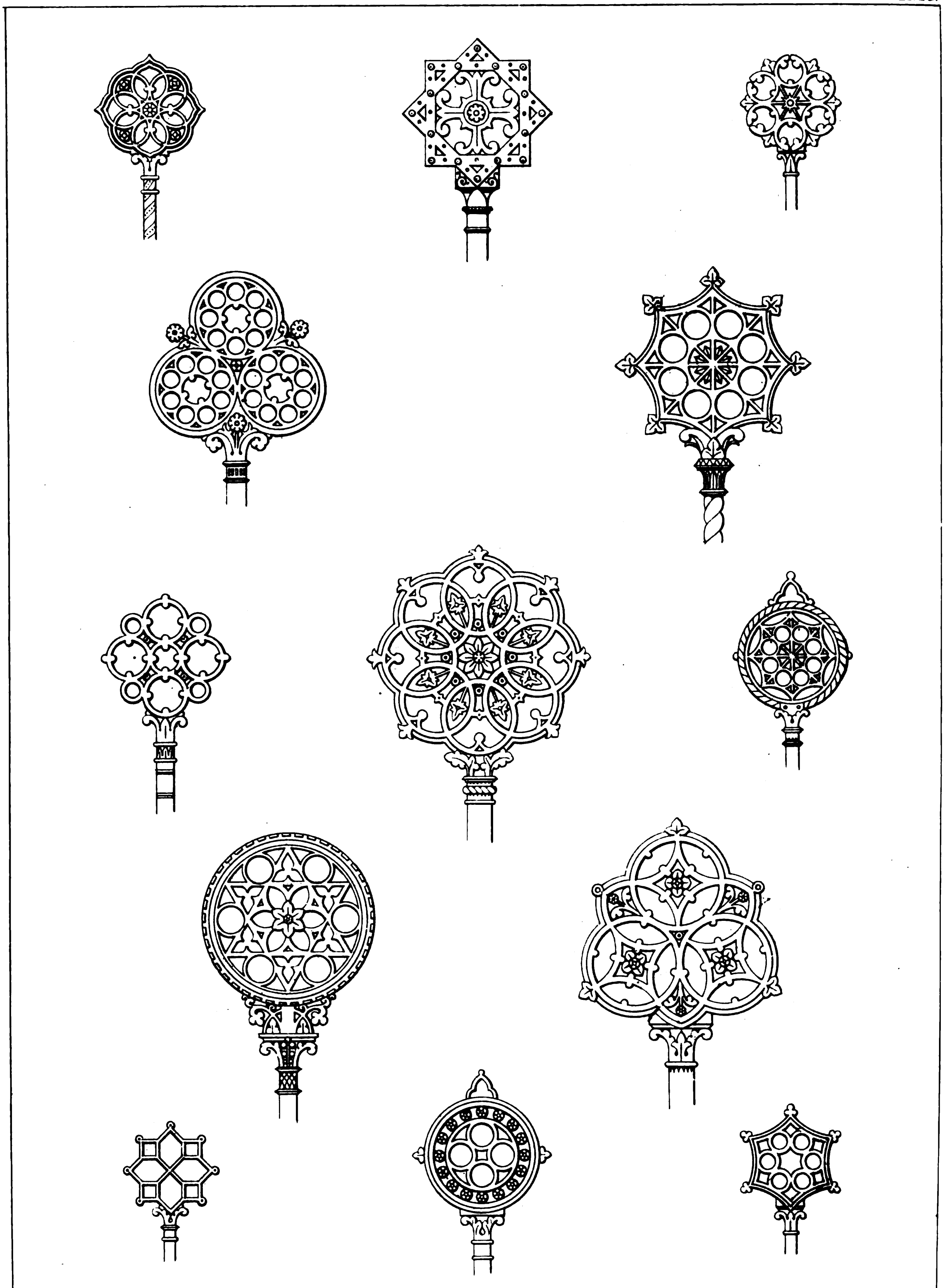
491 Clark, W.—Feeding steam-boilers (com.)—February 24
365 Tolhausen, F.—Vertical boilers (com.)—February 12
384 Davison, T.—Prevention of boiler incrustation—February 13
1450 Porter, C. T.—Steam-engine indicators (com.)—May 14
1380 Tate, P.—Smelting furnaces—May 8
447 Bousfield, G. T.—Prevention of boiler corrosion (com.)—February 19

371 Joseph, J. S.—Utilizing waste heat from coke ovens—February 12
376 Joseph, J. S.—Improved retort oven—February 13
367 Brickhill, J.—Steam cylinders and pistons—February 12
441 Symons, N.—Steam cylinders and pistons—February 19

524 Cliff, J.—Glazing earthenware—February 25

299 Gallafent, D.—Obtaining motive power from elastic vapours—February

544 Asemar, P. D.—Keyless watches—February 28



J.R.Johbins

ORNAMENTAL KEYBOWS IN THE INTERNATIONAL EXHIBITION, 1862.

Designed by J. Drayton Wyatt, Archt.

ORNAMENTAL KEYBOWS IN THE INTERNATIONAL EXHIBITION, 1862.

(With an Engraving.)

The ornamental metal work of which we give an illustration forms part of a set of locks and keys exhibited in the Wolverhampton court, in the style and manufacture of which has been revived, as closely as possible, the principles of ancient wrought work. To the enterprise of Mr. G. Price of Wolverhampton is to be attributed the great degree of perfection to which the iron safes and locks patented by him have been brought, and he has deservedly earned one of the only two prize medals awarded in this "class." The keybows in question have been manufactured expressly for the Exhibition, from designs by Mr. J. Drayton Wyatt, and they may certainly be pronounced to be the most complete and elaborate series which modern skill has produced. There are four ornamental locks, in which the several patterns have been executed with marvellous precision, nor are the keybows, between 20 and 30 in number, and all varying in character, less deserving of praise. From the nature of the hand-work required, the patterns have been devised as much as possible with a view of giving effect to simple and characteristic forms, in which the perforations have all been drilled through by manual labour, and hence the sharpness and brilliancy which have invariably been secured. In some of the patterns monograms have been introduced, others are circumscribed by inscriptions, another variety has jewellery inserted among the scrollwork, and a fourth (which we shall include in a succeeding plate) is of a strictly "masonic" character The addition of incised lines occasionally, and of colour as a groundwork to throw up the monograms, has proved a decided advantage in imparting, not only a variety, but a still higher finish of effect.

THE INTERNATIONAL EXHIBITION, 1862.

Architectural Objects.

In the south transept of the Exhibition, near the eastern dome, a considerable space is allotted to what are called in the catalogue "objects shown for architectural beauty," consisting chiefly of works in stone, marble, and slate, to which more or less decoration has been applied. Some few of these have before come under our notice at other places, but the majority, though intended for some special destination, have been secured for previous exhibition here. Thus, the model of the font (2430, Class 10.) designed by Mr. Daukes for Witley Church, and for which a medal has been awarded, has been already referred to in connection with the Architectural Exhibition in Conduit-street; but it is of so peculiar a type, that it is an excellent contrast compared with one or two others near it. The oak cover is an important feature; it has a textual inscription round the base, and is surmounted by a figure of St. John the Baptist: the whole is the workmanship of Mr. Forsyth. The same hand has been worthily and extensively employed by Mr. Slater in the elaborate carving which is bestowed upon the new stall ends, &c. (5705, Class 30) for Chichester Cathedral, some of which are here shown, and some are in the Mediæval court. Of the beauty of their general form, and the merit of their execution, there can be but one opinion; but it is just questionable whether for such a situation a little more solidity in the material, and a less florid enrichment, might not have been advisable. Figure sculpture, too, might have been introduced more freely with advantage, interspersed with the foliated panels, which, though really varied, have nevertheless the effect of too much repetition. For these a medal has also been awarded.

The chief attractions to these courts are unquestionably the inlaid specimens of decorative materials, as illustrated in the several reredoses, pulpits, &c., in which it is difficult to say whether the conception or the work has been most successful. Perhaps the most novel and vigorous of these is the reredos, from the design of Mr. Bentley (2437, Class 10), executed by Mr. Earp, of whose works honourable mention is made. Without bearing the slightest resemblance, in composition, to the reredos by the same gentleman which we illustrated in the last number of our Journal, a similar feeling is conveyed in some of its details: it would have been well however to have preserved a little more simplicity in some parts, so as to give more value to the rest. This reredos is in three compartments, separated by marble shafts, with richly detailed caps and bands; on each of these shafts, under a canopy, stands an angel with uplifted wings—these personify respectively Uriel, Michael, Gabriel, and Raphael. Each compartment contains a vesica panel, the middle one being enriched with a cross, and that on each side with a sculptured subject—the right hand one, the Annunciation, being particularly successful. Under these vesica panels are smaller ones, of quatrefoil shape—six in all—and illustrative of "virtues overcoming vices." Thus, Chastity is represented as opposed to Lust; Temperance to Gluttony; Faith to Idolatry; Charity to Envy; Peace to Discord; and Bounty to Avarice. The general groundwork of the reredos is alabaster, incised patterns being freely used in surface decoration, as well as exclusively for the subjects in the lower panels.

A reredos (2440, Class 10), exhibited by Messrs. Poole and Sons as a specimen of inexpensive decoration, has the subject of the Last Supper incised on a large scale, and in a very masterly manner. The effect depends entirely on the outline and composition generally, the aid of carving, and even mouldings, being all but entirely dispensed with. In conjunction with this should have been placed (but they are separated) a portion of the corresponding wall decoration, which is also of the simplest kind, the surface being divided into small squares by incised stripes of colour set diagonally, and slightly relieved by inlaid ornament. A plain moulding, fitted with flat conventional foliage, runs along the top. This work has most deservedly received a medal at the hands of the jurors. Another reredos, by Williams, of Ipswich, is far from being satisfactory either in design or execution: it is of Caen stone, arcaded. with a central subject under a flat ogee arch. The other work of this class is the production of Mr. Earp, from the design of Mr. Street; and it is needless to remark that it possesses a high degree of merit. The leading outline is original, but effective; its chief feature consisting of the carved subject which occupies the centre, under a pointed arch, and which represents the Agony in the Garden; the background to this panel is filled in with a triangular mosaic pattern. On each side is a niche containing the figures of St. Philip and St. James, to whom the church for which it is intended (at Oxford) is dedicated.

A very handsome pulpit, from the same hands, and to be placed in the New Church at Bournemouth, is a conspicuous object in this class. In plan it is circular—apparently a favourite form with Mr. Street—and the upper part has an open arcade all round, the shafts being of marble, and the arches trefoil cusped. In the spaces between the arches are small carved heads under gablets attached to the cornice. Below the arcade is a circlet of quatrefoil, in richly efficient colours, composed of various marbles. The stem consists of a cluster of shafts, executed in red Mansfield stone, and having moulded capitals and bases, the whole resting on a plain plinth. The Corsham Down stone pulpit, exhibited by Messrs. Cox and Son, is a curiosity in its way. The stem represents the trunk of a tree, and the boughs and leaves which arise from it form the pulpit itself. Though conceits similar to this may be seen in some continental churches, it is an innovation which we should regret to see introduced into this country. Near this pulpit is a font, sculptured by Mr. Earp, from the designs of Mr. Teulon. It is octagonal, having on each side a sunk panel of fanciful shape, and containing monograms, the lamb and flag, &c. The bowl is supported by marble shafts, one under each angle, and on their capitals rest angels bearing a scroll text, which is continued round the whole circumference. At the base are the emblems of the four evangelists.

The noble doorway in Steetley stone, which is to form the entrance to the Mortuary Chapel of the Digbys, at Sherborne Minster, is one of the boldest and most effective of Mr. Slater's designs; and, though unfinished, bears evidence that it will lose nothing in the hands of Messrs. Poole, by whom it is being executed. In style it partakes most of the "transitional," the arch being pointed, and having four square orders of mouldings over the deeply recessed shafts in the jambs. These latter are of different marbles, with bold caps, bands, and bases; the intermediate angles being filled in with rich conventional ornamentation, as are also the spaces above the plinths. The door itself is square-headed, and in the tympanum over is sculptured the Resurrection.

The competition subjects for the prizes lately offered and adjudicated by the Ecclesiological Society, through the Architectural

Museum, find here a fitting place. The test was as to the treatment of colours only, each competitor working on a copy of the same model, namely, a three-quarter figure as a bas-relief in a cusped Gothic panel. Three prizes were awarded, the first being given to Mr. J. P. Wood. The competition subjects, too, in wood and stone carving, exhibited by the Ecclesiological Society, who have received a medal, may also here be seen; the first prizeman in the former being Mr. H. Reynolds, for a foliage panel in oak, and for the latter Mr. Samuel Ruddock.

Californian marble, as a comparatively new material, will be examined with interest, and several specimens (2428, Class 10) are exhibited by Messrs. Edwardes and Burke, of 142, Regent-street. In particular we may call attention to the large spar-like slab of almost a transparent amber colour, interspersed with darker tints, and having a very rich effect. There are also some smaller specimens showing these marbles inlaid in patterns. The productions of our own Serpentine Marble Company (2444, Class 10) are too well known to need description, and are recognized by the award of a medal). Its applicability to various ornamental purposes is well shown by the numerous collection of vases, fonts, obelisks, &c. which are here grouped. Terra-cotta, too, is not without its advocates, and Mr. M. H. Blanchard is one of the best exponents of its uses (2423, Class 10). In addition to objects with which we are more familiar, there is here exhibited a fire-proof staircase, constructed in this material, and which appears likely to answer the intention, nor is it in itself by any means an unattractive feature. The colour of the terra-cotta is a pleasant one, while this and the material admit of the introduction of tile or mosaic patterns in both the treads and risers, thus greatly heightening the effect, which is also decidedly novel. To the excellent production of Mr. Blanchard a medal has been awarded. Mr. Pulham (2441, Class 10) is also an exhibitor of terra-cotta articles, and has received honourable mention. The table shown by Mr. C. Clay of Sidmouth-street, Gray's inn-road (2426, Class 10), of which honourable mention has been made, is more a curiosity than an article of beauty. It is stated to contain 1363 pieces of marble, some unquestionably very choice in their way, but as a whole not very telling, for the want of being better arranged. In polished granite there are a few specimens, shown by Messrs. Robertson and Hunter, though they do not appear to have any special pretensions.

The respective colours and qualities of the several beds of Portland stone are displayed in the column exhibited by Mr. Field. The plinth is constructed of what is termed the "Roach" kind, which is suitable for river, dock, and sea walls, bridge abutments, and the like; the shaft is of "Whitbed," which is adapted for all kinds of work, and has been used in Somerset House, the British Museum, &c.; the cap and base are of "Base" bed, or "Best" bed, which is of a lighter colour, and is more fitted to inside work generally.

The various capabilities of Magnus's enamelled slate (2435, Class 10) are well illustrated by the large show of articles which that gentleman exhibits, and to which a medal is awarded: among others a large ornamental coil case for hot water apparatus, several sideboards, billiard tables, chimney-pieces, &c. Messrs. Jackson and Son's carton pierre (2434, Class 10), too, has been more than once commended in these pages. It is a material expressly suited to florid ornaments, both in relief and on the flat, as the very handsome Renaissance chimney-piece and pier-glass, which is their principal contribution, will attest. A medal has been awarded to this firm for the introduction of this material.

Messrs. Stuart and Smith (No. 6223, Class 10), of Sheffield, have bestowed great pains upon the superb fireplace, polished stove, with ash-bars and fender to match, which they exhibit. The kind of wall-surface proposed for the room is shown also, with a method of treating the decorations of the cornice and panels generally, so as to produce a harmonious effect, and the aim has certainly proved successful. It is much to be regretted that in the ordinary way such subjects are not considered *as a whole*, but simply in their individual parts; hence that incongruity, not to say absurdity, which is continually allowed to mar the best intentions, and negative the result of an expensive outlay; all for want of either due consideration, or the judicious aid of taste and experience in such matters.

THE CONSTRUCTION OF LIGHTING APPARATUS FOR LIGHTHOUSES.*

By Armand Masselin.

(*With Engravings.*)

The construction and illumination of lighthouses constitute one of the most important of public undertakings at the present day. The development however of the comparative perfection now attained in these two departments has been gradual and unequal. During the century that has elapsed since the erection by Smeaton of the Eddystone lighthouse, when engineering was greatly in advance of practical optics, the art of building towers has received few improvements, while the apparatus for illuminating them has by the introduction of the dioptric system acquired a striking degree of excellence. During nearly the whole of the last century, and in some places as late as 1816, open coal fires, improved occasionally by a flat brass plate placed on the land side, were the rude means usually resorted to for producing light. The Eddystone tower had a lantern to protect the weak light given out by the few miserable tallow candles which were then used, and only in 1807 were these replaced by lights furnished with silver-plated parabolic reflectors. Distinction of one light from another by its appearance at night, a point nearly as important as the range of the light, was of course out of the question.

Lights on the catoptric or reflecting system, composed of silver-plated parabolic reflectors provided with plain cylindrical burners placed in the focus of each, were used exclusively until 1822, when Augustin Fresnel invented and erected on the Cordovan tower his first dioptric or refracting light. The catoptric or reflecting system was, in comparison with the imperfect means previously available, a valuable improvement, and under later modifications is still in extensive use in this country; but having many serious imperfections it is gradually disappearing before the dioptric or refracting system.

The latest optical and mechanical improvements in the dioptric system are illustrated by the fixed light of the Smalls Rock, near Milford Haven, and the revolving light of Lundy Island, both constructed by Messrs. Chance, and the latter attested by mariners as the most powerful light in Great Britain, flashing over 35 miles of the Atlantic. In the present paper it is intended only to notice briefly the existing state of reflecting and refracting apparatus, and the relative merits of each, before giving the particulars of their mechanical construction.

In the dioptric or refracting system, only one lamp is used, placed in the vertical axis of the apparatus. In fixed lights, as shown in vertical section, Fig. 1, Plate 22, the middle or dioptric part having the lamp in its centre is cylindrical, and composed of a series of refracting rings or lenses A, shown black, which are so shaped as to give a horizontal direction to all the rays of light that fall from the lamp upon their inner faces. All the rays of light passing above and below these middle lenses are received by the upper and lower catadioptric prisms BB, shown black, by which they are also transmitted horizontally after refraction and total reflection in the prisms. Every piece of glass in the apparatus forms a portion of a horizontal ring or belt, having its centre in the vertical axis of the apparatus, as shown in the part plan, Fig. 3, where A^1 is a sectional plan at focal plane, and A^2 a plan at bottom prisms. The rays of light given out by the lamp are thus collected and transmitted equally over the horizon, and the light is rendered luminous throughout its entire height. The glass prisms are fixed in eight gun-metal standards, forming an octagonal frame, each prism being supported in the centre by passing through an intermediate standard, as shown in the part plan, Fig. 3.

In revolving lights, as shown in the vertical section Fig. 2, the transverse section of the refracting lenses A and prisms B is precisely the same as in fixed lights: but in revolving lights the rings of glass are concentric round a horizontal axis passing through the brightest part of the flame, as shown by the dotted lines in Fig. 2 instead of round the vertical axis. The circumference is divided into eight flat faces, as shown in the part plan, Fig. 4, where B^1 is a sectional plan at focal plane, and B^2 a plan of bottom prisms, each of the flat faces composed of a series of prismatic rings and segments having one common focus; the light emanating from the lamp is thus transmitted by each face in a brilliant flash extending over the whole width and height of the

* Read at the Institution of Mechanical Engineers.

LIGHTHOUSE APPARATUS.

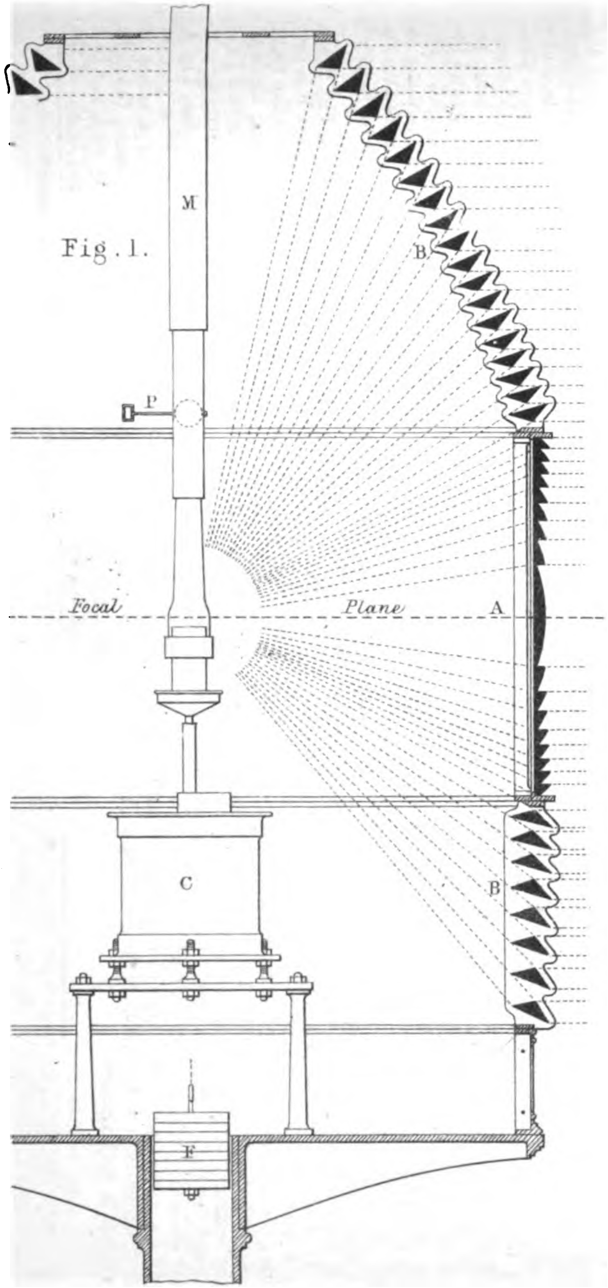


Fig. 1.

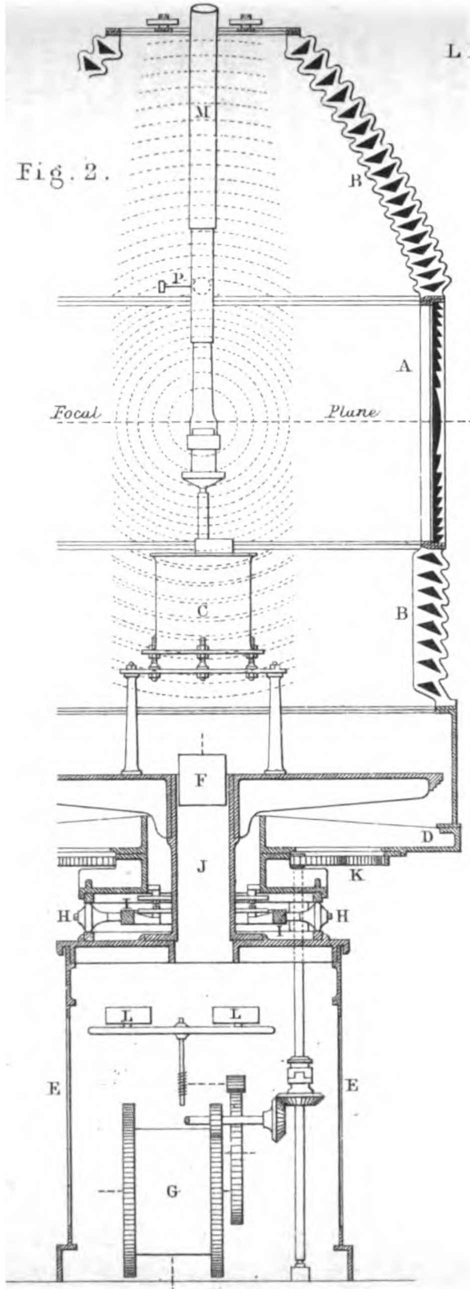
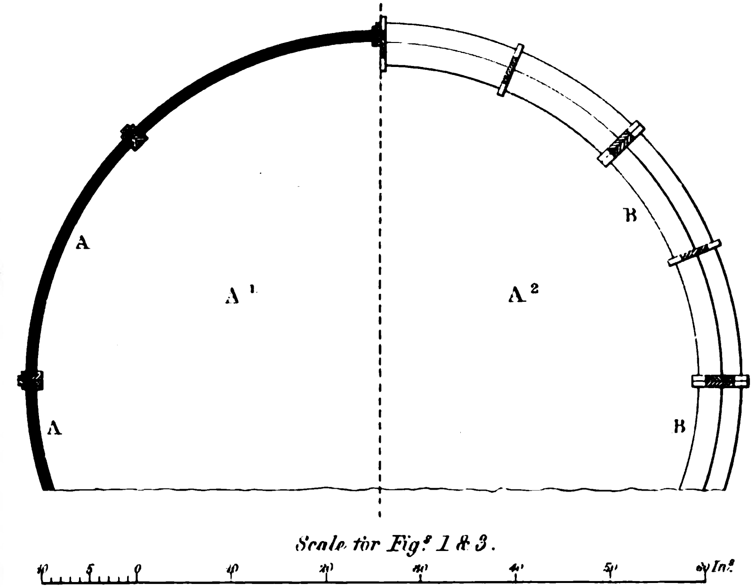


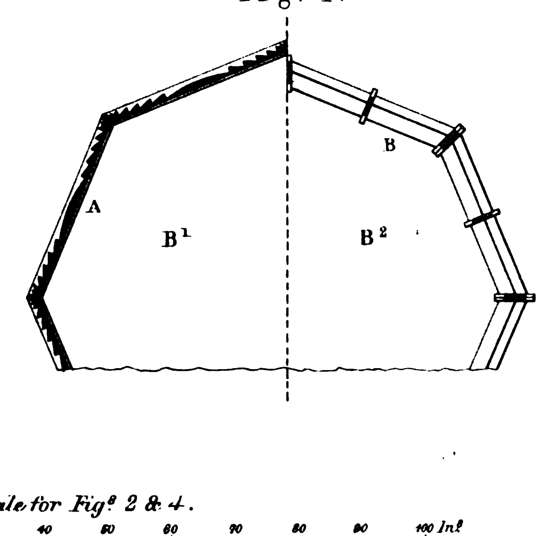
Fig. 2.

Fig. 3.



Scale for Figs. 1 & 3.

Fig. 4.



Scale for Figs. 2 & 4.

J.R.Jobbins.

face; and the whole apparatus being made to revolve by clockwork, every point of the horizon is illuminated by a succession of brilliant flashes corresponding to the several faces, and at intervals of time determined by the speed of revolution. By the use of fixed and revolving lights, or combinations of them in various ways, lights of distinct appearance are produced in a number sufficient for all purposes that are required in practice.

Dioptric lights are made of six different sizes or orders as they are termed; and the following table gives the internal radius of the apparatus or the focal distance in each order, the number of wicks in the lamp, and the consumption of oil in lbs. per hour and in gallons per year, assuming the light to burn 11 hours per night on an average throughout the year.

ORDERS OF DIOPTRIC LIGHTS.

Order.	Internal radius of Light. Inches.	Number of Wicks.	Consumption of Oil. lbs. per hour.	Gallons per year.
First...... ...	36·22	4	1·65	736
Second... ...	27·55	3	1·10	490
Third	19·68	2	0·41	130
Fourth... ...	9·84	2	0·26	116
Fifth	7·28	1	0·17	76
Sixth	5·90	1	0·17	76

The three largest orders are generally termed sea lights, and the three smaller ones harbour lights. The first order, as the most important, will alone be referred to in this paper, the others differing merely in size and number of prisms and lenses.

In the catoptric or reflecting system a number of parabolic reflectors are used, ranged round a framework according to the purpose required, with a lamp in the focus of each reflector. In a fixed light these reflectors, frequently as many as 24 or 30 in number, are arranged round the frame so as to equalise the light as much as possible in all directions. In revolving lights the reflectors are mounted on a revolving frame, having generally three faces, each of which carries an equal number of reflectors. Three flashes of light are thus produced, which illuminate successively every point of the horizon at intervals regulated by the speed of revolution. The loss of light in this system is necessarily very large: indeed nearly the whole of the light from the front of the flame is directly lost by natural divergence, the reflectors transmitting to the horizon only the rays emanating from the back of the flame, and of this light nearly 50 per cent. is lost by the absorption that always takes place in reflection by metallic surfaces.

Comparing the two systems together, it is evident that for fixed lights no possible combination of reflectors can distribute a zone of light of equal intensity round the horizon, whilst this effect is completely obtained by the dioptric system. It is found that whilst only 3½ per cent. of a plain open light would be available round the entire horizon, 17 per cent. is obtained by the use of the best reflectors, but 83 per cent. is obtained by the use of the dioptric lights. The extreme divergence of the rays of light from a usual 21-inch reflector with a 1-inch flame is about 14 degrees; but the variation of the intensity of the flash emitted over this angle is very large indeed, the intensity of the light being only 16 per cent. on the sides of what it is in the axis of the flash, showing how great is the irregularity of the light spread over the horizon. Also the numerous fastenings of the reflectors and lamps frequently get loosened, increasing greatly the irregularity of the light. Nor is the whole amount of divergence taken vertically useful; for, as will be shown afterwards, the lower portion of the vertical divergence required to illuminate the sea between the horizon and the land is but a very small amount. In uniformity of light therefore throughout the horizon illuminated the dioptric system is very greatly superior to the reflecting for fixed lights. With regard to economy of oil, fifteen reflector lamps together consume as much oil as the one central lamp in the dioptric light, and the saving therefore amounts to 50 per cent. in favour of the latter, compared with a reflecting light of the largest practicable size having thirty lamps, but greatly inferior in illuminating power to the dioptric light.

Another very important consideration is the durability of the apparatus. The longest time that reflectors will last, even when treated with the greatest care, is from 25 to 30 years; their thin silver coating will have completely disappeared at the end of that time. With moderate care and no necessity for readjustment dioptric lights may be considered as imperishable; the lenses and prisms never lose their correct form and first polish, never require renewal, and are kept always equally efficient with a far less amount of daily labour than that required for reflectors. The number of attendants or keepers required is the same in both cases, and the first outlay may be considered as generally equal.

For revolving lights however the catoptric system presents fewer points of inferiority as compared with the dioptric; for by sufficiently increasing the number of lamps and reflectors on each face of the revolving frame, a light of equal intensity to the dioptric might be produced. The illuminating power, consumption of oil, durability and original outlay will therefore be the chief considerations to determine the relative advantages of the two systems for revolving lights. The effect of only one of the eight faces composed of annular lenses in a first order dioptric light is equal to that of eight of the largest reflectors in use, 21 inches in diameter; and consequently to produce by reflectors the effect of the best dioptric light a lantern would have to be provided capable of accommodating from 56 to 72 reflectors, an arrangement all but impracticable. Moreover, at the time when most of the experiments were made both in this country and abroad, for comparing the intensity of revolving dioptric and reflecting lights, the dioptric lights were composed merely of the central or singly refracting part A, Fig 2. But in the present holophotal system, in which the upper and lower reflecting prisms BB are made to continue and extend the action of the central refracting lenses A as already described, the intensity of the dioptric lights has been nearly doubled, and the comparison rendered so much more unfavourable to the reflecting system.

The only objection which has been seriously urged against the dioptric system is the use of only a single central lamp, on account of any difficulty in its management affecting the whole light, or danger of its sudden extinction. This is met however, by the successful experience of forty years with an immense number of lights in different parts of the world. Hardly ever has such a case occurred; and as spare burners are invariably supplied, and required to be always kept ready for use, a few minutes only would suffice to remove the defective burner and replace it by another.

(To be concluded in our next.)

THE INTERNATIONAL EXHIBITION, 1862.

Civil Engineering, Architecture, and Building Contrivances.

TAKING altogether the series of objects comprised under Class 10 (civil engineering, architectural, and building contrivances), and so much of the collection under Class 31 (iron and general hardware) as relates to articles in common use on or about buildings, we do not find a remarkable amount of novelty. This is, perhaps, partly to be expected, when we recollect that many of the same exhibitors have made us familiar with their productions at the Architectural Exhibition, or at any rate in their own galleries. Still the collection is a very fine one, both for variety and general excellence, but it is better in its building contrivances, its materials and its objects exhibited for architectural beauty, than in its collection of engineering or architectural models; and the contrast becomes keenly felt between these objects, certainly good in their kind, but few in number, and the crowded collection of models and specimens in the adjoining court, of naval and military engineering, or the interesting collection of French models, with their admirable catalogue.

In passing we may remark, having referred to the subject of catalogues, that the Official Illustrated catalogue does very little credit to the Commissioners; and though it is perhaps better than was to be expected considering the principle upon which it was compiled, it is very far from being in any sense an adequate or a discriminating guide to the study of the objects it contains.

Among the best specimens of the art of modelling we find two or three from the experienced hands of Mr. Stephen Salter: among these a superb one of large size (2354, Class 10), showing the passage of the Tudela and Bilboa Railway across the chain of the Cantabrian Pyrennees, in the North of Spain, attracts peculiar notice by its truthful representation of the aspect of the rugged and richly coloured scenery of those mountains. The engineer-in-chief of this line is Mr. Charles Vignoles, to whom a medal has been awarded "for boldness of design of the Bilboa Railway," A surface of rather more than 200 square miles of country is represented in the model, while the sinuous line of railway is distinctly seen, now clinging to the slope of a steep and rocky hillside, and now threading its way between formidable obstacles. Such a model will convey to the ordinary spectator a far better idea of the difficulties to be surmounted in surveying a mountainous district, laying down a line of railway, and executing the works, than any amount of description. The pictorial effect of this model, which is itself beautifully coloured, is very much enhanced by the addition of painted backgrounds on the inner sides of its case, which serve to represent the more distant ranges of hills—these are cleverly executed by Mr. Percival Skelton. A medal was also given to Mr. Salter for the admirable execution of this model.

Two other models by the same hand, and made for the late Mr. Brunel, are also exhibited, showing the Chepstow and Saltash Bridges (2245, Class 10). They are admirable as specimens of the art, and exhibit very distinctly the chief points of the remarkable structures which they illustrate. A medal has been awarded to I. Brunel for these models, as representative of his father, the late I. K. Brunel, C.E. Some other specimens of modelling are also to be seen, and some series of drawings; but it is to be regretted that the Institution of Civil Engineers have not exerted themselves to procure illustrations of the works of their members, equal to the very excellent collection of architectural drawings exhibited in consequence of the exertions of the Institute of British Architects, and of the representative committee whom they invited to assist them.

Two models may be noticed, not on account of their workmanship, which could hardly be worse, but for their subject; they represent well-arranged and economical Labourers' Cottages, such as might with great advantage be erected in agricultural districts: they are exhibited by a northern architect named Monro. A London Cottage-building Society also exhibits a model, but of a less satisfactory cottage.

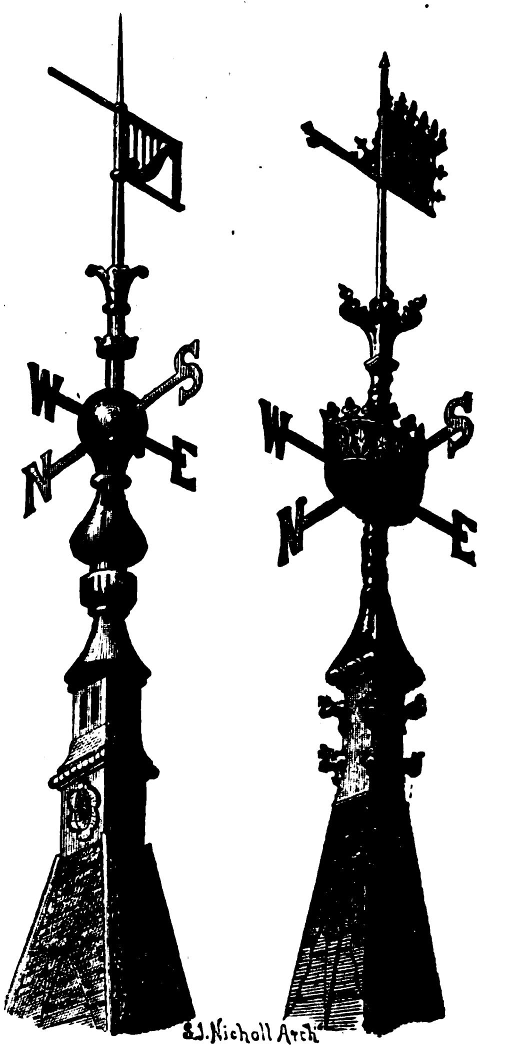
The specifications and working drawings for the Main Drainage (2369), which are exhibited by Mr. Bazalgette in this department, are a very creditable series That the execution of so vast a work must necessarily involve an enormous number of drawings, and a large amount of varied provisions, would be admitted by anyone familiar with underground works, but it assists the forming of something like a just idea of this undertaking when we turn over sheet after sheet of the seven ponderous folios and the seven closely printed quartos here exhibited, and find how unremitting has been the care to provide for varied requirements. A similar series of plans connected with the Metropolitan Railway would have been most instructive for comparison; but these by themselves fully sustain our character for engineering skill and accuracy.

Among the specimens of Building Materials, those made from clay undoubtedly form the most prominent, perhaps the most valuable group. A large space is occupied by a "Collective series of architectural productions, illustrating the clay manufactures of the Shropshire coalfield" (2318), arranged on behalf of the exhibitors by Mr. George Maw; the exhibitors being Messrs. Burton, Davis, Doughty, Evans, Exley, Lewis, Maw, Simpson, Thorne, and the Madely Wood and Coalbrook Dale Companies; and here a great variety of very excellent articles may be seen.

By far the most artistic and important of these contributions are the mosaics (2317, Class 10), contributed by Mr. G. Maw, who has devoted great attention to the revival of this ancient method of decoration. The specimens of pictorial mosaic exhibited are not numerous, and do not include a great range of colour or very deep tints, but they are marked by excellence of a high order, and are no doubt the precursors of a series of specimens which will place within the reach of English architects a means of giving the most artistic of all decorations to the wall surfaces of their buildings. The introduction of such decorations has been hitherto practically impossible; but it may be hoped that it will not long remain so, for in no country is mosaic more needed than in England, where, in consequence of the humidity of the climate, and the general want of skill in the use of the finest sorts of limes, fresco painting is at best but an uncertain mode of obtaining high class mural decorations. A medal has been awarded to Mr. G. Maw for his excellent productions.

Mosaics of a more ordinary character for flooring purposes also abound here, and show great excellence. With these may be compared specimens more remarkable for workmanship than for design, shown by the Poole Pottery Company. Messrs. Minton, who were among the earliest manufacturers of flooring tiles, do not exhibit in this locality, though specimens of their work may be found elsewhere. Among the applications of tiles shown by Mr. Maw may be noticed a chimney-piece, well intended, but of very indifferent effect, as are also some specimens of enamelled terra-cotta. Mr. Digby Wyatt's designs for ornamental roofing are shown (2317); and a very excellent specimen of roofing in glazed tiles of various colours, arranged in a simple pattern, hangs here, to remind us of an almost forgotten mode of gaining effect which was used in the early Renaissance buildings of parts of France and Germany with marked success. To Mr. D. Wyatt a medal is awarded for the designs here exhibited. Good ridge, hip, and gutter tiles are exhibited. Of these last, a very good specimen by Mr. Exley deserves notice.

Fig. 1. Fig. 2.



Weather Vanes.

Of bricks and blocks this group of Shropshire manufacturers show a good variety; but other makers compete with them successfully. Beart's Patent Brick Company exhibit beautiful specimens both of facing bricks and moulded ones (2237), the latter good enough in execution to be available for many decorative purposes. The colour of all these is good, but perhaps rather light. Honourable mention has been awarded to this company for their bricks and drainage pipes. Somewhat richer in colour, but less finished in surface, are the blocks of Fayle and Co. (2279). These are of very good forms, and seem very dense and sound; they are readily procurable, and might, we believe, be often substituted with advantage for stone, especially in buildings which are to withstand a London atmosphere. Near these is placed a collection of various and excellent moulded bricks (2243), by R. Brown, of Surbiton. Some of these bricks, arranged so as to show their powers of forming architraves or moulded jambs, exhibit great artistic merit, and excellent tints of both red and stone colour. To Mr. R. Brown honourable mention has been awarded for his bricks and tiles. Messrs. R. and N.

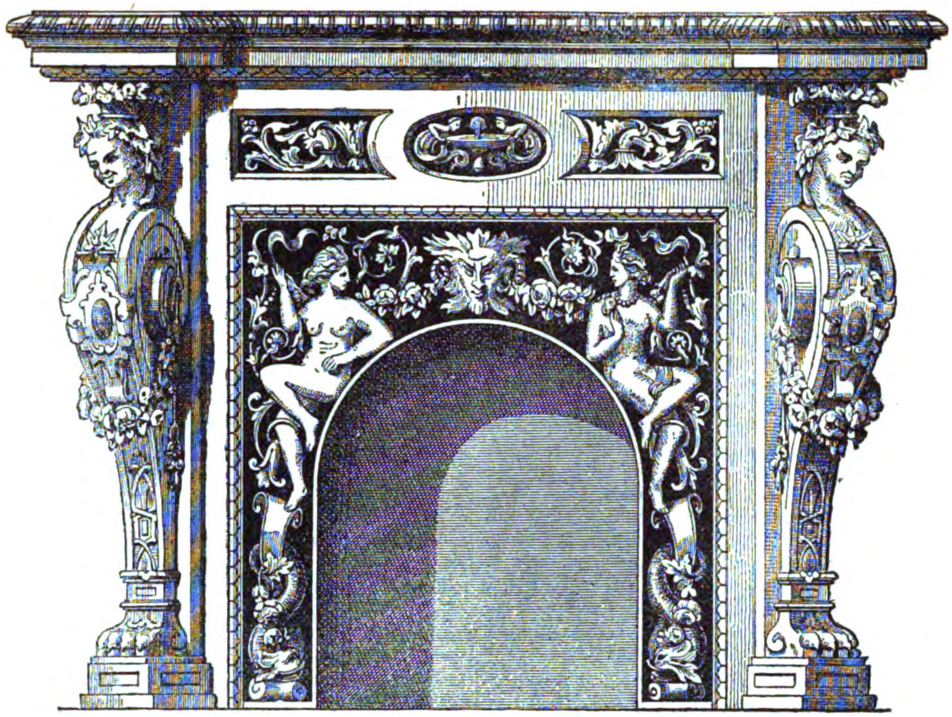


Fig. 3.—Patent Enamel Company's Grate Front, in Limousine Enamelled Iron.

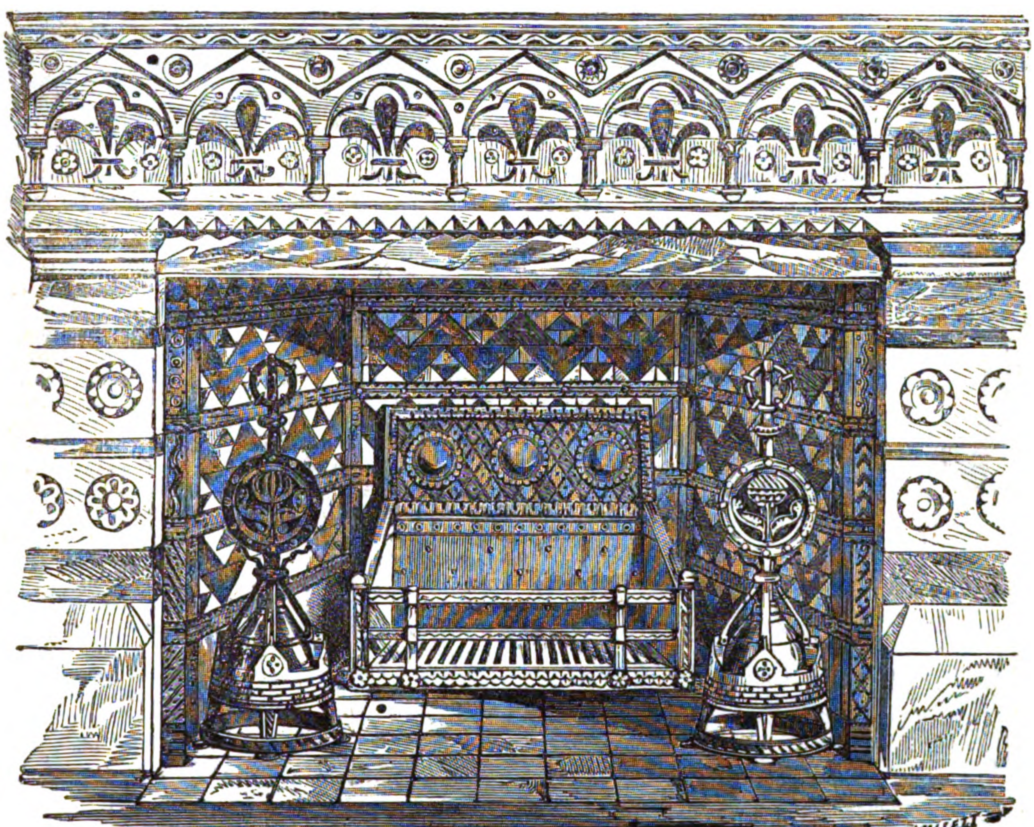


Fig. 4.—Messrs. Benham and Sons' Independent Stove with Dogs.

Norman also exhibit good bricks and ridge-tiles (2324), the latter an article of which most of the specimens sent by other makers are scarcely of average merit. A medal has been awarded to this firm. Near these we found a specimen of compressed and unburned bricks of artificial stone (2372), not attractive in colour, but very hard, dense, and heavy; these are exhibited by Messrs. Bodmer, Brothers, and seem worth the attention of builders requiring a very solid and indestructible article. C. O. Fison exhibits a fine show of Suffolk bricks, cutters, and facing bricks (2282, honourable mention); and some of the merchants, particularly Eastwood (2271, honourable mention), show collections which include excellent specimens of many varieties.

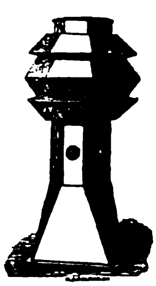
Of stoneware, the Lambeth manufacturers send specimens which will probably never be surpassed. Doulton and Co.'s collection

(2268, medal) seems one of the most extensive and complete, and their segmental blocks for forming sewers of large size are among the best specimens of contrivance and execution shown. A neat and well-made stoneware sink, by this firm, deserves the attention of those interested in the sanitary improvement of the dwellings of the poor. Cliff, and Jennings, are also both large exhibitors of this class of goods; the latter has had the good fortune to get conspicuously posted throughout the building, by the adoption of his well-made conveniences by the Commissioners.

Near the collections we have referred to is a specimen of workmanship which more properly belongs to the Sub-class C, although it is placed away from most of the articles belonging to that class—we refer to the marble paving (2440) for Chichester Cathedral, executed by H. Poole and Son, from the designs of Mr. Slater. This paving is very good in design and satisfactory in effect; it is, as a specimen of workmanship, one of the best articles we have noticed, and reflects great credit both on the designer and the manufacturers, to each of whom a medal has been awarded.

Among the articles which are exhibited in Class 31, there are, as we have observed, many that may with propriety be grouped together with those in Class 10, and none more so than iron gates. The park gates sent by Bernard, Bishop, and Co. (5098, medal) have been already alluded to in a former notice, and certainly far surpass in workmanship any other specimen of the kind. Feetham and Co., Cottam and Co., Bailey, and Potter, may be named as each sending a pair of gates of remarkable excellence. Perhaps those of Mr. Potter are the most thoroughly artistic (6183, medal), but the border is better in design than the panels. The specimen (5977, medal) by Bailey is remarkable for its very excellent workmanship.

Messrs. Benhams and Froud exhibit a variety of articles of architectural character (6280, medal), especially good copper, zinc, and iron weather-vanes of various styles. The two shown, Figs. 1 and 2, are of wrought copper, from designs by Mr. S. J. Nicholl, architect. The same firm also send a peculiar patent chimney-head for preventing smoky chimneys, the object of which is to direct the currents of air produced in windy weather into such directions that, passing the openings out of which the smoke issues, they shall assist instead of impeding its exit. The appended illustrations, Figs. 5 and 6, show the form and construction of the article, upon which Mr. Billing,



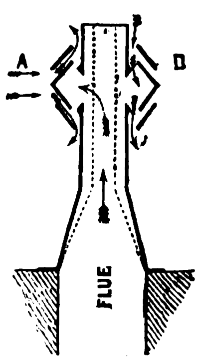


Fig. 5. Octagon Chimney-head. Fig. 6.

perhaps the best authority on such subjects, is understood to have pronounced a very favourable opinion. The price is moderate at which these tops can be supplied, and their appearance is less unsightly than that of many such inventions.

In the South Eastern Court will be found specimens of a new manufacture (6175, medal) contributed by the Patent Enamel Company, of Birmingham, which claims to possess both novelty and excellence, and to be applicable to a variety of purposes. The articles consist of wrought-iron plates and tablets, covered with a bright and glossy enamel, so hard as to be incapable of being scratched with a steel point; or, indeed, any instrument short of a diamond. This material is stated to be also incapable of receiving a stain, and incorrodible by the action of the atmosphere, and if experience prove it to be so, it undoubtedly offers considerable advantages for all purposes where inscriptions are desired to be made legible and permanent, though exposed to the action of the weather. An important advantage claimed for these plates, is their conspicuousness at night, when the white and highly polished surface of the letters reflects sufficient light to make the inscription distinctly legible. The material also seems to be applicable to decorative purposes—as panels and grate-fronts of a highly decorative character are exhibited, of which we append illustrations, Figs. 3 and 7. Specimens are also shown of domestic and culinary utensils coated with the same hard and

Fig. 7.

Altar Frontal, in Limousine Enamelled Iron, style of the 15th Century.

glossy enamel, and tubes, both of wrought and cast-iron, covered both within and without by a coating of the same material, and thus preserved from the rapid change and destruction which water and gas pipes speedily undergo, when left without such protection to the action of the earth impregnated with damp and the escape of gas. This last application of the invention seems especially worthy of notice.

Messrs. Benham and Sons, of Wigmore-street, are represented (5986), and among the cooking ranges and stove-grates exhibited here they will be found to have contributed numerous examples, combining great utility and novelty. One of their more artistic contributions—a stove with dogs and fire bars, adapted either for wood or coal, of which Fig. 4 is an illustration, forms a conspicuous part of the trophy in the south-east transept. It is of excellent Mediæval design, and its adaptability to two sorts of fuel would render it possible to introduce it in any locality, where so ornamental an object was desirable. We may add that a medal was awarded to Messrs. Benham and Sons for the excellence of their productions.

Another branch of metal manufacture—that of bells—claims a word of notice, though the specimens exhibited are not very numerous.

Messrs. Taylor and Co. exhibit one large bell of 3 tons weight, (6531, honourable mention,) having a diameter at mouth of 5 ft. 8½ in., and a thickness at sound bow of 5 inches. The note of this bell is B natural, and it is considered by good judges to possess a remarkably fine and very powerful tone. This is the one requirement which alone ought to determine the excellence of a bell; and while it is not surprising that so eminent a firm should have been so successful as in this instance they have proved, it is to be regretted that novelties, often of doubtful merit, should be sought after so eagerly in an art where the oldest examples are often the best.

Messrs. Naylor, Vicars, and Co. send a peal of eight bells (6448, Class 32, medal), to which the palm for novelty may be very justly awarded, as the material—steel—is one which has only very recently been made available for bell-making purposes. But, except as good workmanship, and as cheap compared with the best bell-metal bells of the same pitch, these bells have not much to recommend them; they are noisy and loud, but not powerful, or rich in tone; and while their notes are over-poweringly loud, near, they are soon lost. Much praise is, however, due to the inventors for having brought forward a new material for bell-making; and it is quite possible that if they continue their experiments, and try various modifications of proportion, shape, and weight, they may at last produce a bell which in tone, as well as in cost, will be a formidable rival to those now in ordinary use.

Messrs. Warner and Sons exhibit a successful peal of eight bells (6358, Class 31; medal), with a chiming apparatus much like that attached to chiming clocks, only that the barrel upon which the pins are fixed is arranged to be turned by hand, so that where there are no ringers available this mechanical method may be substituted. The whole arrangement is simple, and it has this to recommend it—that its application need not interfere with the use of the bells in the usual manner. We trust that, however well adapted for use under such circumstances as admit of nothing better, it will not be suffered to replace the method of chiming by hand, which when well done gives better chimes and affords an exercise of skill for the ringers.

(*To be continued.*)

THE NEW TOWN HALL, PRESTON, LANCASHIRE.

This large building, the foundation stone of which was laid with so much ceremony on the second of last month, in part celebration of the pageant known as the "Preston Guild," has been for some years in contemplation, but unforeseen difficulties have hitherto prevented its being in a fair way of accomplishment. The special powers however, recently granted to the corporation, for the improvement of the town, specifically included this building, and the public markets which are soon to be commenced; and consequently the old town hall was levelled to the ground in March last, to be replaced, on the same site, by the costly building which has now to be described, and for which Mr. Scott is the appointed architect. The isolation of its locality is an advantage in every respect, and peculiarly so in a public edifice of this class, where ready access from different quarters, abundance of light, and varied groupings of architectural features, are important desiderata. Thus, with the exception of part of the east side, where the street is narrow, there are no encroachments to interfere either with the convenience or the effect of the building.

In the internal arrangements three objects had to be comprised; an exchange-room, a music-hall, and rooms for the transaction of the business of the borough. The first will occupy the entire frontage on the ground floor, the second the front on the upper floor, and the third the whole of the northern side of the building on the three different stories. In general idea the design exhibits an adaptation of the foreign Hotels de Ville to English requirements, with a partial engrafting of foreign details.

The principal front is towards the south, which presents on its lower story a covered arcade of five bays, that at the south-west angle being underneath a lofty clock-tower. This arcade is carried on coupled shafts, which will be executed in polished granite, the capitals are to be of stone, and to have bold leaf-carving. The music-hall is to be lighted by a series of two-light windows ranging over the respective centres of the arcade, while below runs a continuous balcony, and above is the handsome cornice and parapet, which on this side terminate the wall, except at the clock-tower, and this is raised an additional story before we come to the clock itself, which will have four faces, and be on an unusual scale of magnitude. This tower is intended to be covered with a low spire from the top of which springs a small bell-turret. The north front is smaller, and is of uniform design, flanked with large octagonal turrets. There is a porch in the centre of both this and the west fronts, affording a ready through communication to all parts of the interior. The hall, or exchange-room, on the ground-floor, will measure in the clear 82 feet by 39 feet, its roof being groined in stone, and supported by granite columns corresponding with those outside. The entrance to the exchange is under the clock-tower. The music-hall is over the exchange, and gains additional size by extending itself over the open arcade, so that its dimensions become 82 feet by 55 feet. It will be a lofty apartment, and have a handsome open-timbered roof, the principals being of curved outline, and framed double. The orchestra is to be at the west-end, and there will be a gallery on the east and south sides. The walling will be of local stone, marble shafts and other materials being occasionally introduced, also a considerable quantity of carved enrichments, in arches, cornices, medallions, and statues. The roofs are to be covered with Westmoreland green slate. For the erection of the building tenders were invited in a limited competition, and that by Messrs. Collis and Son, of Preston, has been accepted, at an amount of £36,000. The foundations have cost about £2000 extra.

FOREIGN RAILWAY PLANT AND APPLIANCES IN THE INTERNATIONAL EXHIBITION, 1862.

The Exhibition of 1862 is distinguished from its predecessor of 1851 in nothing more than in the greater number and variety of contributions from foreign states connected with locomotion on railways. On the former occasion, a locomotive engine from France and one from Belgium constituted, we believe, nearly the sole representatives of the industries of continental countries as applied to communication on iron roads; but in the present International Exhibition there is abundant proof of the exercise of skill and good workmanship in that direction by foreign engineers.

Austria, which was principally conspicuous in 1851 by its exhibition of room furniture, has now sent two remarkable locomotive engines, of prodigious size, besides various specimens of rails and wheels, and of other articles applicable to railways. The locomotive engines are exhibited by the States' Railway Society of Vienna. They are placed opposite each other, near the north-west end of the western annexe. One of them is a monster mounted on five pairs of wheels (548, class 5, medal), and is specially intended for working on sharp curves and steep gradients, such as are to be often encountered on the Austrian railways. It would appear, at first sight, that so long an engine was very ill adapted to work on sharp curves; but it will be observed, on closer inspection, that the furnace and the boiler are mounted on separate frames, connected together by a swivel-joint, the former being supported on four wheels, and the latter on six, the whole of them nevertheless coupled together. To enable the coupling-bars to accommodate themselves to curves in the road, sufficient play is allowed at the joints for a slight lateral movement. The cylinders are 12½ inches diameter; and the engine exhibited is one of several of the same class that has for some time drawn heavy loads up inclines unknown in the railway system of this country. The rails on which the engine stands are curved, to show its adaptability to run on the sharpest curves. There is a steam break applied to the wheels, so that the driver by merely turning on the steam may bring the breaks to bear firmly on the peripheries of the wheels without any other manual exertion. The other engine exhibited by the States' Railway Society (549, Class 5, honourable mention) is intended for high speed. It has four cylinders, of 10½ inches diameter, placed on each side, parallel to each other.

There are thirty-two French exhibitors of railway appliances, which consist of three locomotive engines, for passengers and goods; railway carriages and waggons; materials for the permanent way; breaks; wheels, and other apparatus. In the catalogue published under the direction of the French Imperial Commission, it is observed, that among the improvements introduced during the last ten years in railway locomotion are: 1st. The more general use of powerful locomotives on lines of great traffic, accompanied with arrangements to strengthen the railway, and to obtain greater adhesion to the rails: 2nd, Arrangements for facilitating the running of powerful engines on sharp curves: 3rd. The use of smoke-consuming furnaces for the combustion of coals in locomotive engine furnaces: 4th. Improvement in the condition of steam by separating it from particles of water: 5th. The more general use of steel in the manufacture of tires, wheels, boilers, and other mechanism: 6th. An improved plan of feeding the boilers: 7th. An improvement in the means of securing the safety of passengers, by the use of more perfect and more resisting materials in the construction of carriages and of the permanent way; automatic breaks more judiciously chosen for the different kinds of trains; fixed day and night signals, particularly at level crossings; and means of communication between the passengers and the engine-driver and guard. Of the above improvements the last, we regret to say, has made but little advance in England. On the Continent, indeed, arrangements have existed for many years past for facilitating the communication between the passengers and the guard, by fixing a travelling platform to each carriage, along which the guard can pass, and thus enter any carriage when the train is in motion.

The Orleans Railway Company exhibit a locomotive engine (1012, Class 5, medal) in which the smoke-consuming arrangement of M. Tembrinck is applied. The plan is similar to those adopted in some stationary furnaces in this country. The coal is supplied down an incline, and falls gradually on the fire-grate, and the smoke, being conducted over the incandescent fuel, is consumed by access of air at the throat of the furnace, and the flames are then drawn through the tubes of the boiler. The same company also exhibit here a tender for the engine, and a first-class passenger carriage, fitted with all the conveniences which our continental neighbours consider necessary for comfort in railway travelling; all of which are well executed.

A locomotive (1022, Class 5) constructed according to Mr. Crampton's plan, is exhibited by Messrs. Cail and Co., of Paris, from whose extensive factory about 1000 of such engines have been turned out; Crampton's engines having been adopted very generally on the railways of France, Russia, Spain, and Italy. The axles of the engine exhibited, which has six wheels coupled together, are fitted with the apparatus invented by M. Caillet to enable the wheels to move sideways, so as to adapt them to run on sharp curves. Messrs. Cail have been awarded also a medal for steam-engines and boilers (1144, Class 8).

The third French locomotive (1032, Class 5, medal) is contributed by the company of the Chemin de Fer du Nord. It is a powerful engine, intended for goods trains, and is mounted on four pairs of wheels coupled together. It is chiefly remarkable for its great size and strength.

There are several kinds of breaks exhibited by French engineers, two of which are called self-acting. One of these, exhibited by the Lyons Railway Company (1016, Class 5, honourable mention) is intended to act on a greater declivity than it would be possible for the mere locking of the wheels to produce effect. The automatic action is not very clearly perceptible, but it is said "to act of its own accord by the snapping of the cable." In a model of a break (1040, Class 5) exhibited by M. Didier, of Paris, the plan is adopted of bringing three blocks to rest on the rails without locking the wheels, which is, we conceive, the most effectual plan of stopping a railway train without risk of injury to the wheels or to the rails. Among other articles exhibited in the French machinery department there are several axles with contrivances for supplying grease; there are four exhibitors of wheels and tires; there are rails and crossings, and models of signals; and in cases where it did not suit the convenience of the inventors to send locomotives of full size or models, drawings have been forwarded.

The contributions from Belgium of articles connected with railways is neither so numerous nor so worthy of notice as might have been expected from the country on the continent in which railways were first introduced, and wherein the system was first brought to the greatest perfection. Only one locomotive engine is exhibited, which presents no remarkable feature; and there is also a summer railway carriage, and a weighbridge for railways; all the other contributions, consisting of wheels, tires, axles, and rails, rather intended to show the quality of the iron of which they are made than any peculiarity in the mode of construction.

The Prussian manufacturers have made great efforts to display their works, for though there are only eleven exhibitors in Class 5, some of their contributions are the most striking of the kind of any in the building. Mr. A. Borsig, of Berlin, has sent a locomotive and tender (1254, Class 5, medal); the Berlin Company for the manufacture of railway requisites, have contributed specimens (1052, Class 5, medal) of the four classes of passenger carriages used in Prussia; the Bochum Mining and Cast Steel Manufacturing Company exhibit specimens of wheels and tires (1253, Class 5, medal), some of which are 9¾ feet in diameter; there are several other contributors of steel and of iron wheels, but the greatest display is made by M. F. Krupp, of Essen, who has a magnificent trophy of cast-steel articles of all descriptions (1308, Class 8, medal), including cannon, crank-axles, railway wheels, and tires. M. Krupp possesses, we believe, the most extensive steel works in the world. In 1851 he received a Council Medal for an ingot of steel that weighed two tons, which was the heaviest then known, and he now exhibits a sample of a cylindrical ingot weighing twenty tons, broken in the middle to show that these ingots in the rough state are quite free from honeycombs or faults. There are various samples of cast-steel railway tires without weld, such as have for some years past been used on the railways on the continent and in England. Among the specimens exhibited are the tires of wheels taken from an engine on the Eastern Counties Railway, after having run upwards of sixty-six thousand miles without being turned; also similar tires from the wheels of an engine that weighs twenty-eight tons, and which had run on the North London Railway for seventy-seven thousand miles.

The railway wheels of various descriptions, made of steel or iron, or case-hardened, and of axles, contributed by the Bochum Company, by the Hörde Society of Mines; by Messrs. Lehrkind, Falkenroth and Co., of Arnsberg; by M. Ruffer, of Breslau; and by the Sieg-Rhine Company, together with those of M. Krupp, form a collection that for number, variety, and excellence is scarcely surpassed by those in the English portion of the Exhibition.

Of the other states of the Zollverein, Saxony is the only one that has sent any specimen of manufactures connected with railways, and the sole contribution of Saxony is a locomotive engine, manufactured by R. Hartmann, (2319, Class 5, medal) with moveable fore-axle, for mountainous districts and short curves. There is a great deal of workmanship in this engine, which is very well finished, and the external couplings for the attainment of a lateral motion, give it an appearance of great complexity compared with the simple couplings by connecting bars to the cranks of most locomotives of English manufacture.

It is a remarkable feature of the present Exhibition, that while the only contributions connected with railway locomotion from the United States of America are some lithographs and photographs of locomotives, yet Italy, Spain, Sweden, and even Russia are represented in that class. Italy, indeed, sends a large locomotive engine, with six coupled wheels (1002, Class 5, honourable mention) from the Pietrarsa Royal Works at Naples, and judging from the models sent by other exhibitors it appears that the inventive genius of Italy is beginning to be directed towards railway engineering. There are, for example, an atmospheric railway with a valveless tube, exhibited by V. Fucini, Pavia (1000, Class 5); "steam engines for railways and steamers on a new principle," exhibited by G. Vanossi, Chiavenna (1004, Class 5); the model of a locomotive tender, exhibited by Volini and Co., Verzaro (1005, Class 5), applicable to steep inclines; and the model of "an electric signal to prevent collisions," exhibited by E. Vincenzi, Modena (1006, Class 5, honourable mention). The inventive genius of Spain seems, also, to be awakened, for of the three objects in Class 5, sent from that kingdom, one is a waggon wheel "constructed so as to move without friction at the axle," and another is the model of a locomotive "moved by hydrogen gas." The four contributions from Sweden consist of railway wheels, axles, tires, and rail-spikes; and the two from Russia are specimens of rails.

Many of the objects exhibited in the foreign division of the western annexe deserve more particular notice than we have now bestowed on them, and we may probably return to the subject again, but we have said enough to indicate that foreign engineers have made important strides in the construction of locomotives and of railway appliances since 1851, and that it is necessary for the engineers of this country to be on the alert to keep in advance of those on the continent, especially in Germany.

Explosions of Copper Gas-pipes.—Dr. T. L. Phipson, states that it has been discovered that when gas-pipes constructed of copper or bronze have been long submitted to the action of ordinary coal-gas an explosive compound of copper and acetylen (one of the many ingredients of coal-gas) is formed. When dry, this compound detonates with extraordinary violence as soon as it is rubbed, struck, or heated. Already some accidents have occurred and some workmen have lost their lives while cleaning large copper gas-pipes from this circumstance. No such explosive compound appears to be formed when iron or lead are used. It is evident that large copper gas pipes are unsafe, and that some other metal should be substituted for the copper, as the latter may give rise to explosions at any moment. As concerns small pipes constructed of this metal, they should not be allowed to get foul, and when about to be cleaned hydrochloric acid should be introduced into them for about ten minutes before they are submitted to any heat or friction. Hydrochloric acid decomposes the explosive compound, combines with the copper, and puts the acetylen in liberty. The acid may then be washed out with hot water.

ON THE CONSTRUCTION OF WROUGHT-IRON LATTICE GIRDERS.

By Thomas Cargill, C. E.

The many and peculiar advantages possessed in general by wrought-iron bridges of every description, in the facility with which they can be rendered available in situations where similar structures of masonry could only be erected at a far greater cost, attended with much risk and uncertainty, are daily rendering them more important objects of study and attention to the professional man.

It is true, that these advantages may be also claimed by cast-iron girders, but they lack one indispensable requisite—namely portability, for a cast-iron girder must arrive at its destination in as sound and perfect condition as when it left the workshop, and this is rather a hazardous matter to accomplish, when we take into consideration the chances of injury which may accrue to it during its transit from one country to another; the difficulty of transporting the castings safely increases with their size and weight, which depend, *cæteris paribus*, on the span of the bridge.

It is widely different with respect to a wrought-iron girder, the component parts of which can be separated, respectively packed together, and dispatched over land and sea to the future site of their erection, with very little fear of accidental injury; moreover, in the event of any occurring, the nature of the material and the size and form of the different portions would more readily admit of repair than in the former case.

I am aware that large castings have been sent from this country, and reached their destination in perfect safety; but that the preference is given to wrought-iron (with the exception of the system introduced by Col. Kennedy) as the material for railway bridges intended for foreign countries, is amply manifested by its very extensive use in the iron bridges and viaducts of our Indian Railways, all of which I believe were, and continue to be, manufactured in England. The viaducts over the Soane, Jumna, and other large rivers, furnish magnificent examples of its utility, and of the engineering skill displayed in its application.

There are however far weightier considerations, such as the failure of several cast-iron bridges, together with the treacherous and uncertain nature of the material, which altogether preclude any comparison between cast and wrought-iron bridges, except in the case of very limited spans. The latter cause for non-reliance on such a substance has, unfortunately, been but too well evidenced by the New Hartley Colliery accident, which cost us the lives of over two hundred of our mining population. It may not be out of place here, in illustration of the difficulty experienced in transporting large and heavy castings to even a comparatively short distance, to quote from the Report of Mr. W. Tierney Clark respecting the proposed bridge to connect Buda with Pesth, across the Danube, in Hungary. Mr. Clark in his report alleges, on the supposition that the bridge was to consist of cast-iron arches, that "it would be next to impracticable" to obtain the safe transport of the necessary castings from England.

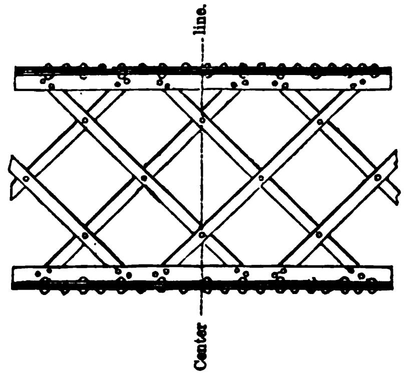
The different forms in which wrought-iron girders have been constructed are exceedingly numerous, but all those which experience has shown to be adapted and safe for railway traffic may be classed under the following heads:—1, all girders having continuous webs, such as the plate, tubular, box, &c.; 2, those having open webs, including the trellis, lattice, triangular, &c.; 3, the arch; 4, the bow and string—under which denomination the late Mr Brunell's stupendous Royal Albert Bridge might come, although in reality it embodies a variety of principles in its construction.

I exclude from this enumeration all bridges purely on the suspension principle, hanging girders, and others of a similar description, which have not yet been sufficiently tested in practice to warrant their being included under the head of Railway Bridges. Some might think that the Niagara Suspension Bridge should be made an exception to the above, but when we consider that railway trains are not permitted to cross it at a greater speed then five miles an hour, it can hardly be called in the proper sense of the term a railway bridge—at any rate, not in this country; for it is certain that no Government Inspector would pass a line as fit for public traffic, over a portion of which it would be always unsafe for a train to travel at a greater velocity than five miles per hour. Wrought-iron lattice girders have been gradually gaining ground with the profession, since the erection of the Boyne Viaduct, one of the largest, if not the largest example of the kind, taking the span as our datum. It is true that the Commissioners appointed in 1848 to inquire into the Application of Iron to Railway Structures reported that "lattice girders appear to be of doubtful merit," but now we might safely, without fear of contradiction, substitute the term "undoubted" for the word "doubtful." Lattice girders, trellis, triangular, and the different modifications of the open web form, have been often included under the same denomination. Without going into all their respective differences, I will briefly mention as sufficient for my present purpose the chief characteristics of the lattice girder proper, which serve to distinguish it from the other forms which have been sometimes confounded with it. One distinguishing feature is, that all the compression bars, or struts, composing its web are inclined at the same angle as the tension bars or ties, and that it does not admit of vertical struts; any that are so placed being intended to act merely as stiffening bars; this is a very common arrangement with single lattice girders, and is indispensably requisite when they have any considerable depth. Again, the connections of the different parts are all made by the use of rivets, and never by the employment of pins, as is the case in Warren's triangular girders. There must also be, at least, one crossing of the diagonals in the web to constitute a lattice girder; this occurs in the very smallest examples, namely, those which are used for the cross girders of large bridges. Lattice girders may be either single or double; the former require so very large an amount of bracing to keep them steady, that they have been greatly superseded by the latter form; they are however, when of limited dimensions, exceedingly well adapted for cross girders and accommodation under bridges, &c.

Fig. 1, which is drawn to a scale of $\frac{1}{36}$, is the elevation of a central portion of a wrought-iron double lattice girder, showing the plates, angle-irons, tension and compression bars, and connecting rivets. The girder may be divided into three principal parts, viz., the top and bottom flanges, and the intermediate portion attached to them. In the following investigation I shall use the word "flanges" to denote the collective area of the plates and angle-irons at the top and bottom of the girder; while the tension and compression bars, or ties and struts, forming the intermediate portion, will be included in the term "web" (for a further explanation of these terms, the reader is referred to Mr Latham's excellent work on Wrought-iron Bridges.) The compression bars are, generally speaking, those which slope away from the center of the girder towards the ends; and the tension bars those which slope in the reverse direction. Sometimes a careful calculation is necessary to decide whether a bar is in tension or compression, as a bar may be acted upon by both tensile and compressive strains at the same time; but a bar is correctly said to be in tension or compression, according as one or other of these strains preponderate.

In Fig. 1, the web is shown attached to the angle irons by rivets; at a certain distance from the center they increase gradually

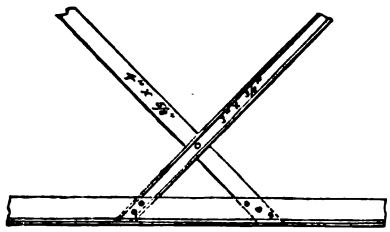
Fig. 1.



toward the ends of the girder, according to the scantling of the ties and struts, which vary similarly in the same directions; the strains upon the rivets of any one strut and upon those of its corresponding tie are by no means equal, as might at first be supposed; for, if the ends of the struts be cut to the proper angle and abut fairly against the upper and lower plates, the rivets are relieved of some portion of the strain which would otherwise fall on them; if the struts were perpendicular to the flanges, that is if we made uprights of them, so that the pressure should be in a vertical direction, there would be very little need of rivets, except to keep them from being shifted from their proper position by the vibration of the girder under a load, the tendency of which is to destroy the equilibrium of the structure by altering the normal directions of the lines of pressure. It is otherwise with the bars in tension, as in their case the rivets have to bear the whole of the direct pull, or longitudinal strains which pass along the bar, and transmit them to the angle-irons.

Towards the ends of the girders, where, in consequence of the increased amount of strain brought upon the web, the ties and struts are of larger scantlings than at the center, it would be more advantageous, instead of inserting the rivets, as is frequently done, along the line of the longitudinal axis of the bars, to place

Fig. 2.



Scale 1-36.

them in the manner shown in the tie bar, Fig. 2; this evidently cannot be done with the channel iron strut shown in the same figure, and it may be remarked, that the principle disadvantage of this form of iron, otherwise so well suited for compression bars, is, that more than one rivet cannot be inserted in the breadth of the channel portion of the sections usually manufactured. It will be seen, on referring to the figure, that the latter method distributes any strain, which is induced in the bar through the medium of the rivets, much better than the former, for when they are all placed in the center line of the bar the direct strain also passes along that line, or, so to speak, along the central longitudinal fibre; when placed as in the example before us, they distribute the strain along three parallel fibres in lieu of one, and it needs no explanation to show, that were it possible to attach each individual fibre of the bar separately to the angle-irons, the maximum distribution of the strain along the bar would then be obtained. Judging solely from this statement, combined with the well known fact that small bars and plates are proportionally stronger than others of the same length but of greater sectional area, it might be inferred, that the most judicious arrangement in a lattice girder would be to have a large number of bars of small dimensions; the extent to which it might be advisable to carry out this in practice will be limited by the consideration, that the closer we bring our bars together within a certain distance, the more we encroach upon the properties belonging to girders having continuous webs. Into a comparison of the relative merits of the two kinds of structures, it is not my intention at present to enter. The best example of the practical application of the above principle is to be found, as far as my own knowledge goes, in the strands of the cables of the Niagara suspension bridge; these strands are composed of wires so small, that it requires sixty of them to make up one square inch of section;* making use of mathematical language, and putting $\pi d^2 = \frac{1}{15}$, we obtain the thickness of the wire equal to about 0·146 of an inch.

We will now pass on to investigate the manner in which the longitudinal angle-irons perform the duties imposed upon them. Their chief office is to attach the webs to the plates, they should also distribute the strains uniformly over the plates as much as possible; and, moreover are intended to act as stiffeners to the flanges; this last duty they perform principally by the trough-like form they impart to them; it would thus appear advisable to employ unequal-sided longitudinal angle-irons, with the longer side vertical, which would also afford more bearing for the webs; but, on the other hand, it is well to have all the material used in calculating the strength of the flanges as close together as can be conveniently done, and there is no advantage to be gained in giving the bars more hold than is necessary, on the contrary, there would be a loss of metal without any adequate compensation for it.

In order that the angle-irons may connect the plates and web together, they must themselves be riveted to the plates first; and here occurs a serious disadvantage inseparable from their use, for, to obtain this connection, a certain amount of metal must be punched or drilled—the latter is preferable for many reasons—out of the top and bottom plates, which are therefore weakened, although not equally so, in proportion to the size and number of rivets employed for the purpose.

This will be at once understood by a reference to Figs. 3 and 4, which represent a portion of the plan of the inside and outside of the plates shown in elevation in Fig. 1. The rivets are there shown 6 inches apart from center to center, breaking joint, or, as it might be termed, with an alternate pitch of 3 inches. Instead of disposing the rivets in this manner, it is a very common practice to place them all in the same line across the plate, so that the line of fracture, or direction along which the plate would have the greatest tendency to split, would be through the rivets 1, 3, 4, 6, instead of through 1, 2, 4, 5; and it is alleged in defence that the plate would be as likely to split through the latter as the former direction. When the rivets have a pitch of only 3 or 4 inches, this statement becomes practically true, for then the net section (by which I mean the section of material left to resist fracture after deducting for rivet holes) along these two different directions is so very nearly equal that it is a matter of indifference whether they break joint or not; in the whole I consider it preferable in any case not to insert the rivets in the same line, partly because there must always be a slight increase of section obtained by causing them to break joint, varying directly as the pitch, and also they distribute more efficiently the strain which is brought upon the plates by the angle-irons. I may state here that it is not my purpose to give a design for any particular bridge, but simply to make use of such portions of a design as may serve to illustrate the present remarks. The dimensions of the various parts in the figures originally answered for a girder of 60 feet span for a single line of rails. In order to show clearly the comparison between these two methods of disposing the

Fig. 3.

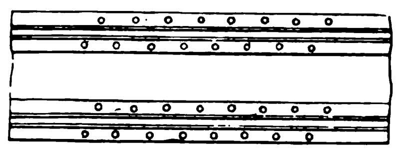
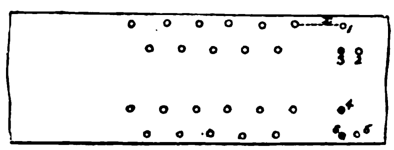


Fig. 4.



Scale 1-36.

rivets in the plates, we will take an example. Let b be the breadth of the plate; n the number of rivets along the line of fracture, or the line through which the net section is calculated; d the diameter of the rivets, and t the thickness of the plate; let x also = the distance from the edge of the plate to the center of the first row of rivets, and p the pitch of the rivets. Putting L and L_1 for our two lines of fracture, and S and S_1 for the corresponding net sections, we obtain, when the line of fracture lies through the rivets 1, 3, 4, 6 (see Fig. 4),

$$L = (b - nd); \quad S = Lt = (b - nd)t;$$

when the line lies through rivets 1, 2, 4, 5, as in the case of the rivets breaking joint,

$$L_1 = 2x + \sqrt{\left\{(b - 2x)^2 + \frac{3p^2}{4}\right\}} - nd$$

$$\text{and } S_1 = L_1 t = \left\{2x + \sqrt{\left((b - 2x)^2 + \frac{3p^2}{4}\right)} - nd\right\} t.$$

Now making $b = 24''$, $n = 4$, $d = \frac{3}{4}''$, and $t = \frac{1}{2}''$, we have $S = 10·5$ square inches; using the same notation in our second example, with the addition of $x = 1\frac{1}{2}''$ and $p = 8''$, which is about as far apart as would be desirable to place the rivets in this instance, we obtain $S_1 = 11·05$; as x, although not introduced in the first equation, is common to both, insomuch as it forms a portion of the total breadth b, it follows that the difference between the two sections is as the pitch of the rivets. With respect to the disposition of the rivets in a longitudinal direction, the nature of the construction leaves us very little choice; the position of

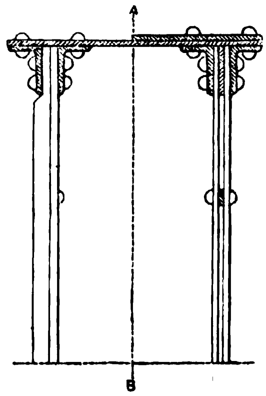
* See Supplement to Cresy's Encyclopædia of Civil Engineering.

the angle-irons determines that of the rivets; the first angle-iron is usually placed as shown in Fig. 3, with the edge of the horizontal side flush with the edge of the plate, the space between it, and the one closely adjoining it, is fixed by the maximum thickness of the web to be inserted between them, as will be mentioned hereafter; the other couple are similarly placed, and the rivets run along the center of each. It results from adjusting the angle-irons in this manner that there is a much wider space between the two rows of rivets nearest the center of the plates than between them and the outer rows, and the consequence is that the bearing is confined more or less to the edges of the plates instead of throwing the strain well into the central portions of the flanges: this could be obviated, and the distances between the rows of rivets more equalised, by shifting all the angle-irons nearer the center of the plate, still retaining the same space between each couple; but, by doing so, we also bring the webs nearer each other, and thus virtually destroy the very principle of the double lattice girder, which is to keep the webs as far apart as the breadth of the top and bottom plates will permit, in order to obtain that degree of lateral stiffness which a single lattice girder never affords; for it is certain, that in nine cases out of ten, a single lattice girder would fail through the distortion of its web long before its ultimate strength could be rendered available. Suppose that we continue to move the angle irons, in pairs, until they are in contact, then the webs will also touch one another, and the structure becomes changed from a girder of the former to one of the latter description.

In all double lattice girders I am strongly inclined to doubt whether the full strength of the plates is ever called into play, except in the joints, where the riveting is continued right across the plate, by the method employed of riveting the plates and angle-irons together in a longitudinal direction; and where the plates exceed 2 feet in breadth, I think the whole value of the material is not obtained without the aid of occasional transverse stiffening pieces of some kind or other, which would also tend to prevent the crippling or buckling up to which the plates are always liable. In girders of very considerable length, this object is accomplished by the use of cellular tops, as in the Menai bridge, but unless the girder exceeded 200 feet in length, it is questionable whether the advantages resulting from their employment could not be economically obtained in another manner. A cellular top applied to any girder is nothing more than the addition of a small three-sided box girder along its whole length, the top plate of the main girder supplying the place of the fourth side; taking in consideration the number of joints in its top and sides, together with the numerous stiffening pieces, we shall find that the cellular top would demand an amount of workmanship little less than that required for the main girder; moreover, unless when they accompany bridges of very large spans, they are of dimensions so limited that there is no getting at their interior when they are once put together and placed in their proper position. The observations made above respecting the central portion of the plates of the lattice girder not being called into play, also apply to the cellular top, but not so forcibly, as there are usually internal bracings or diaphragms constructed at certain distances, which cause a more equal and uniform distribution of the strains.

To return to the double lattice, the manner in which the connecting angle-irons tend to stiffen the flanges is at once seen on inspection of Fig. 5, which represents two half-vertical sections; that to the right of the line AB is taken through the center of the girder where the ties and struts are both plain bars; the other section is made near to the end, where the struts are usually formed of either angle, T, or channel iron; in the figure channel is the form shown, and the thickness of the web at that point is a maximum, which, as I have before stated, regulates the distance at which the pairs of angle-irons are to be placed from one another. As the thickness of the web is continually varying, it becomes necessary, wherever it falls short of the maximum, to insert filling or packing pieces between the bars, to compensate for the deficiency, and to insure the angle-irons being retained at a uniform distance apart; the packing pieces are shown in the section to the left of the line AB, Fig. 5. To avoid confusion in this respect I have shown the web as altogether in elevation, although it is evident on looking at Fig. 1, that a vertical section through it would cut the bars in one or more places, which crossings are omitted in the section for the above reason. If we call d the maximum thickness of the web, or, what is the same thing, the distance between the couple angle-irons, and if t be the thickness of the web at any point, then putting p for the thickness of the packing peice required, $p=(d-t)$: this equation will however only hold good where the construction is similar to that represented in Fig. 5. At first sight, the weight of the packing pieces would not appear to be of much consequence, and one would be ready to put them in, here and there, wherever they might be required, without considering whether they might be dispensed with or not; in taking out the quantities of a double lattice girder of the moderate span of 80 feet, I have found the weight of the filling pieces to amount to a considerable item. Also, as the packing pieces cannot be included in obtaining the area of the flanges, in the calculation respecting the strength of the girder, they merely add to its weight without increasing the strength. When channel iron is employed for the compression bars there are three different ways of attaching them to the flanges. In Fig. 5 the strut is shown rivetted between the double angle-irons, and to effect this a small portion of the webs are cut off at each end, which allows the channel part to be inserted, but at the same time it somewhat weakens the strut; this may be avoided when thought necessary, by placing the strut outside one of the angle-irons, and thus getting the full net value of the metal; this advantage, however, is gained at the expense of the far better hold which is afforded by the insertion of the struts between the angle-irons, and it also makes the distance between the double angle-irons so small, that it might be preferable to use T iron, instead of pairs of angle-irons when this method is adopted, and thus reduce the number of filling pieces to those required at the crossings only of the ties and struts. The arrangement represented in Fig. 5 may be adhered to without depriving the compression bar of any of its strength, for instead of cutting off the ends of the webs, they may be bent over and forged down upon the channel part, thus increasing its thickness, but at the same time it would increase the distance between the double angle-irons, and so necessitate an addition to the thickness of every filling piece employed.

Fig. 5.



Scale 1-18.

If T or angle-iron is used, instead of channel for the struts, there must still be some cutting off or forging of the ribs, in order to make them fit in between the angle-irons. The manner of attaching the tension bars is too simple to require any remark. The opposite lattices in the same girder are very often joined together by either a piece of bar or angle iron running from one crossing to another, and in large girders the opposite compression bars are united throughout their whole length by diagonal bars; in the latter case T or angle-iron would be better sections than channel, as, unless the compression bars are of very heavy scantling, the webs of the channel iron would be very unfavourable for the insertion of rivets.

Having now considered the main features in the construction of wrought-iron double lattice girders of moderate span, I will endeavour to point out in what manner I think some of the defects may be remedied, without losing any of the advantages possessed by the present methods in use.

(To be continued.)

THE ANTIQUITIES OF WELLS.*

By J. H. Parker.

I consider Wells as one of the most interesting cities we have remaining anywhere, from the unusually complete series of Mediæval buildings belonging to its ancient cathedral establishment. I believe there is not such a complete collection anywhere else; and the cathedral would lose more than half its interest if deprived of these adjuncts. I would strongly urge upon the inhabitants of Wells and of the county of Somerset the importance of preserving this series of buildings as complete as possible. If they are not patriotic enough to appreciate them for their artistic

* Paper read before the Somerset Archæological Society.

and historical value, they may perhaps be more open to the consideration of money value; and I am much mistaken if they do not find in a very short time, the number of visitors who are attracted by the unusual interest of their city is large enough to become a valuable consideration, especially now that it has the advantage of railway communication with the rest of the world. I have reason to believe that the interest taken in our Mediæval buildings by all classes, high and low, has increased in a very extraordinary manner, within the last two or three years especially, and I may mention one or two facts in proof of this. Only last week I was informed, on good authority, that the number of visitors to see Westminster Abbey has been not less than a thousand a day during a great part of the present season; and on one particular day upwards of three thousand persons paid their sixpences to the fabric fund for seeing the royal tombs and chapels. During the same period the number of visitors to see Windsor Castle, on the days on which the public are admitted, which are five days in the week, has been upwards of twelve hundred a day. Of the interest taken in the subject by the higher classes I can myself bear witness; for I am overwhelmed with invitations from the highest nobility and gentry in the land to explain to them the history of their castles or houses, abbeys or churches. The hundreds who attend the numerous architectural meetings testify to the same fact. I am also engaged upon the architectural history of Windsor Castle for her Majesty, who expresses great personal interest in the subject.

Nor are our neighbours across the Channel one whit behind us in the interest taken in the subject. The French Government, which reflects the opinions of the majority of the French nation far more faithfully than some of our friends are willing to allow, expends large sums every year in the preservation and restoration of their historical monuments, and in the formation of museums of antiquities. I am sorry to find that the people of this country, which is one of the richest districts in Europe in historical monuments, are rather behind the world in their appreciation of them; and that during the last year one of the old canon's houses in Wells, with a fine hall of the fifteenth century, has been wantonly destroyed under the name of improvement; and that the organist's house, another of the series, which has first been almost spoiled by neglect and by the stupid alterations of the last century, is now threatened with entire destruction for the purpose of opening a view, one of the usual excuses of ignorance. I do not know who the parties are who are at the bottom of this spirit of destruction, and I do not wish to inquire; but I could almost be answerable that some old man, or old woman, of seventy is the prime mover of it. I have always found it so everywhere; and, the obstinacy of old age being added to the usual obstinacy of ignorance, it is generally quite impossible to move it or make any impression upon it: the only chance is that some younger men may overrule him; and we must endeavour to bring public opinion to bear upon all such cases, The last generation was entirely ignorant of the value of any Mediæval buildings. The history of England itself was very little studied or understood in their youth, and they could not understand at all these great landmarks of history. But in the present day, when every girl in her teens who has had a decent education is ashamed of her ignorance if she does not understand something about them, and is generally willing enough to show her own knowledge by laughing at the ignorance of others; and when every educated man points the finger of scorn at those who would destroy any historical monument; it is only necessary to expose such attempts, and not allow the mischief to be done in a corner.

But it is time that I came to my immediate subject—the Mediæval buildings of Wells. The Cathedral has been sufficiently done by others: the Bishop's Palace I described last year. I also gave a slight account of the Deanery, the Archdeaconry, the Vicars' Close, and the old houses of the canons and officers of the cathedral; but these, I think, will bear a little further elucidation.

The Deanery is said to have been built by Dean Gunthorpe (1472—1498); and, though a good deal spoiled by modern sash windows and other alterations, it is still nearly a perfect specimen of a gentleman's house of the fifteenth century, and has its own gate-house and wall of inclosure. The principal apartments were all on the first-floor, which was a very common arrangement in Mediæval houses, the ground rooms being commonly cellars and storehouses; for the state of the country, the want of roads, the scarcity of shops, and the bad supply of the markets, made it necessary to keep a much larger quantity of provisions in store than is called for in these days. The salting-house, the bake-house, the brewhouse, the spicery, and many other similar apartments, were quite necessary in a large house; and the whole of the ground-floor was frequently occupied in that manner. In the Deanery, the principal apartment was in the garden front, or back of the house, on the first-floor, and is a valuable example of the transition from the earlier Mediæval hall, with its lofty roof, and the more comfortable dining-room of later days. At the upper end it has the beautiful bay window for the sideboard at the end of the dais; and at the lower end the music gallery, which is of stone, carried on a wide arch, with the stone staircase to it at one end—an unusual arrangement; and under the arch is the lavatory, for the guests to wash their hands before going into the hall, as this was behind the screen which crossed the entrance. But, instead of a lofty open roof, it had a flat panelled ceiling. The approach to this hall was by an external staircase at the corner of the house, of which the newel-post remains; and the doorway to it may be seen in the wall, with the marks of the pent-house over it. The present staircase was originally for the servants only, leading straight down to the kitchen and offices, which were on the ground-floor. Behind the dais at the upper end of the hall is the solar, or lord's chamber, known as Henry the Seventh's chamber, because that monarch is said to have slept there on his visit to Wells. The house has formed three sides of a quadrangle, with a curtain wall across the fourth side or front, towards the principal court and the gate-house. It has octagonal turrets at the corners, apparently more for ornament than for defence.

The Archdeaconry appears to have been a house of at least equal importance with the Deanery: in fact, the hall of it is larger and more imposing; and, in this instance, it occupied the whole height of the building from the ground to the roof. The house was originally built in the time of Edward I., as is shown by the windows in the gable at the east end, and one of the doorways near to this end, which has a fine suite of mouldings on the exterior, and a foliated arch within. This was the back door to the servants' court; the front door towards the close was larger and more important; but only a part of the foliated inner arch can now be traced in the wall, the front of the house having been entirely modernised. The hall occupied about two-thirds of this part of the house, and still retains a very fine open-timber roof of the early part of the fifteenth century, probably of the time of Bishop Bubwith, as it agrees with the roof of the hall and chapel of his almshouse. In the east wall of the archdeacon's hall are the three doorways of the buttery, pantry, and kitchen, as usual, showing that the offices were at the east end of the house, but have been destroyed. At the further end of the house, beyond the dais, it was divided into two stories—the cellar, or store-room, or parlour below, and the solar, or lord's chamber, or withdrawing room, above: this solar is itself a room of considerable size. The whole of the arrangements indicate that the archdeacon was a person of considerable importance, and able to exercise hospitality on a grand scale; or the house may have been a sort of residentiary, where the Chapter exercised their hospitality as a body, like the Guests' hall, recently destroyed at Worcester.

The house of the Choir-master, at the east end of the cathedral, is a small gentleman's house of the fifteenth century, tolerably perfect, with the roof and the upper part of the windows of the hall remaining, but disguised and concealed by modern partitions. The porch, with the room over it, remains perfect, and adds much to the picturesque beauty of the house, the rest of which is entirely modernised; and the original offices seem to have been destroyed, as is frequently the case.

The Singing-school is over part of the west wall of the cloister, and joins on to the south-west corner of the cathedral. The Organist's house is close to this, and is one of the smaller houses of the fifteenth century, the plan of which was that of the letter T, the hall forming the top-stroke, and the rest of the house the stem; but the house has been almost entirely spoiled during the last century; vile additions have been made to it, encroaching on the small space originally left between the house and the cloister, and destroying the outline of the house; which, when it stood clear, must have been extremely picturesque. The interior is also spoiled by modern partitions, now become more old-looking and more rotten than the original roof of the hall, which remains.

Most of the Canons' houses have been either rebuilt entirely or much spoiled by modern alterations; one of them to the north-east of the cathedral (now occupied by Canon Brodrick) has a good porch and a panelled battlement of the fifteenth century.

Another house, rather farther to the east (now the School), is partly of the fourteenth century, with a good finial on the gable, and the moulded arch of a doorway of that period, evidently the chief entrance to the hall originally, but long blocked up. This hall has a fine timber roof with angel corbels, but quite concealed by modern lath-and-plaster ceilings. The cellar or store-room remains, with several lockers in the wall, and is now the school-room. The solar over this is modernised, but this also contains the old roof, with its gable and coping. To this wings have been added in the fifteenth or sixteenth century, apparently to obtain additional bedrooms; and it is probable that at that time the original kitchen and offices at the other end of the hall were destroyed, and new ones made in the new wing. Such a change as this was very frequently made in the sixteenth century,

The very remarkable and picturesque Vicars' Close is so well known that it is not necessary to repeat any long story about it, but the outline of its history may be mentioned. The vicars choral formed part of the original establishment of the cathedral, and were incorporated by Bishop Joceline in the beginning of the thirteenth century; and as he was a great builder, it is probable that he built houses for them; but all that we have remaining of his time are some fragments of beautifully-sculptured ornament used up as old material, and built in the spandrels of the arches of the windows, and in the parapet. These correspond exactly with his work in the cathedral, and with the remains of his palace at Wookey; but they may have been brought from some part of the cathedral now destroyed, and the original vicars' houses may have been of wood only, as was very usual at that period. These were rebuilt by Bishop Ralph, of Shrewsbury, in the fourteenth century; and he expressly mentions in his will the houses that he has built for the vicars; but all that remains of his work is the hall, with its west window and side windows; the east end over the gateway was lengthened in the time of Henry VIII. by Richard Pomeroy.

The present houses were entirely built or rebuilt by the executors of Bishop Beckington, late in the fifteenth century, on one uniform plan, and several of these remain nearly perfect, though in many cases they have been altered, and two houses thrown into one. Nor can we complain much of this, when we remember that the houses were originally intended for bachelors only, and each consisted of two rooms with closets at the back, but no offices. The vicars dined together in their common hall, and required no kitchen in their houses. The close was, in fact, a college, in which each student had a small house, instead of his two rooms in a large one.

The very beautiful gate-house and bridge over the road from the vicars' hall to the cathedral, is part of the numerous works of Bishop Beckington, one of the greatest benefactors of the city. The southern arch of this bridge, the one nearest to the chapter-house, has long been concealed from view on the east side by a wall which has lately been removed; on the west side by a stable built against it probably in the seventeenth century, but constructed of old materials so ingeniously put together as to deceive the eye at a very short distance, and to appear like part of the original structure. This obstruction, I am happy to say, is about to be removed, and the arch left open, which will greatly improve the effect of this very remarkable bridge. I can see no reason for keeping the passage across this bridge always closed, or why the theological students should not be allowed to go across it from their library, formerly the vicars' hall, to the cathedral, as the vicars did of old. This would be, in fact, restoring it to the purpose for which it was built; for the present theological students much more truly represent the class of persons for whose use the Vicars' Close itself and the bridge was built, than the present corporation of vicars does. The degradation of the class of vicars choral generally, now called singing men, is one of the curses brought upon the Church by the change in the value of money.

The only other Mediæval house in Wells is, I believe, Bishop Bubwith's Almshouse, near St. Cuthbert's Church. This is remarkably perfect and very interesting, though much spoiled about a dozen years ago by some stupid builder, who could not understand or appreciate the wise arrangements of our ancestors. The original plan was a great hall, with a chapel at the end of it, and with cells along the sides for the almsmen, which which were open at the top to the lofty and fine timber roof, so that each old man had the benefit of many hundred cubic feet of air; and, in case he became ill or infirm, he could hear the service chanted daily in the chapel without leaving his bed; and if he was able only to crawl to the door of his cell, he could see the elevation of the host by looking along the central passage to the chapel, and could always attend divine service, however old or infirm he might be. At the opposite end of the hall was a building of two stories, the lower one of which would be the common room of the almsmen; and over it the chaplain's or master's apartment. In this apartment is now preserved a very fine money-chest of the fifteenth century, with the usual three locks, and painted in the old style with a scroll pattern. This is supported on a stand made for it in the time of James I., with some curious doggerel verses upon it. It is, perhaps, hardly necessary to observe that the arrangement of the cells along the sides of a large hall is exactly the same as that of the dormitory of a monastery. This arrangement is the most economical of space consistent with an abundance of air, and has been adopted in the dormitory of Ridley school, and some other large schools where the masters are enlightened enough to profit by the wisdom of their ancestors. The same arrangement is also adopted in some of the public baths lately erected in various places and for the same reasons. The partitions of the cells give privacy without losing space; and being open at the top to the roof, there is plenty of air. At Glastonbury, an almshouse of this description has had the hall roof destroyed, and each of the cells roofed over, so as to turn them into a little street of cottages. I cannot see the advantage of this change. When the old arrangement was kept up, the almsmen, or the monks, were kept warm in the winter by hangings and an awning over the cell. But the modern builder has effected the improvement of making each cell as nearly air-tight as possible with lath and plaster, and introduced a second set of cells on a floor over the original ones; thus entirely spoiling the old hall, and allowing each almsman only a very limited supply of air, hardly sufficient for health. I know nothing of the history of this alteration, but it seems natural to suppose that it has been done under the direction of some corporate body of governors, and has been considered a clever and ingenious construction, to accommodate double the number of almsmen in the same space and under the same roof; and it looks as if the trustees of the property with which the hospital was endowed by the founder had, after long neglect, been seized with some qualms of conscience, or some wholesome fear of the Charity Commission, and had observed that their funds were more than sufficient for the then existing number of almsmen at the then rate of payment. In such cases it very commonly happens that the change in the value of money since the time of the foundation is entirely forgotten. If the endowment was in land, as it probably was, it is worth now, in nominal money value, twenty times the sum at which it was reckoned by the founder. This is no random assertion, but it is well known to those who have studied the subject: and I am not now speaking of the Wells case in particular: I only guess from appearances that the case is one of those of constant occurence everywhere.

But to return to architecture. I have omitted to mention the Bishop's Barn, which is a very fine and perfect one of the early part of the fifteenth century, probably built by Bishop Bubwith, as the construction of the roof is the same as that of his almshouse, although plainer.

St. Cuthbert's Church does not properly belong to my subject; but in order to complete the history of the Mediæval buildings remaining at Wells, perhaps a short account of it may be desirable. It was originally a cruciform church of the thirteenth century, with a central tower and with aisles to the nave, but of the church all that remains in the original state is a part of the north transept; the central tower has been removed, the church entirely rebuilt in the fifteenth century, without a vestige of the old work. The pillars and arches of the nave have been rebuilt in the fifteenth century also, and the pillars lengthened considerably. The arches, with their dripstones preserved and used again on the taller pillars, and most of the capitals have had the foliage cut off. The aisle walls, the clerestory, and the roof, are all Late Perpendicular, about the time of Henry the Seventh; but the beautiful west tower is evidently earlier than the clerestory and roof, and has the mark of the old roof on the east side of it, coming below the present clerestory. This fine tower, which is certainly one of the finest of its class, and which Mr. Freeman considers, I believe, to rank only second to one other, is said to have been built in the time of Bishop Bubwith, or about 1430; and this appears to me probable. The character of the work is rather Early Perpendicular, and the groined vault under the belfry appears to be an imitation of the Decorated vault of the cathedral. The arms in the spandrels of the west door belong to benefactors whose families disappear from the city records about 1450. If the tower prove to be of the time of Bishop Bubwith, it is a valuable date to have ascertained, as these rich Somersetshire towers are usually considered to be half a century later; and it seems more probable, as Mr. Freeman observed to us last year, that they do in reality spread over about a century, than that they were all built in twenty or thirty years at the end of it.

As I have now said all that appears to me to be necessary respecting the buildings of Wells, I may perhaps be allowed to add a few words as to the manner in which it is probable that funds were provided for building them. There were, no doubt, at all periods some men who were fond of building, and when these men happened to be wealthy they built a great deal, as in the case of Bishop Beckington, who must have expended a very large sum during his lifetime in building, and left the remainder of his fortune to his executors to be expended in the same manner. But there are men who are fond of building in these days also; the difference is that building was almost the only mode of displaying wealth in those days, and every one likes to leave some memento of himself behind him if he can.

For those buildings belonging to a cathedral chapter there is however another mode in which funds may have been supplied, at least in part. In nearly all these foundations certain estates were set apart by the founder or by the chapter, from its earliest days, to form the fabric fund; out of this fund a gang of workmen was kept in the regular employ of the chapter, and we find from the records of several of our cathedrals that the same families continued to serve the chapter as masons or carpenters or smiths generation after generation. In this manner they acquired great skill in their art; and although the architect, or master-mason, may have travelled and got new ideas from time to time, the greater part of the workmen were stationary, and naturally formed a school of their own, which accounts for the provincial character we very often find in Mediæval buildings. After the cathedral was completed these men would naturally be employed by the chapter in any other works that were required, such as houses for the canons or officers, or for building churches on the manors belonging to the chapter. When a parish was an independent rectory it commonly had a fabric fund of its own; and any one who has read many of the wills of the middle ages must have met with many bequests to the fabric, and these do not always prove that any particular work was going on, although they were, of course, more numerous at such times. When great works were going on, and funds fell short, the chapters sent round briefs or begging letters in all directions, and frequently obtained large contributions to their fabric fund. It was therefore by the joint action of the voluntary principle and the hereditary principle, or the endowments bequeathed by our ancestors, that those magnificent series of structures were erected.

Extract from the Chapter Books, A.D. 1325.

"Item—That the bishop shall contribute to the fabric of the new work of the church of Wells one moiety of the proceeds of his visitation.

Item—Because the stalls in the choir are ruinous and ugly, it was ordered on the same day, that all and every of the canons who are duly constituted in the dignity and office, shall make their own stalls at their own expense, and that the dean may compel them to do so."

This shows that the buildings were not completed in 1325; it is probable that the Lady Chapel and the Chapter House were the works then carrying on. The stalls then ordered to be made were turned out as rubbish a few years ago, having previously been much spoiled. One of the ends of a stall-desk has been fortunately preserved by Mr. G. G. Scott, who obtained it by accident, and knew its value. (A photograph of this was exhibited by Mr. Parker, and was acknowledged by all to be a very fine specimen of the woodwork of the fourteenth century.)

THE ECONOMIC CONSTRUCTION OF GIRDERS.

(*Continued from page* 280.)

GIRDERS OF GREAT SPANS.

The striking conclusions arrived at in our last paper will, we believe, be readily acquiesced in by those who are at the same time sufficiently acquainted with the practical requirements, and have thoroughly studied the simple mathematical questions, involved in the determination of the weights of great girder bridges. But many readers, to whom the results may be surprising and interesting, may not care to follow the processes by which these have been attained, and cannot therefore have clear impressions of the causes of such great disparities in the weights of girders when extreme spans are attempted. We shall therefore endeavour to give here a more direct and sufficiently simple exposition of the excessive influence which the value of the economic merit of any particular form of structure has upon its weight when the dimensions are greatly increased.

Familiar Exposition of the Relation between Span and Weight of Girder Bridges.

Let the general factor of safety be assumed, for the sake of simplicity, the same for all spans.

Let P represent the whole load belonging to one line of railway exclusive of the weight of the bare girders required for its support. P includes a movable loading at the rate of 1 ton per foot of span besides the weight of the shares of the roadway platform, horizontal and transverse bracings, permanent way, &c. of the complete structure, due to one line of railway.

Let G represent the weight of the bare girder or girders required to support the above loadings, besides its own weight.

Then G+P represents the whole load supported, and therefore the whole practical strength required, of the girder or girders.

Then G represents the portion of the practical strength of the girder not usefully available, being devoted to sustaining the girder itself.

And P represents the useful strength, or the portion of the practical strength available for the support of the necessary load.

Now let us assume that for a span of 50 feet the weight of the train, roadway platform, &c., or P, amounts to 65 tons; and let us suppose that two girders constructed on different systems, A and B—and each capable of supporting, under the proper factor of safety, its own weight in addition to the above 65 tons—weigh respectively 4 and 6 tons: we then have

	G+P, or Whole Practical Strength.		G, or Strength Self-absorbed.		P, or Available Strength.
Girder built on System A ...	69 tons		4 tons		65 tons
	or as 17¼	to	1	to	16¼
Girder built on System B ...	71 tons		6 tons		65 tons
	or as 11⅝	to	1	to	10⅝

Now since the weights of similar girders are as the *cubes* of their spans, while their strengths (measured by the whole of the supported loads) are only as the *squares* of their spans, it follows that the ratio of the weight of a girder to its strength, or of G : G+P, varies inversely as the span, or in other words, the ratio of G : span (G+P) is constant. Furthermore, these ratios are not materially affected by moderate changes in the absolute strength of the girders, since, within practical limits, a girder which does not vary in span, depth, or design, but only in the general scantlings or sectional areas of the parts, will have its strength varying in the proportion of its weight. Therefore if we increase the above spans from 50 to 400 feet, the ratios of G : G+P, shown above as 1 : 17¼ and 1 : 11⅝, do respectively

$$\text{become} = 1 : 17\tfrac{1}{4} \times \frac{50}{400} \text{ or } 1 : 2{\cdot}16, \text{ and } 1 : 11\tfrac{5}{8} \times \frac{50}{400} \text{ or } 1 : 1{\cdot}48.$$

And the ratios of G : P will evidently be obtained by deducting a unit from each of the foregoing, or

	System A.		System B.
When G : G+P =	1 : 2·16	and	1 : 1·48
Then G : P =	1 : 1·16	and	1 : 0·48

Now for the span of 400 feet let us assume the value of P to be=600 tons; and we consequently have

$$G = \begin{cases} = \dfrac{P}{1{\cdot}16} \quad \text{(System A.)} \quad \text{and} \quad \dfrac{P}{0{\cdot}48} \quad \text{(System B.)} \\ = \dfrac{600}{1{\cdot}16} = 518 \text{ tons, and } \dfrac{600}{0{\cdot}48} = 1250 \text{ tons.} \end{cases}$$

So that instead of the weights of the girders being as before in the proportion of 1 : 1·5 for the 50 feet span, they are for the 400 feet span in the proportion of 1 : 2·4, although the relative economic merits of the systems A and B remain the same as before.

The economic merit of each system may be represented by the relative value of the ratio $\frac{S(G+P)}{G}$; for the two systems A and B, the values of this are as 1·46 : 1, and on decreasing the spans of the girders the proportion of their weights to one another would assume more and more nearly this value taken inversely.

For a span of 500 feet, the ratios of G : G+P become $=1:17\frac{1}{4}\times\frac{50}{500}$ and $1:11\frac{1}{8}\times\frac{50}{500}$ or 1 : 1·725 and 1 : 1·183, and consequently the ratios of G : P become = 1 : 0·725 and 1 : 0·183; and if we assume P=800 tons,

$$G \text{ will become}=\frac{800}{0{\cdot}725}=1103 \text{ tons, for the A system,}$$

$$\text{and } G \quad ,, \quad =\frac{800}{0{\cdot}183}=4371 \text{ tons, for the B system;}$$

or in the proportion nearly of 1 : 4. We consequently have the following results:—

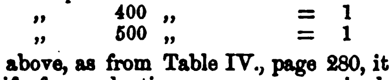
		System A.		System B.
Ratio of the economic merits taken inversely	=	1	:	1·46
Ratio of the weights of the girders—				
when the span is 50 feet	=	1	:	1·5
,, 400 ,,	=	1	:	2·4
,, 500 ,,	=	1	:	4

From the above, as from Table IV., page 280, it will at once be seen that if—from adopting a more economic design, or employing a stronger material—we can reduce the weight of a girder, taken in proportion to the load it can carry, even by what in the case of a small structure might at first sight be thought an insignificant amount, yet when a case occurs requiring a girder so great that its own weight constitutes an important portion of its load, the saving of material from that slight improvement may become immense. It is therefore an imperative duty of the engineer intrusted with the establishment of any very large structure of this class—who would not do injustice to those whose capital is embarked in the undertaking, nor bring discredit on the engineering character of his country—to search out the most economic systems of construction, and by a careful investigation, founded on the principles we have already indicated, to ascertain what materials it is best in the circumstances to employ.

Bowstring and other Girders.

There are various excellent forms of girders for which it is desirable that the values of k should be determined; of these we may mention the bowstring girders (see page 35), and the original design, Fig. 1. We may return, on some future occasion, to the consideration of these. There is little doubt however that the bowstring girder, when made of sufficient depth, and also the design, Fig. 1, have great economic merits. But when such

Fig. 1.



forms as these, and No. 9 of page 164, are made use of under the ordinary arrangements, a great deal of material must be added to the upper members towards their extremities to give the necessary lateral stability, since the introduction of horizontal or transverse bracings at these parts is prevented by the position of the roadway. By modifying the arrangements however we may obviate this objection. Our first proposal for this purpose is, that for a double line of railway the bridge should be composed of four single girders, the two central ones being placed a considerable distance apart, as in Fig. 2, this gives space for the application of continuous horizontal and transverse bracings; at the same time the amount of material E, to be added to resist the longitudinal stresses induced by the wind, is diminished on account of the increased width given to the structure; and further, the length of bearing of the transverse girders becomes reduced to a minimum.

Another arrangement, which we propose as possessing some advantages, is shown in section, Fig. 3.

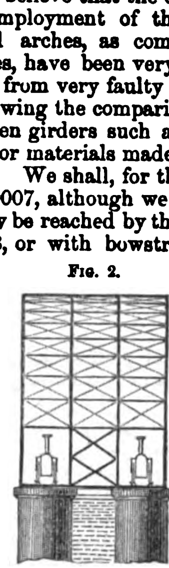
Girder Bridges compared with other Systems, for Great Spans.

We have treated of that branch only of the general subject of *great spans* which comes under the heading of *girder* construction, or wherein the pressures upon the supports are vertical. We do not at present purpose entering upon the other branches, which include suspension bridges and untied arched structures; but much of what we have said regarding girder bridges, and the principles of calculation we have exhibited, are equally or with slight modifications applicable to these other systems of construction; thus, for instance, formulæ 1, 2, and 3, pages 233, are of universal application.

We believe that the economic advantages to be derived from the employment of the so-called *rigid* suspension bridges and untied arches, as compared with properly constructed girder bridges, have been very much over-estimated: this must chiefly result from very faulty examples of girders having been chosen in drawing the comparisons.

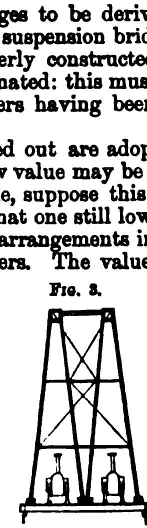
When girders such as we have pointed out are adopted, and superior materials made use of, a very low value may be assigned to $k_{3{\cdot}5}$. We shall, for the sake of example, suppose this value to be=·0007, although we have no doubt that one still lower could readily be reached by the adoption of the arrangements in Figs. 1, 2, or 3, or with bowstring or other girders. The values of the

Fig. 2.



End view.

Fig. 3.



Transverse section.

parts composing F may also be considerably reduced below what are shown in Table II., page 280, on account of increased width of structure, shorter bearings for the transverse girders, and the use of steel for the ties; and for extreme spans the movable loading may be taken at less than one ton per foot run. Under these assumptions a span of 800 feet, and that in a non-continuous structure, would be of easy accomplishment; thus, let us take—

For a Girder spanning 800 *feet.*

E	=	120 tons
H and T bracings	=	80
Platform, &c.	=	200
F	=	400
W_2	=	600
$F+W_2$	=	1000 tons

And by formula (3) we have

$$G=\frac{kS(W_2+F)}{1-kS}=\frac{{\cdot}56}{{\cdot}44}1000=1273 \text{ tons}$$

G+E, or girders complete	=	1393 tons
G+F, or half of complete bridge for a double line of railway	=	1673 ,,

It should be borne in mind that this result, although so very satisfactory on the score of lightness, is obtained with the factor of safety taken so high as 3·5; for such spans a lower rate of strength would be sufficient according to some authorities. We venture then to think that the girder system, when its combined advantages of rigidity and facility of erection are taken into account, will contrast favourably in a general point of view with any other system of construction, even for such spans as 700 or 800 feet. Its rigidity gives it a favourable distinction from the suspension system; while its facility of erection will in most situations prove an advantage over the arch.

The suspension bridge if thoroughly braced, and when the cost of the *land chains* and that of the heightened towers are included, will not probably be much, if any, cheaper than the best girder one, especially if, as would probably be the case, a higher factor of safety were insisted upon for the former than for the latter. In some situations indeed, as when an unnavigable torrent of great width has to be crossed, the suspension principle is the only feasible one.

The untied arch must ever have a great excess of sectional area, or a large addition of material to stiffen and brace it, which will greatly reduce its economic merit; a centering being required for its erection, will also in many situations prove almost a barrier to its use.

If it be desired, instead of employing a general factor of safety $=3{\cdot}5$ as in the above calculation, to have a higher factor (say $=4{\cdot}5$) for the movable portion of the loading, and the ordinary value $=3$ for the fixed loading; all we have to do is to substitute for W_2 the value of $\frac{4{\cdot}5}{3{\cdot}0}W_2$, and make use of 3 as the *general factor*, and instead of $k_{3{\cdot}5}={\cdot}0007$ to employ $k_3={\cdot}0006$: thus,

$$G=\frac{{\cdot}0006\times800}{1-{\cdot}0006\times800}F+\frac{4{\cdot}5}{3{\cdot}0}W_2=\frac{{\cdot}48}{{\cdot}52}1300 \quad = \quad 1200 \text{ tons}$$

G+E, or girders complete ... ... = 1320 „

G+F, or half of complete bridge for a double line of railway ...... = 1600 „

The results being somewhat less than when the general factor 3·5 is used (see page 233 *ante.*)

Approximate Comparison of the Weights of Plate and Openwork Girders for various Proportions of Depth to Span.

Whether the web of a girder be made of platework or openwork, the sum of the weights of the top and bottom may be set down as the same.*

Now we found that when S÷D=8, the weight of the bracing of an openwork girder was equal to half the weight of the booms; and that its weight was nearly constant, although the depth of the girder underwent considerable changes. Other things equal, we may take the weight of the booms in both systems as inversely proportional to the depth, or as S÷D.

In the plate system, we believe, we do not overstate the case when we assume that the weight of the sides will vary nearly in proportion with the depth of the girder; this takes for granted that any saving that can be secured from thinning the plates of the sides when the depth is increased will be fully absorbed in necessary additions to the sections of the L and T irons to give the requisite lateral stability and stiffness.

In the Conway tube the weight of the sides is equal to half that of the booms, and we have shown that S÷D is fully equal to 18, but as we do not wish to be chargeable even with not favouring the plate form, we will call this=16. From these data, and taking the value of S÷D to represent the weight of the booms, we at once obtain the results in the following table:—

Proportion of Span to Depth, or S÷D.	Total and partial Weights of the Girders, when the same load is supported.					
	Openwork Girder.			Platework Girder.		
	Booms.	Web.	Total.	Booms.	Web.	Total.
32	32 +	4 =	36	32 +	4 =	36
28	28	4	32	28	4·57	32·57
24	24	4	28	24	5·33	29·33
29	20	4	24	20	6·4	26·4
16	16	4	20	16	8	24·0
12	12	4	16	12	10·67	22·67
8	8	4	12	8	16	24
4	4	4	8	4	32	36

This table, although professedly only a rough approximation, offers many interesting points of comparison, several of which give us confidence in its contents not being very far from accurate.

We may take the weights given in larger type as practically correct. Those for the webs of the shallower girders of the openwork character are probably overstated, so that it is for the last example only that any economic exaggeration can exist. In the plate girders there may be room for more doubt, but the fact of the minimum weight for these pointing to the proportion of 1:12 as the most economical for that of the depth to the span is important, since if we are wrong in our views regarding the increase in the weight of the web—and it should really not increase in weight so rapidly as the depth—then the girder of minimum weight would result from a still higher proportioned depth than one-twelfth, which would stultify the practice of the advocates of this mode of construction. One-twelfth of the span is the greatest depth for large plate girders that would probably be attempted. There may however arise subordinate questions here.—viz., that the economic laws governing the ratios of span to depth (for plate girders especially) may not be constant for different spans, and that for a short girder a higher value of the depth may be resorted to. Various reasons could be adduced in support of this, besides that of every-day practice.

We may further notice that in the above table the girders become equally economic when the depth is made equal to the span divided by 32, or about half the proportional depth of the Conway. For depths less than this the economic merit would be on the side of the plate system; this value, 32, is that of the *x* contained in the article at page 236 of vol. xviii. of this Journal.

Edinburgh. R. H. B.

* This ignores the moments of the longitudinal stresses of the plates of the web; against these may be placed the fact that the lower boom of an openwork girder may be made stronger for its weight than the corresponding boom of a plate girder. Where however the depth is great in proportion to the span, these moments may become of such importance as to require account being kept of them; the effect being to reduce somewhat the weight of metal in the booms of such girders. The late Mr. Robert Stephenson seems to admit that in ordinary cases at least, these moments should not be counted upon, as we find at page 597, article "Iron Bridges," in the 8th edition of the 'Encyclopædia Britannica,' these words: "The central strain on the top and bottom flanges, which depends solely on the depth of the girder, and is perfectly independent of the system which connects them......"

THE GUILDHALL, LEICESTER.*

By Gordon Hills.

This building, called also the Town Hall, has been used for nearly 300 years for the administration of the municipal affairs of the town. This, however, was not the original purpose of the guildhall. The Corpus Christi Guild owned a hall, which stood on this spot, and held in it their own meetings, independently of, and (as it is stated by Nichols) exercising sometimes superior authority to, the mayor and burgesses. The original Mayor's Hall stood in what is now named Blue Boar-lane and Holy Bones. Although no trace of the building is to be seen at this day; yet, in the two important points of its beginning and its end, its history is known with remarkable precision. The site was purchased by the mayor and burgesses in the 13th century, and the charter of conveyance is said to be still extant, though I have not seen it. A deed of the tenth year of Henry VI. speaks of the Common Hall standing on the Holy Bones, and again another deed of second year of Edward IV. speaks of the Town Hall standing on the Holy Bones, in the parish of St. Nicholas.

It is to be presumed that in course of time the hall became dilapidated, and in the early part of the 16th century it was gradually disused. It remained in the hands of the mayor and burgesses for some period after its disuse, till in 1653 it was sold for £30 to John Kestian, maltster. At the time of the sale it is described as the old "Town Hall," or "Old Shop," containing three bays of buildings, in length twenty yards and one foot, in breadth at the east end nine yards, on the west seven, situate in a street called "Blew Bore Lane."

The guild of Corpus Christi was founded in 1350. It was an association for the regulation of commercial affairs, similar in character to others mentioned in the history of every town or city in the kingdom enjoying a commercial reputation in that age. Other guilds were founded in Leicester. The guilds of St. John, St. George,, and St. Margaret, and the guild Mercatoriam, are constantly mentioned in the hall books. In the great work of Nichols, the historian of Leicester, the site of the Guildhall of St. George is erroneously stated to have been where the Town-hall stands, but that he wrote this under a mistake will be evident from what follows:—An entry in the Hall Book of the 10th year of Henry VII. shews that a common hall was then holden in the hall of Corpus Christi Guild. In the 21st year of Henry VIII. we have the account of the meeting of the town body in Corpus Christi Hall. Other instances occur showing it to have become a matter of ordinary practice to use Corpus Christi Hall, and when, in the fifth year of Queen Elizabeth, the mayor and burgesses came into possession of the present hall, the deed describes it as lately in the occupation of Corpus Christi Guild.

Corpus Christi Guild, according to Nichols, contributed largely to the public charges, as in the purchase of charters; and the masters of the guild had great interest in the government of the town, having power with the mayor to levy penalties on the burgesses for their misdemeanours; and upon the mayor's neglect they were empowered to levy them upon him. It is evident that the chief persons of the guild would be the most influential men of the town and its corporation, and that the two bodies must

* Paper read before the British Archæological Association, at Leicester.

have been very intimately associated. To this community of interests may probably be traced the neglect and final abandonment of the old Town-hall in Blue Boar-lane. The masters and brethren of the guild, being nearly identical with the mayor and burgesses of the town, found it convenient to transact municipal as well as commercial business in the same hall.

The guild of Corpus Christi dates from 1350. No part of the buildings belonging to the present guildhall possesses any architectural features entitling it to a higher antiquity than the reign of Henry VII.; so that of the nature of the buildings which accommodated the commercial body for more than 200 years no account can be given; but the first known meeting of the municipal body in the hall of Corpus Christi guild, above referred to, occurs at a date which makes it just possible that the hall there spoken of may be the one in which we are now assembled. The features which may be referred to this period are the two timber framed arches in the west part of the hall, and the windows in the grand jury room.

The two eastern spans or arches of the hall differ in form from the two to which attention has been already directed. They are different in construction and form, and of ruder workmanship; and the moulding, which is not alike on the two, is in both cases simpler than in the first instances. I do not, however, see any reason to suppose that they are older. The ruder character and evident divisions of the work show no more than an intention to divide the hall into two parts, one of inferior character to the other. The windows of the grand jury room in the west wing appear from their mouldings to be of the same date as the framing of the hall. Very little of the framing in this west wing can now be seen, but some of the ceiling beams are of a character which would also agree with that date; so that there is reason to attribute the whole framing of that wing to the reign of Henry VII. The case is not so clear with regard to the east wing. It has been much altered by later works, and cased on the surface. Where the framing is not completely out of sight, it is evidently much older than the casing; and in one of the tie-beams of the roof the timber had so much decayed, when the casing was applied, that inside of it a substantial addition to its strength was thought necessary, two strong timbers being fastened on to the sides of the old beam. The date of these casings is very clearly of the seventeenth century; and so it may certainly be believed that the internal work is much earlier: how much earlier, may be judged from the resemblance which the external form of the wing bears to that of the west wing; and this reasoning, I think, with much certainty, leads to the belief that the two wings, as regards their main framings, are coeval, and therefore coeval with the hall. The arrangement of the hall and its adjuncts has therefore undergone but little change. This conclusion is somewhat opposed to the received history of the buildings; but it will not be difficult when we come to the few further historical references to reconcile them with this view of the case.

Over the seat of the president at the west end of the hall, in a little niche, occurs the date 1586, between the initials E. R. (Eliz. Regina.) The form of the niche exhibits the character of the Italian element, which then overflowed the Tudor Perpendicular work. The niche has however been subject to subsequent alteration and mutilation, and seems to have been taken down and refixed. Some carving (the little leaflets in the spandrels of the arches) seem to be in imitation of earlier work. I should say there is a beautiful example of carved work of the time of Henry VII., on which this seems to have been imitated, in a small room at the end of the library. At the date given on this niche extensive renovations seem to have been effected, of which there remain the windows of the two western bays of the hall, and the whole of the library windows in the east wing. About this period, according to local tradition, the hall was the scene of the performances of Shakespere in his earliest plays. The hooks upon which the scenes were suspended are pointed out in one of the beams. In that age of pageant and feasting it cannot be doubted that many a civic feast did honour to the hospitality of the corporation, and this custom continued to very recent times. The modern residence of the police-superintendent occupies the site on which stood, a very few years ago, the kitchen and its culinary offices.

After 1586 the next date to be mentioned is 1632. The library, which had first been kept in the tower of St. Martin's church, and then in the chancel, was this year transferred to the room it now occupies, in the east wing of the guildhall. It is stated that the wing was then erected to receive it. In a document drawn up in 1644, a very precise account is given. This document states that "the library was erected and builded at the onely cost and charges of the Corporation of Leicester, at the motion and by the approbation of the Rev. Father in God John Lord Bishop of Lincoln, and by the prosecution of Mr. John Angell, publique lecturer for the said borough of Leicester. The building whereof was begun in the time of the maioralty of Mr. John Norrice, Anno Domini 1632, Thomas Somerfield and Richard Ludlow being chamberlins; and finished in the same time of the maiorality of Mr. Nicholas Gilliot, Anno 1633, Thomas Bursnal and Alexander Baker being chamberlins." We have some reason to believe that the building is much older, and the preparation made for the library consisted of the wainscoting and casing of the walls and timbers, and in the removal of the upper floor of the building, which rested on the tie-beams. The windows of the upper floor were, however, retained; and thus it is that this room is furnished with two rows of windows. On the transfer of this library to its present abode, a very interesting letter was written to the Mayor of Leicester by John Williams, Bishop of Lincoln. The letter is given in Mr. Thompson's History of Leicester, and its interest arises not only from its reference to the formation of the town library, but from the remarkable character of the writer. From a humble origin he rose to be Bishop of Lincoln, Lord Keeper of the Great Seal, and Archbishop of York, being the last ecclesiastic who held the Great Seal of England. He shared in the misfortunes of the adherents of Charles I., and died in the period of the direful disasters of the cause.

In 1636, according to Nichols, Richard Inge being mayor, the parlour belonging to the guildhall, with the chamber gallery, evidence house, and other rooms adjoining thereto, were newly erected at the charge of the common chamber. This statement, again, is not literally true. An extensive work was executed here in the way of wainscoting, a very fine chimney-piece was erected, the gallery re-fitted, and, perhaps, the windows renovated, for they are different from any others we have encountered, and evidently more modern.

Until the recent abolition of the kitchen and its offices there is no substantial change to record in the form or appearance of the buildings. Of ancient ornament but very little remains. I have referred to the carving now affixed to a chimney-piece in the apartment at the end of the library. The coats of arms on the hall ceiling are recent restorations of old paintings. They are the arms of the town of Leicester, and of its patron the Earl of Huntington who flourished in the days of Elizabeth. Some stained glass, now in the windows of the Mayor's Parlour, was, when Nichols wrote, in the windows of a house which was the chantry house of Corpus Christi guild. In the transfer to the present place they have suffered some dilapidation.

Mr. James Thompson said he thought Mr. Hills had made a little mistake in his reference to Nichols about the glass in the window. He was confounding two distinct things. The glass that remained was in thirteen lights, just one more than the twelve months of the year. Of course they originally began with January, and went on in succession to December. Fragments of three months were readily made out. For December a man was represented warming his hands at a fire. Another of the months was represented by a figure thrashing wheat; and another by a man digging the ground. The glass, though possibly taken from the chantry house, was at some period complete, representing the agricultural operations of the twelve months of the year; whereas the other subjects represented the ordinances of the ancient church. This portion was in the possession of the Rev. R. Stephens, at the Vicarage, Belgrave, near Leicester.

Mr. Hills said he had not seen the other specimens of glass, and when described to him they appeared as all one with that at the Town-hall. This he must have misunderstood.

Mr. North said that the local histories told them that the Corpus Christi guild was held at the east end of St. Martin's Church, where the public-house now stood.

Mr. Hills said this was manifestly a mistake. It was said that the mayor and corporation met in the hall of Corpus Christi; and again, on the final sale of the property, in the reign of Queen Elizabeth, 1563, the deed called it "all that cottage"—a peculiar name—"situate and being near the cemetery of St. Martin's, in the town of Leicester, in the county aforesaid, now or lately in the occupation of the mayor and burgesses of Leicester, and formerly the guild of Corpus Christi."

PAPERS ON HYDRAULIC ENGINEERING.*

By Samuel McElroy, C.E.

The general theory of embankment reservoir construction presented involves a certain chain of details, each connected with and to a certain extent dependent on the other. The basis of the structure on which the superincumbent weight is placed must be firm, the banks must be built so as to guard against settlements and slides, the puddlings must be compact and solid, or the slope walls and top angles will lose their lines of symmetry, and to some extent their usefulness.

This brings us to a theory which does not seem to be as fully admitted and promulgated as is desirable—viz., that correct engineering science ought to be able so to erect and join together these several links of the chain, that the proper result may be obtained as a rule, bringing failures within the class of exceptions. In other words, that as to this special department of construction, as in others contingent on the same law of design and execution, engineering ought to take rank as a profession endowed with control of exact results, and not as a calling which naturally disclaims infallibility. Without denying then the argument, that each distinct construction is subject to local peculiarities of material, we assert the doctrine, that the workmanship should overrule and insure their proper combination. To build any engineering structure with an implied reservation for defects in its progress or use, is a custom to be distinctly condemned. While we do not therefore propose here to give any rules for universal application, some allusion to methods which have secured satisfactory results will illustrate in a brief way some of the links in this chain of construction, as applied to embankment reservoirs with artificial slopes, and without regard to mathematical questions of stability in form.

Earthwork.—It rarely happens that a reservoir is so located as to require an embanked base for the whole structure; there is a case at Cleveland, and it certainly requires great care in formation, although a uniform settlement after the water is introduced may obviate any injurious effects realised when such settlement is not uniform. Here the general rules for the embankment walls also apply, which may be thus stated:—

All vegetable soil should be carefully removed from the proposed base of the embankment, nor should the foot of a slope be carried over spongy and compressible material. Where work is partly in embankment and partly in excavation, it is best to build the heaviest banks first, so as to give them time for their additional settlement.

The section of the bank should be carried up entire, and not bisected by walls or pyramids of other material.

For the outer slope inclination, the sharpness in rate may be varied with clay, gravel, and sand in their order, flat slopes being relatively objectionable.

For the outer slope there are some advantages in the use of sodding, but seeding properly done will answer the purposes of protection from wash, &c.

The top should have a drip from the inner angle towards the outer, and the former should be protected by coping; for the other, the sod line should be returned on the top from the slope.

No banks should be built with a heavy dump, but in thin level layers, somewhat modified in thickness to suit the material,—for gravelly earth about nine inches, less for clay, more for sand. Unless the "lead" is so great as to require the use of teams, carts are better for consolidating the layers. Water is objectionable for clay, of no use for gravel, though beneficial for sand. Rollers are also objectionable for both the former. In a case of a gravel embankment partly constructed with the use of water and rollers, I have found distinct water seams formed between each layer, which would operate badly under a reservoir head. In a case at Ridgewood Reservoir, where it was necessary in the winter to cut through part of an artificial bank, and to use gunpowder in blasting on account of its solidity, the smoke was observed to follow these seams for several feet on each side of the cut.

In side and end filling on slopes, benches should be cut. All slopes should be crowded or over-filled, so as to trim down to form, when the face is to be finished for protection from the weather, and thus obviate the effects of wash.

No slope lining should be built on the inner slopes until experiment has shown that their settlement is complete, a result which can be determined with proper care.

The inner slopes must be protected from contact with the reservoir contents, by water-tight facing.

Walls of masonry, as far as possible, should not be connected with the banks until the latter have come to their bearing; and water pipes leading from them should be protected, by arches or otherwise, from the effects of settlement by their back-fill.

These are some of the prominent processes in construction which insure stability. Questions of stability are so fully guarded by the ordinary conditions of section, which are controlled by convenience of top bank width and slope angle, as to need no discussion. The principal defects are settlements after final construction of slope walls, slides, and leakage, and these may be obviated on smaller sections than convenience and effect suggest. For the enormous thrust of the water prism, the counteracting weight of the section is modified by its form and its material; sand, gravel, and clay having relative weights per cubic foot of 95, 124, and 165 pounds, as compared with water at its maximum weight of 62·382* pounds, and being therefore largely in excess.

Puddling.—A mixture of clay and gravelly earth is better than pure clay. What is known as "hard-pan" is a specimen of natural puddling. At Ridgewood, in making 82,150 yards, 44,000 of clay and 51,500 of gravel were used, the shrinkage being about 14 per cent. The materials were carted or wheeled on in thin alternate layers, to an aggregate depth which would work down to about 8 inches for each general layer, gangs of men being employed in spading and mixing them. As little water was used as possible, to prevent the effect of subsequent shrinkage by evaporation. Some engineers make their puddling entirely dry, preferring material which will work close, and their theory is undoubtedly correct, as to the prevention of settlement and fissures. But gravel is always an improvement in mixture, and in certain forms of puddle walls they may be more advantageously worked with a limited use of water. The object is to obtain a compact impervious, homogeneous mass, not only to prevent filtration, but to distribute weight uniformly over the sustaining slope or bottom earthwork.

It is a difficult matter to make puddling tight at the joints, when connected with other materials, and frequent breaks in the joint surface are therefore advisable; nor is it easy to make a water joint on wood, in connecting with sheet piling or flooring. On division banks, at gate-houses, the masonry backing should be built with buttresses, and the faces left rough to take the puddle walls, and prevent continuous threads of water under pressure.

Slope puddling is to be preferred to vertical inner bank walls, on the ground of economy in material, ease of access, prevention of bank saturation and its results, facility of construction, preservation of bank-section, and distribution of pressure; and in all cases it should be connected with the bottom puddling, the latter (or its equivalent) being assumed indispensable. It will be found in laying it, that some compression of the bank face occurs, though not large, which should be accomplished before the cement masonry is built.

Concrete.—This, as lining, may be made to serve two important purposes: one, in being carried up with the slope puddling, as a protection to its face from wash while coming to its bearings; and another, as an additional means of tightness, and a break line of surface to the courses of face masonry, whether of brick or stone. It may be made in a thin layer, and should be carefully prepared with fresh hydraulic cement mortar.

In the use of concrete for the various purposes to which it is admirably adapted, it is sometimes forgotten that it is only, after all, an improvement on ordinary masonry in convenience of application; and, as to its proportion of cement mortar, ought to be governed by the same rule,—viz., that weight is to be resisted by the pressure of face upon face, and the chief object of mortar is to fill up crevices and irregularities, and distribute uniformly the load over the surfaces in contact. Consequently, in concrete, no more mortar should be used than will properly fill up the interspaces of gravel and stone. This applies more particularly to foundations, as in thin slope lining a cement face is not as objectionable. A certain proportion of screened gravel with the basis of broken stone, is an improvement in filling up more completely the openings. In an extensive use of concrete at the Brooklyn Navy Yard, five parts of broken stone with two of gravel made, when properly added to the mortar, a very solid mass.

* Continued from page 275.

* Instead of 62·5 as commonly assumed.

Brickwork.—The first care in brick masonry is that of proper selection. Very little attention is paid to the process of manufacture at the yards, which is open to objection as to the material and the burning. If the clay is charged with an efflorescent salt, which will appear after the masonry is laid, and frequently spalls off parts of the face, the work is injured; and from the rudeness with which the kilns are built and burned, part of the bricks are vitrified and spoiled, part well burned, and the rest, half or less than half baked. Until these defects are more carefully guarded, as they can and should be, great precaution is needed in inspection. The second care is that of mason work. Here it is requisite to have the bricks properly moistened, to prevent the effects of too rapid absorption on the mortar, which should be carefully mixed, and laid with close joints. Brick-work is injured for hydraulic purposes by want of attention to this point, and the joints fail after short exposure, with a bad effect on appearance, tightness, and durability. With proper attention, however, in selection and construction, a comparatively light brick wall can be made much more tight, with much more symmetrical and ornamental appearance, than rubble work.

In face work of structures there is considerable range of cost and ornament in the use of pressed bricks and close putty joints. In work which requires the use of arches to sustain weight, or for appearance sake, the use of moulded arch bricks—or for plainer work, of alternate "headers" and "stretchers"—ought to be maintained, since a "rowlock" arch has neither beauty nor strength; and in all cases where the stability of the arch is important, the centres should be struck as soon as the keys are driven home, to bring each member to its bearing, and expose any weak points before the backing is carried up to any height.

Stone Masonry.—For ordinary rubble work, in which "bank" stone or quarry stone are used, the least thickness which can be conveniently worked is about sixteen inches on slope lining. In point of quality, as a general rule, the former, having come down to us through the action of floods and time exposure, as water-worn boulders, are to be prefered; although defective boulders as well as defective quarry stone are not uncommon. This is a matter of inspection, selection, and relative cost in special localities, certain classes of quarried stone being of course unexceptionable.

The objection to the use of rubble masonry lies partly as to its rough appearance, and partly as to the difficulty of teaching masons to make close and solid work, the craft being, as a rule, strongly disposed to work with wet and soft mortar, and to neglect the proper use of spalls, whence follow, in too many instances, the usual building and wall settlements and fissures; for if the walls were themselves solidly jointed, the foundations, with ordinary care, would be more evenly pressed. This assumes, of course, the use of due precaution in foundations for a broad and uniform bearing, fully guarded against the contingency of water threads, by puddling or concrete with sheet piling, as the special case may require.

The use of dry stone walls, in rubble work, for reservoir slopes is unequivocally condemned, the mass of testimony against them being conclusive, with the ordinary thicknesses in practice. Nor is their economy in first cost a matter of very positive demonstration. Their beds are continually exposed to undermining by rain wash while building, and to wave wash while in use, and the walls to injurious effects from frost and otherwise.

For other kinds of stone masonry which pertain rather to superstructure, we need only refer to well known principles and methods in use, without special designation. The same principle of jointing and construction controls them.

Nor is this brief memorandum intended to cover all the points to be considered in these parts of reservoir workmanship, but rather as allusions to certain details in method, which are sometimes overlooked, and which tend to produce and insure desirable results without much additional cost. A few words also in reference to general plan of structure will conclude this branch of our subject.

Division Walls.—For purposes of cleansing, repair, subsidence, æration, circulation, and their attendant benefits, and for reduction of areas exposed to surface waves, it is always desirable to build reservoirs with one or more division walls. No reservoir can be considered complete with less than one, and with water which requires much care, the number may be increased with great advantage. The several divisions of the Fairmount Reservoirs, at Philadelphia, may be instanced as an evidence of the manner in which impure water may be much improved; and a recent report on the Delaware Reservoir at the same city shows that the deposit is about one inch per month, as a comment on subsidence and surface supply. It is customary in some instances to build these division walls below the ordinary flow line; but while this may accomplish a certain use of surface supply, it is open to the objection of exposed area, which becomes serious in the case of large sheets of water. The heads of these submerged walls are also subject to the action of breakers, in a different manner from that due to slope wash.

Connecting Weirs are therefore preferable, arranged with a gate pier, and with gates which open downwards from the surface in alternate positions, for a given depth. Pipes may be built across the foot of the division wall for bottom drainage at any time. With weirs of this kind, which are readily built, and which can be managed at will, a very complete and desirable control may be had over the contents of the separate divisions, and a positive supply of the purest water secured.

Gate Houses may be also arranged so as to secure the general principles of action discussed. For gravitation supplies, the influent chamber may be arranged for the top bank, with suitable descending channels; but for pumping supplies, it should permit an accommodation, by a proper gate pier, of the engine load either to the flow-line head or that of the actual reservoir level. By this means, if the engine be properly designed and managed, in many cases a very important saving may be made in annual cost of pumping.

For effluent chambers, it may be assumed as a rule that the gate piers should be so arranged as to take only a surface supply at all times for domestic and public use, and to waste occasionally the bottom strata by suitable blow-offs. Too much importance cannot be attached to this law, which involves the comfort and health of the consumers to no small extent, and the reputation of the supply.

Depth of Water is also important, in preventing solar action on its contents. It seems to be the European experience, that less than ten feet is always objectionable, and it will be observed from our preceding papers that twice this depth is the common American standard. If this consideration obtains with distributing reservoirs, it should be urged with greater force on all fountain or supply reservoirs, which are generally natural lakes, of great area and shallow depth, constantly subject to impregnation by vegetable and other organic matter and all the results of fermentation. Especially is it objectionable that supply reservoirs should contain a large disproportion of contents to daily supply, unless prompt and efficient means of æration, circulation, and bottom waste are provided.

These general and rapid suggestions are made, not as a professional dictum, but as the results of experimental science in a direction which needs yet more enlarged observation and trial. Water works with us are yet in their infancy in an important sense, and are exceptions throughout the country rather than a general rule, and several of our most prominent supplies already warn their consumers of the necessity of early steps for an entire reconstruction and enlargement. Discussions of this kind are therefore desirable, and the best results of experience ought to be embodied in general rules of practice, similar in method, if not in detail, to those presented for consideration.

(To be continued.)

THE ANNUAL REPORT AND TRANSACTIONS OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Although the year of the Institute is considered to commence and terminate in May, and the Report of the last completed session is consequently the one which was read before the Annual General Meeting in May last, almost five months ago, and extends only to that date, yet it is but just now that it is issued to members, an arrangement which deprives it of much of its value.

We learn from this document that the number of members has continued steadily to increase, having risen within the last ten years from 225 to 348, an addition of more than 50 per cent., and as by far the larger increase has taken place in the number of Fellows, who must be architects of at least seven years' standing, these numbers show that the Institute is receiving accessions of established architects to an important extent.

The losses by death which have been experienced include the Prince Consort, who had been connected with the Institute in the honorary character of Patron, Messrs. Lochner and Clayton, Professor Eaton Hodgkinson, Mr. W. L. Donaldson, late Honorary Solicitor, and two foreign architects, honorary and corresponding members, Herr Zwirner and Monsieur Brunet de Baines.

The most important paragraphs of the Report, referring to matters probably of more moment than any which have, since the first establishment of the Institute, been decided upon, are thus indicated:—"The Council may congratulate the members on the nearly approaching settlement of two questions which have occupied their attention for a considerable time, namely, the Rules on Professional Practice and the Architectural Examination."

The reports of committees on both these subjects, adopted since the date of this Report, have been embodied in our columns, and it is therefore unnecessary to dwell upon them here, further than to remark that, as tending to raise the position of the profession generally, we consider the measures taken most important and most creditable to the Institute, which by directing its attention to such subjects is fulfilling the most valuable function belonging to it.

The action very properly taken by the Institute with regard to the Thames Embankment is referred to; and a series of suggestions, which were addressed by it to Mr. Cowper in his official capacity, having for their object the securing due attention to architectural effect in so important a public work, is appended.

The exertions of the Institute with regard to the representation of architecture at the International Exhibition,—the state of the library,—the portrait of Mr. Cockerell,—the memorial of Sir Charles Barry,—the appointment of a committee on the conservation of ancient monuments,—the conversazione,—the examination of candidates for district surveyorship certificates,—the retirement of the late active and energetic secretaries, and the suggestion that the day is shortly coming when a paid secretary will be necessary, are all referred to; and the mere enumeration of these varied subjects shows how much has occupied the attention of the council during the past session. The only point we regret is the smallness of the amount which it was found possible to devote to the increase of the library, and the very moderate number of books presented as donations: a sum of £100 is however voted for books, to be purchased during the present session.

The only other subject demanding notice is that of prizes, a most attractive array of which was offered, including the Institute medals for essays and drawings,—the Soane medallion,—Mr. Cockerell's prize,—Mr. Tite's prize,—and the students' prize of books. The result appears however to have been rather disappointing, as in two cases the prize was not adjudged owing to the want of merit in the drawings and essay; while, in a third instance, a similar fate was narrowly escaped. Mr. Cockerell's prize seems however to have provoked a brisk competition: this prize does not seem to be again offered; but one of ten guineas for the best design for a civic or domestic building in a Mediæval style, given by Sir F. Scott, seems likely to attract many students; and so we hope will a prize for an essay on moulded bricks or terra-cotta, which is announced.

The volume of papers read accompanies the Report, and includes several papers of value which have already appeared in this Journal. It is not quite so elegant in appearance as the previous volume, being less fully illustrated by engravings, but with this exception it seems to keep up the character of the Transactions for excellence and interest.

IRON PIERS FOR RAILWAY BRIDGES IN ALLUVIAL DISTRICTS.

(Continued from page 270.)

As it is considered that uniformity of parts, as far as practicable, is of as great importance in bridge work as in other mechanical structures, a uniform span of 60 feet is adopted for all the iron bridges on the Bombay and Baroda line, this being considered the most economical in reference to the general heights of the piers. One end of each girder is fixed on the pier, while the other end is left free to move, and carried on a pair of small rollers C, Fig. 9, to allow of expansion and contraction. The weight of the entire 60 feet superstructure for a single line of rails is 24 ton, being 8 cwt. per foot run, and the cost is about £400. In the construction of piers adopted for inland rivers with deep water, say 20 to 50 feet deep, but not tidal, where the current is always in one direction only, here the oblique piles acting as struts are required only on the lower side of the bridge, and the timber fenders only on the upper side. In the case of piers for inland rivers with shallow water of not more than 20 feet depth, the oblique piles can be dispensed with altogether. Where there is a rock foundation, the screws are omitted, and the piles are simply let into the rock about 2 feet and filled round with cement, allowing of great rapidity of erection in this case. The position of the roadway may be either between the main girders, or upon the top of them, both of which methods are shown in the single diagram, Fig. 1. The upper position is preferable for the roadway, because it combines the effect of both the main girders in resisting forces that tend to produce buckling of the compression beams. The upper or lower position of the roadway however is decided by the amount of headway under the bridge, or the clearance between the bridge superstructure and the highest known flood level of the river, which should not be less than 5 feet. In every case the power of the compression beams to resist buckling is made ample, and a horizontal diagonal bracing of T iron is provided between the cross girders carrying the roadway, as shown in the plan, Fig. 7, continued from pier to pier; and where the roadway is on the top of the main girders, oblique stays are added, as shown in Fig. 1, to secure the requisite stability and freedom from vibration in the roadway and girders.

The use of animal power was adopted in screwing down the piles at the great Nerbudda bridge, where a large part of the river bed is uncovered at low water, and it is only in such situations that animal power has been made available direct by means of a long lever. The general practice has been, where the foundations are not always under water, to hoist the piles into the proper position by shear legs, and hold them in this position by guides whilst they are screwed into the ground by a crab winch acting on the end of the lever; but where the ground is always covered with water a staging has been erected on timber piles surrounding the site of the pier. Latterly the principle of floating rafts has been successfully adopted instead of fixed staging.

Of the piers nearly half were supplied by the Horseley Iron Co., Tipton, and the rest by the Victoria Iron Co., Derby. There is always a difficulty in carrying cast-iron safely across the sea, from the great risk of breakage in shipment and in conveyance by land, as well as the chance of disasters at sea; but in the case before us altogether only about 5 per cent. of loss from all causes in the cast-iron work occurred, which is a smaller proportion than usual in similar cases. The first part of the superstructure was made by Messrs. Kennard at Crumlin; but the greater portion by Messrs. Westwood, Bailey and Campbell, London Yard, Isle of Dogs. For the erection of the work in India the engineers and foremen alone were sent out from England, and all the other workmen employed were natives: Colonel Kennedy states that the natives make good workmen in a very short time and then get on rapidly. As a consequence of the additional employment, the price of labour has been doubled by the railway works throughout the district traversed by the line.

The practice of cutting down the dimensions too fine in such structures is to be avoided, and a liberal margin ought to be left beyond the calculated strength, to allow for strains which could not be taken account of with the same accuracy as simple transverse and longitudinal strains. Buckling is a frequent source of extra strain, particularly where there is any considerable depth of girder, and is therefore required to be carefully provided against by increasing the size of the sections and arranging the iron in such a form as would enable it best to resist buckling under compression. In the girders employed, all the bars subject to compression were made of a cross shape in section, as shown by the illustrations (Figs. 10 to 16, Pl. 19); and the greatest strain either of tension or compression on any part of the girders amounted to only $3\frac{3}{4}$ tons per sq. inch under the heaviest practical load. The greatest longitudinal motion observed in 24 hours amounted to $\frac{3}{16}$ inch in one span of 60 feet. In the dimensions of the girders great allowance was made to provide against buckling and the strains produced by concussions, and there were only a very few places at which the strain ever came up to the maximum of $3\frac{3}{4}$ tons per square inch, while everywhere else it was much below this amount, so that the strains never approached the elastic limit of the iron.

The pile lengths were cast vertically, and the joints were generally cast with sufficient accuracy to go together without any fitting; but where necessary they were chipped to a level face, and care was taken to insure a uniform thickness of metal throughout the flanges. Every piece of the ironwork was dipped when hot in a bath of linseed oil, and had afterwards two coats of good oil paint. After erection frequent and thorough painting are relied upon for keeping the iron from rusting. From an examination of several old iron structures it has been found that the cast-iron generally stood well, but the wrought-iron shows evidences of corrosion after it has been up about 20 years, and it could never be relied on unless frequently painted or otherwise protected. The prevention of iron from rusting is a question of general importance, and every encouragement should be given to investigation of the subject, with a view to obtaining some really permanent protection. It is clear that even with its present liability to oxidation iron is decidedly the cheapest material for large bridges in general, particularly in alluvial districts: but its durability and renewal are dependent mainly on its thorough protection from oxidation. The object to be sought is not simply to secure the best protection out of a number of modes, of which all may be defective; but to arrive at an absolute means of preservation, if that be possible.

Tar has proved a very effective material for preserving the bottoms of iron ships from rusting, and is applied also inside vessels. On the Clyde large ships of 2000 or 3000 tons burden are protected inside with a coat of varnish made from purified coal tar, which is found a very efficient protection. A clean surface of the iron for laying on the varnish is all that is required, and it has a fine polish; the coat lasts 7 or 8 years when protected by a lining of woodwork in front. The varnish may be laid on cold, and the smell is all gone in a few days; the cost is much less than red lead paint. This plan has also been applied to the inside of steam boilers, where the uptake from the furnace passes through the steam room of the boiler, and it prevents oxidation and scaling of the iron from the action of the steam for a long period; it ought therefore to be suitable for such structures as the bridges described.

The lower lengths of the piles are filled with concrete, which renders them solid inside, so that each pile stands on a solid foundation of 4½ feet diameter. Much accuracy was required in getting the piles correct in level: this was managed by screwing them down a little further if necessary; and as there are four lugs at each end of the several lengths for attaching the diagonal bracing, the level could be adjusted to one quarter of a revolution of the screw. Where the piles stood on a rock foundation a piece of the required length was cut off the bottom of the lowest length, leaving the flange at top for bolting to the next length; or else the rock was cut away deeper to get the proper level. A few cases occurred of a pile being broken in screwing down, and it was then very difficult to get the screw out again; this was one of the chief difficulties that had been met with in erecting the bridges. At the Nerbudda bridge the sudden abandonment of the work, caused by an outbreak of cholera and followed by monsoon floods, left some single piles unsupported, which were broken; and one or two of these could not be got out again, so that it became necessary to alter the spans in two cases, selecting fresh sites for the piers in order to get clear of the broken piles. Rapidity of fixing is of special importance in India, for on account of floods and storms the working year for such operations can be reckoned at only about eight months; and the facility of erection with this construction of piers and superstructure is so great, that by beginning at both ends at the same time they could now bridge the broadest river in a single season.

THE ANCIENT CHURCH IN DOVER CASTLE.

An almost unrivalled interest attaches to this edifice on various accounts, but more particularly from its antiquarian history, and the more or less perfect developments of primitive architecture in this country which its ruins exhibited, and which have been rendered still more abundant and curious in consequence of the additional discoveries brought to light during its recent restoration and refitting in order to be again used for the purposes of a church. These restorations were commenced nearly two years and a half ago, and have been most conscientiously pursued under the direction of Mr. Scott, assisted by the vigilant superintendance of Mr. J. N. Marshall, the clerk of the works.

The church is situate within the castle walls, on a lofty cliff, and close to the ancient pharos, or lighthouse, which has been often depicted in elucidating the characteristics of Romanesque architecture, and of which a woodcut may be seen in our journal for July 1858. See Bloxam's 'Gothic Architecture' (Reviews). The date of the latter is surmised to be early in the second century; and the use of the building was to guide the Roman galleys across the strait. The material employed is a casing of flints and tufa, in blocks about 12 inches by 7 inches, strengthened with bonding courses in large Roman tiles, and filled up with stones and mortar. Originally it had on the east side an arched door, on the other sides Roman windows 13 feet 6 inches by 4 feet, which Bishop Gundulph blocked up and reduced into Norman loopholes. Without pursuing the history of this pharos any further, we may remark that the doorway just mentioned communicated with the west end of the fabric which it is our purpose now more minutely to describe.

This church is considered by Mr. Scott to be probably the most entire (as to its general outline at least) among all the pre-Norman remains which have come down to us: for though till recently a ruin, it retained the general form of nave, transept, and central tower so completely, that one felt that its entire design could with little difficulty be reproduced. Though the subject of its history has provoked much discussion, there can be no question as to its belonging to that variety of Romanesque architecture which we know prevailed in this country prior to the Norman conquest; but whether the fabric is *late* or *early* Saxon is not so certain. It is known that in the seventh century (616—40) King Idbald founded a college of secular canons in this place to minister to the garrison. The combination of military with ecclesiastical structures within one inclosure occurs also at Porchester, Exeter, in the Tower of London, and in the curious instance of St. Germain's Cathedral, and Peel Castle in the Isle of Man. The decay of the church and its disuse may be fairly attributed to the latter end of the seventeenth century, and its subsequent injuries to the carelessness of the Board of Ordnance. In 1635 the church and its monuments were in complete repair; but it has since been repeatedly threatened with complete demolition. It was not till 1855 that Lord Panmure, then at the head of the War Department, promised that it should be cleared of coals(!) and kept more decently and respected for the future. These orders, however, if issued, were not destined then to be carried into effect.

Of authors who have more or less described the building, we may quote Essex, Rickman, and Bloxam. In the MSS. of the former, reference is made to the materials as consisting chiefly of ragstone and brick, and of the arches to the middle tower, which have undergone several alterations, "particularly the addition of stonework," and which originally "seem about the time of Henry III., or the earliest in the time of King Stephen."

The nave is externally about 62 feet long by 34 feet wide; the chancel about 27 feet long by 25 feet wide. The transepts each above 22 feet long by 20 feet wide, and the tower about 35 feet by 33 feet 6 inches. The walls of the church generally are about 32 feet high, and those of the tower remain to a height of about 70 feet. We extract the following, as part of a description written a few years ago:—

"The church is cruciform. On either side the nave are the remains of two clerestory windows of great size: between those on the south side was a door, circular headed, with double arches of tile: underneath the west window, on the north side, was a more pointed door, and beneath an acute-angled pediment the weather-moulding of a porch, the principal entrance. Two round windows were in the gable of the north transept; one *was* in that of the south wing; in the east and west walls of the former was a trefoiled lancet-window. In the west wall of the south transept was a round-headed window, and in the north-west is a late Tudor window of three lights. In the south wall of the nave appear two huge indents, which in some old prints are erroneously fashioned into windows, but are evidently the effect of a design to destroy the entire edifice by gunpowder. The choir was lighted by two lancet-windows, separated by a shaft with a simple capital on either side: the east window (perhaps a triplet) was 13 feet 8 inches in width, and the splay is 2 feet 3 inches wide: on the south side remain a bracket piscina and sedilia, Early English. A covered porch unites the nave to the pharos. In the angles of the tower are graceful Early English shafts, and the springers and ribs of arches are filled with a dog-tooth moulding. On the east face (of the tower) were two round windows; on the south two pairs, of the same form; and on the north three, disposed in an inverted triangle. On every side was a round-headed window, opening below the roof into the church, and forming an internal lantern, above which were two stories, the uppermost lighted by two small windows, a pair on every face, and of pointed form, probably added when the second roof was added. A round-headed window is in the west wall of the nave. The choir-arch is 12 feet wide; the transept arches each 17 feet; and that of the nave 15 feet. There are three tiers of weather-mouldings on the west side of the tower, apparently indicating that the first roof was of slight pitch, the second high and steep, when three windows of corresponding date were added on each side of the nave, above the ancient windows; and, subsequently, a third roof, more depressed, was added. In the old views of the church the cills of these windows are plainly marked."

Of the three great classes of architectural features, the doorways, the windows, and the arches supporting the tower—all possess characteristics distinctively Saxon. The doorways, instead of having recesses or orders externally, and the door being hung in some plane within the thickness of the wall, have their openings cut straight through the wall with perfectly flat and unrelieved sides, the door itself being hung against its inner face, upon hinges projecting into the church. The openings in the tower are in this respect treated rather as doors than windows. The windows proper have a rough splay of brick, nearly equal and similar within and without, and meeting near the centre of the wall in a groove which contained a wood frame; the cill was similarly splayed, and was plastered. Several of the windows added to the above a most remarkable feature; their heads, instead of being arched, were square, and were covered over with oak lintels, which assumed the same splayed form both within and without as the rest of the window. These lintels had perished, but the exact impression of their ends was left in the mortar, showing almost the very grain of the wood.

The arches of the tower (of which the eastern and the western are the only original ones) are formed in the manner which is so frequent in and so characteristic of Saxon work. They have near either jamb a brick pilaster, which, instead of stopping at the springing of the arch, is continued round it. This is almost entirely of brick, as in fact are the majority of the architectural parts. The imposts are, however, of stone, and singularly moulded. The external quoins are partly of stone and partly of brick, the former being bonded on the "long-and-short" principle peculiar to Saxon work, that is to say, an upright stone alternating with a flat stone bonding into both of the wall faces. The door jambs seem to have been somewhat similar in construction, having flat stones on edge forming the sides of the opening, and flat stones laid horizontally upon them.

The church underwent considerable alterations (as already stated) about the close of the twelfth century, These alterations consisted, firstly, in the change of the whole internal character of the chancel into Early Pointed, by adding vaulting, inserting lancet windows in the sides and east end, and an elegant Early English sedile; secondly, of the vaulting of the space below the tower, and the formation of pointed arches on the north and south sides of that space; and thirdly, of the insertion of a fine pointed doorway (and apparently a porch) on the north side of the nave. The character of the work introduced at this period is especially fine; and it is pretty evident, on comparing it with the beautiful porch and chapel to the keep of the castle, that it was the work of the same architect: for, though the latter has generally round arches and has some Norman decorations, the details of the two are so much alike as to show the same hand, while both bear considerable resemblance to those of the second architect of Canterbury Cathedral. The Norman choir of the latter having been burnt in 1174, a French architect—known as "William de Sens"—was engaged for its restoration; and he, having been obliged after some years to relinquish the work, was succeeded by an Englishman who had been engaged under him, and who is called "William the Englishman." To the work of this architect the details in question bear the closest similarity, so that little hesitation can be felt in attributing them to him, or to some of those who had been engaged under his direction.

One very curious circumstance with regard to this work was brought to light during the late excavations. Many portions of the vaulting ribs of this period were discovered, several of which had been formed out of small baluster pillars belonging to the Saxon church, one side of which remained quite perfect at the back of the Early English rib-moulding. These balusters are about 2 feet long, and do not suit any existing part of the church, yet they are so distinctly Saxon that one cannot doubt that they belonged to it. They are of Caen stone, and have been carefully turned in a lathe; the surface, with the marks of the turning-tools, being almost as fresh as if new. This latter circumstance makes it evident that they could never have been used externally, and Mr. Scott thinks it probable that they formed parts of a screen. These originals are now in the museum at Dover, but casts have been made and are deposited in the Architectural Museum at South Kensington. The doorway of this period on the north side of the nave, though some symptoms of it were before visible, may almost be said to have been discovered during the late excavations, for it was not till the earth had been removed to a considerable depth that its true form was ascertained. The arch mouldings and capitals had disappeared, but the full sections of the jambs, with the bases, were traced. One of the early couplets of the chancel had been altered in the succeeding century into an incipient tracery window, with a quatrefoil in its head, and the double arch of the interior had been converted into a semicircle. It was at first intended to preserve this altered form, but the inserted stonework was so ruinous and decayed that it was found necessary to take it out; and during the excavations the capital of the central shaft was found in a perfect state, with others of its details, so that the decision was reversed, and the arch restored to its original form. The opposite window had had its external features destroyed, but on the south side the jambs remained; and one window with another, and with the aid of discovered fragments, the original forms and details were recovered with entire certainty. The capitals of several of the vaulting ribs, &c. were also found while excavating, and re-used.

There are also Early English remains of a second period, probably some thirty years later than those just described. They consist mainly of sedilia, and a piscina in the south-eastern angle of the nave, and belonging to an altar which stood against the southern jamb of the tower arch. Each arch of the sedilia had a small window-opening in its centre. These were in part discovered during the progress of the work. A little pedestal, probably for a figure, was found attached to the jamb and tower-arch adjoining, and was refixed where found. The Early English work of this second period is distinguishable from that of the first period by its having been worked with the claw-tool, whereas the olden work bears the marks of the plain chisel.

In the eastern walls of the transepts were recesses of considerable width, under pointed arches. In excavating below them were found the lower parts of cross walls projecting from them westward; and, on a careful examination of the arches, evidences were discernible of groined vaulting having existed, rendering it clear that they were the remains of projecting vaulted canopies, or ciboria, for the reception of altars; their date being probably coeval with that of the sedilia in the nave. On excavating internally, two ancient floor levels were discovered;—the original floor of the Saxon church, and that of the Early English period, which was on a little higher level. The latter has been adopted for the restored church. That portion of the older floor which was under the tower was paved with squared chalk, about six inches thick, laid on concrete, and the bed, similarly prepared, was found in other parts. The stone made use of in the Saxon portions of the building is of (at least) three descriptions:—some parts, as for instance the imposts of the tower arches, are of Caen stone; other parts, particularly some of the quoins, are of large masses of Kentish rag, such as one sees near Folkestone and Hythe. Others, again, are of a very peculiar kind of coarse oolite; and it is a singular fact that the same stone has been found at St. Mildred's Church at Canterbury, which has been supposed by Mr. Hussey to contain old Roman materials; and that the curious pillars from Reculver, which are now put up at Canterbury, are also of the same stone. Both these points were verified by the clerk of the works. Tufa also exists in the older parts of the structure. The walls are mainly of flint, but the jambs and arches of windows, &c., and portions of the quoins, are of Roman bricks, some of which are rounded on their edges as if they had lain on the beach, and to others portions of Roman mortar were found to adhere.

In clearing out the debris within the walls of the church, at the outset of the undertaking, human bones were found in all parts, at depths varying from 1 foot to 5 feet in the nave, but 8 feet below the surface in the transept, also a leaden coffin in the chancel, and a steined chalk grave in the nave. At the end of the south transept there was discovered, in forming the trench, a singularly-shaped steined grave, formed with hewn chalk sides and top, the head or upper part being recised to receive the head; the joints of this work are pretty closely fitted together, but no sign of any mortar appears to have been used in their construction. In various parts of the old building were found fragments of the old red tile, with the old pounded brick mortar jambs attached thereto, precisely similar to some of the old mortar used in the ancient pharos adjoining. The foundations of the church are formed mostly of large flint and flat pieces of stone at the sets-off, and plinth lines of the green sandstone formation, and very hard. This description of stone has been ascertained to have been quarried at Saltwood, about eighteen miles to the west of Dover. The whole superstructure rests upon a very uniform and excellent bottom, formed of very stiff clay with a large proportion of flints intermixed. The chalk floor extends over the whole area of the tower, but not beyond, except on the east side, where it runs one foot into the chancel, and finishes off in a straight line. The other sides stop against the walls under tower arches leading into the transept, the walls of which stand about a foot above this level. The floor is formed of blocks of hewn chalk, averaging 9 inches square, 6 inches thick, and firmly bedded and jointed in close mortar. No traces of floors were found in either transept.

The course which was followed throughout the restoration has been to preserve every ancient feature which remained in its place, to restore to their places all fragments whose original position could be discovered, to leave unrestored those ancient features whose restoration was not necessary to the safety or reasonable completeness of the building, and to restore others, as nearly as evidence would permit, to the old forms, without any attempt to disguise what was new, or to render it mistakeable for old work. In cases where it was necessary to restore parts formed of Roman brick, either a similar brick was employed from the excavations, or modern paving tiles. The latter sufficiently harmonise, but are at once distinguishable.

REVIEWS.

A Treatise on Ventilation, Natural and Artificial. By Robert Ritchie, C.E. London: Lockwood and Co. 1862.

This work, on a subject which is still open to elucidation, and the very rudiments of which are far from being universally understood, will be of value both to professional and general readers. It is the work of a practical engineer who has been actually and repeatedly employed in the ventilating of buildings, and who has made himself familiar with most, if not all, of the methods actually in use, or which have been at various times employed. The author states in his preface, that "the groundwork of this book formed the matter of an article for the Cyclopædia of the late Dr. Nichol, Professor of Astronomy in the University of Glasgow." This article it seems did not appear in that work, on account of want of space; and it was at the suggestion of the learned editor that it is now published in its present form, enlarged, and extensively illustrated by woodcuts.

There are here and there defects of style, and the whole work, praiseworthy as it is for its candour and impartiality, is a little open to the objection that it is more suited for an article in an encyclopædia than for a separate treatise; for while displaying the nature of various contrivances, their defects, and their advantages, it somewhat fails of fulfilling the office of a guide-book to those practically engaged in ventilating. A book which should show what expedient can be best relied upon under certain sets of conditions, and shall, in fact, place at the disposal of the student the condensed results of a long experience, is still to some extent a desideratum; and though Mr. Ritchie's book is full of information both as to facts and principles, it is hardly more of a hand-book to the ventilating engineer than several others already before the public.

One of the points on which Mr. Ritchie gives a more decided expression of opinion than usual with him is the advantage of using a current of hot water at a great heat, circulating in pipes of small diameter, for raising the temperature of the air. He has certainly done good service in showing the superior convenience, safety, and efficiency of this mode of exciting a current in an extraction-shaft.

"The writer of this work was long ago impressed with the advantages that the system of high temperature tubes presented for ventilation,—seeing the danger that attended placing open fires of any kind at the roofs of buildings to extract vitiated air. It occurred to him that if an artificial heat to a high degree were produced in a small accessible chamber at the roof of a building, with hot-water pipes heated by a fire placed at the basement of the building, there would not be the same objections to this as to the methods which have been alluded to.

After various experiments he succeeded in applying the hot-water apparatus or artificial concentrated heat at the roof of the Circuit Court-House in Glasgow in 1843, and shortly afterwards at the Police Buildings in Edinburgh. It was found that by this means, not only could a sufficiently powerful extracting force for the withdrawal of vitiated air from buildings be obtained, but that the plan was free from all risk of fire, and attended with much less trouble in the management than any other plan. It required no fire to be kindled at the roof, and was noiseless in its operation, nor was there any risk from it of the products of combustion finding their way into the apartment below, which might happen both with fire and with gas. The expense of the great consumption of gas was avoided, and there was little trouble in lighting; neither was there the risk of the escape of gas nor the liability of burners being affected by strong currents of wind. For the method of ventilating with hot water the writer received a high premium from the Royal Scottish Society of Arts, and he has successfully applied this system to several buildings in Scotland.

The result of ample experience has fully proved not only its utility and safety, but that the hot-water pipes, even in such exposed situations, have stood the test, without any accident, of twelve or more, and many of them very severe winters,—and the effect of strong frost has been easily guarded against by keeping on a slow fire during its continuance, and filling the pipes with water saturated with salt. By recent improvements the apparatus can be so arranged that the water may be withdrawn from the pipes, and these refilled at pleasure.

In the process here referred to the air is rarefied by being heated to about 200° Fahr. in a chamber at the roof, by means of hot water apparatus. Above this chamber a shaft or ventilating chimney is carried as high as conveniently can be, in order to prevent the reflux of the vitiated air, its escape into the atmosphere being aided by means of a turncap, to which a large louvre is adapted. This cylindrical turncap is made of zinc, and revolves by means of a wind vane always turning its protected surface towards the wind. The rarefaction or partial vacuum of the air in the chamber causes the vitiated air at the ceiling of the apartment to rush towards it, from which the ascensional current carries the foul air into the external atmosphere. It is obvious that by this process the ventilating apparatus itself cannot deteriorate the air of the apartment, whereas the fumes from a coal fire, or the combustion of gas in the same position, would do so. The success, however, of this plan of ventilation in a great measure depends upon three points: first, the elevation of the shaft or chimney above the heating apparatus, and free escape of the foul air into the atmosphere; second, the egress of the vitiated air from the room at the ceiling into the hot chamber; and third, the regularity with which the heat is maintained."

Mr. Ritchie has however neglected to inform us to what temperature he raised the 4-inch pipes which formed part of the system, but were employed to heat the air of the court; nor has he dwelt upon the danger (in employing a system of high-pressure pipes as a heating system) of injury to the properties of the air. This ought to have been here mentioned as a point to be guarded against, but the only reference to it is in another part of the book, where we learn that Mr. Perkins has invented an arrangement for modifying the temperature of his pipes. On the general question of heating air to excess, Mr. Ritchie has some excellent remarks, in which however we do not find any reference to the modern discovery of "ozone," although the questions of dryness and of "burnt air" are well and popularly treated.

"From the preceding observations it will be apparent that it is the degree of temperature to which the air is raised that produces its drying or evaporative action;—hence in producing an artificial atmosphere in apartments, the degree of moisture to be imparted to it should be in exact proportion to the degree of temperature of the air in the apartment; for the air may be rendered so dry and greedy in its action, or what is termed its capacity for moisture may be so increased, as to render it unfit 'for the healthy respiration of human beings or of plants.' This being generally known and admitted, the author finds it stated in one Scientific Journal* that 'it is not of the smallest importance how the increased temperature to the air is given—whether by an air-stove, or by an open fire-place, or by steam or hot water pipes; the drying effect is exactly the same, and exactly proportioned to the degree of temperature to which the air of the apartment is raised.'

Surely there is another element which comes into action in the effect of these different heating mediæ, though the drying effect may be the same, which may render them more or less injurious. It is a well-known and admitted fact that the atmospheric air in contact with heated surfaces of iron undergoes two chemical changes:—First, at a black heat of about 300° Fahr., a partial decomposition commences, by the burning or scorching of the dust mixed with the atmospheric air (visible in the sunbeam), which is chiefly composed of animal or vegetable matter;—in the second stage, or when the iron reaches a red heat (often visible in stoves, even in daylight), say 700° of Fahrenheit, complete decomposition takes place; the oxygen is rapidly consumed, forming an oxide on the surface of the metal, and the vapours are converted into hydrogen or carburetted hydrogen gas. The rarefied air which passes from the stove must be chiefly composed of nitrogen, and the effluvia arise from the burning of the floating

* Trans. Royal Soc. of Arts, 1859, p. 89.

matter. As hydrogen is of itself inodorous, the smell is more likely to be produced by the carburetted hydrogen disengaged by passing over the heated iron surface, or by the decomposition of animal matter. To inhale such air even for a short time must be highly injurious to the human frame. The effect, however, is not generally perceptible, and it is in some measure modified by the rarefaction of the air, which partially retains it at the upper part of the apartment, while the increased capacity for moisture causes the warm air to receive more rapidly back its oxygen, and remixes it with atmospheric air. It is incorrect to say that the effect of all heating agents is alike. The combustion of coal gas will dry the air, but in doing so it injures its purity by consuming the oxygen and producing carbonic acid gas. In the preparation of artificial atmospheres, stoves are unquestionably the most pernicious in imparting drying properties to the air, and hot water is preferable to steampipes* or gas heat."

It is to be regretted, perhaps, that in a work of which the chief merit consists in its comprehensive review of most existing systems, so little should be said of the methods adopted on the Continent. The much vaunted system of Dr. Van Hecke, and that of Messrs. Laurent and Thomas, are indeed mentioned, but only as referred to in the 'Barrack Report,' and the 'Lancet.' A full description, with particulars drawn from personal examination, would have enhanced the value of the book exceedingly; and it is possible that a careful personal examination of some other continental hospitals—especially the well-known one at Bordeaux—might have induced the writer to modify a little the views he has expressed on the subject of hospital ventilation.

Interesting particulars will be found relating to the ventilation of mines, and to the use of the steam-jet and fan as motors; an account of some of the many attempts to ventilate the Houses of Parliament will also be read with interest, and so will many other portions of the work; but we consider that the sections describing examples of the author's own practice in ventilation are by far the most valuable, and we would have willingly dispensed with much of the second-hand matter contained in the volume to have had those sections enlarged.

The book is well illustrated with woodcuts and lithographs, and is supplied with an efficient table of contents; but an alphabetical index is wanting—and in a book of this character the absence of such an index is to be regretted.

The Mausoleum at Halicarnassus Restored in conformity with the recently discovered Remains. By James Fergusson, F.R.I.B.A. London: Murray. 1862.

A restoration of the ruined tomb of Mausolus at Halicarnassus was—like a restoration of the Roman Forum—one of the problems which few architectural antiquarians of the Classic school left unattempted. With the change that has taken place within the last half century in the general direction of architectural studies some of the interest of these problems as matters of frequent debate has vanished, but enough remains to render the recent discovery, on the spot, of remains both of the sculpture and the architectural features of the mausoleum, a cause of general satisfaction to the learned. That discovery, as is well known, was made by an exploring expedition sent out by the British government; and the volume before us, by the author of the well-known 'Handbook of Architecture,' contains a short account of the materials for restoration previously existing and of those recently added, followed by a detailed statement of Mr. Fergusson's views as to the use to be made of those materials, together with representations of the monument as he supposes it to have appeared when complete.

After a careful perusal of Mr. Fergusson's treatise we cannot say that we feel convinced by his reasoning on all points. Where the remains on the spot, or the descriptions in Pliny and other writers, fail or disagree, he has attempted to reconcile descrepancies, or to supply missing links, by an ingenious application of a theory of geometrical proportions in Greek architecture, which, however ingenious and even probable, is not one universally accepted. So much, therefore, of the restoration as rests solely on this theory must be considered as open to question. The theory itself, one of the most interesting portions of the book, is not original, but is that elaborated by Mr. Watkiss Lloyd, after a careful study of existing Greek buildings, and so much of it as was considered applicable to the subject under consideration is contained in the subjoined seven propositions, "which," observes Mr. Fergusson, "may be considered axiomatic."

"The establishment of proportions of low numbers between—

1. The length and breadth of the basement, either upon its upper or lower step, or both.

2. The breadth of front and full height of the building; in most cases also the length of flank and full height.

3. The length and breadth of any other conspicuous rectangle, such as in the present case would be the plans of the cella, of the pyramid, of the base or pedestal of the statue.

4. The division of the grand height of the structure into a pair of well-contrasted parts, having a ratio to each other of which the terms differ by unity, as 2 to 3, 3 to 4, &c. The further subdivision of these parts is effected again by definite proportions, and a favourite scheme here, as elsewhere, is for an intermediate section of a vertical line to have a simple proportion to the joint dimensions of sections above and below it, these upper and lower sections being then proportioned independently. Thus in the entablature of the Mausoleum the frieze is just half the joint height of architrave and cornice; that is, one-third of the height is given to the frieze.

5. The lower diameter of the Ionic column has usually a ratio to the upper diameter expressible in low numbers with a difference of unity. In the Mausoleum the ratio is 5 to 6, the same as at Priene. In the columns at Branchidæ, which were more than double the height, the difference is slighter—viz., 7 to 8.

6. The height of the column is usually, but by no means invariably, commensurable with the lower diameter, or at least semi-diameter, and the columns are spaced in one or other of the schemes that supply a symmetry with their height; that is to say, the height of the column will be found invariably to measure off a space laterally that coincides with centre and centre of columns, centre and margin, or margin and margin of the foot of the shaft or base. This symmetry was of more importance than the commensurability of height by diameter.

7. In the architecture of temples, at least, the height either of the shaft or of the full column compares with the complementary height of the order, or of the front, in a ratio of which the terms differ by unity, and the larger term pertains to the columns. For example, the height of the Parthenon column is two parts out of three into which the full height of the order at the flank of the temple is divisible; the remaining part being divided between the entablature and the steps."

We cannot here follow the ingenious application of these principles made by Mr. Fergusson, but the reader interested in such matters will find much pleasure in doing so; and whether he agrees entirely with it or not, he will admit that the graphic representations of the restoration have much elegance and beauty. The work is creditably got up in every respect, is not too large, and well fitted to find a place on the library table of every antiquarian and architect.

On Heat in its relations to Water and Steam; embracing New Views on Vaporisation, Condensation, and Explosions. By C. Wye Williams, A.I.C.E. Second Edition. Longman & Co.

(Concluded from page 244.)

Resuming our notice of this work, we find the subject of the jet treated in an original and masterly manner by Mr. Williams. He detects an induced current of air by the simplest possible experiments; on this current depends the power of the jet, and not on the quantity of air or gas that is forced through the nozzle. From the exposition of the dynamical laws, so clearly established for the first time in the work before us, quantities are easily calculated to suit any required development. It is easily observed that the tuyeres of blast furnaces, fan blowers, and such contrivances, may be made more effective by constructing them in accordance with the law detected by Charles Wye Williams. He observes—

"The jet may, at first sight, appear to be of minor importance, and scarcely entitled to recognition as an agent for developing power. All think they know its character, and the cause of its action and efficiency. On examination, however, it will be found to involve results both practically and dynamically of the deepest interest. To the jet belongs all that the increase of draft, and the consequent increase of combustion, effect in the locomotive steam engine. Although this is recognised by all engineers, yet none have examined the true cause of this *primum mobile* in reference to railway speed.

So important has been the result of the jet of waste steam in the chimney of the locomotive, that a contest of violence, and even acrimony, has long been carried on as to whom belongs the merit of its application at the time of the great rival contest on the opening of the Liverpool and Manchester Railway, in which Stephenson carried the day, his success being solely the result of the introduction of the jet of waste steam in the chimney. Of the peculiarity or cause of this result as a power, he was at

* "By an ingenious arrangement Mr. A. W. Perkins of London modifies the temperature of his patent hot-water pipes to any degree by passing the flow-pipes from the furnace through tanks of cold water."

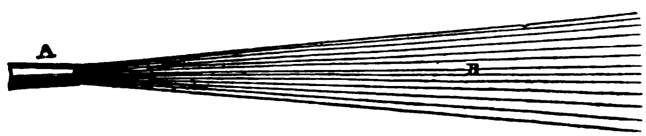
at the time wholly ignorant. Even to this day no one has yet given a correct scientific account of the true *modus operandi* by which the effect is realised. So little indeed was this known when first introduced into the Rocket engine, that the best mode of applying it, as regards area and position, was wholly undecided. All that was known, or considered requisite, was, that by throwing the waste steam from the cylinders into the chimney a great accession of draft was obtained, combustion accelerated, and a commensurate increase in the amount of steam generated. Subsequently, scientific men began to consider these points; the present position, however, of the jet at the base of the chimney, and the regulation of the sectional area of the jet, have been determined by practice alone, and without reference to principle.

From the use of the steam jet in the locomotive came its application in aid of the draft in marine boilers, where, of course, the benefit and effect of high chimneys, as adopted on land, cannot be available. Still, however, we shall see how little was known as to the principle on which the efficiency of the jet depended. In proof of this it may be mentioned that in a recent instance steam jets have been introduced into the chimneys of large vessels with so little judgment, that not only is their effect to a great extent neutralised, but it is accompanied with an unnecessary waste of steam. This will hereafter be explained and illustrated."

The following simple experiments establish the theory put forth, and define the principle upon which the force of the jet depends. Our author commences to illustrate his views by the action of a common house bellows, and remarks,

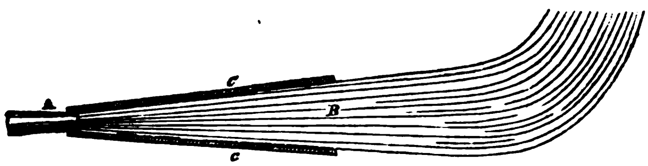
"With the view of illustrating the principle on which the efficiency of the jet depends, let us take the most familiar instance, that produced by the common house bellows, used for urging combustion in our domestic grates. We all imagine that the effect is produced by the air which actually passes through the bellows and issues through the nozzle. That this is not the case, and is but a popular error, may be proved by allowing no air to enter the fire but what absolutely passes through the bellows and its nozzle. On doing so we shall find that but little effect would be produced in urging the fire. The following experiment will sufficiently illustrate this fact. Let A, Fig. 1, represent the nozzle

FIG. 1.



of the bellows, and B the conical stream of air impelled through it. Now, if that represented all the air that entered the fire we should find the effect to be altogether insignificant. To prove this, let the stream of air be absolutely confined to that quantity, by placing on the nozzle the tin conical tube C, Fig. 2, this tube being about six or eight inches long. On urging the bellows we shall be suprised at

FIG. 2.



the comparative insufficiency of the blast. Whence then, it may be asked, is the additional supply obtained which makes the ordinary action of the blast so efficient? This may equally be made visible by placing on the nozzle, in place of the cone C, the cone D, Fig. 3, of the same size, but made of the perforated zinc plate used for window blinds, or a tin cone perforated with numerous holes, each of about one-eighth of an inch in width. If the bellows be then worked, strong currents of air will be found rushing into the cone through the numerous holes, and which will be found sufficient to restore the action to its ordinary force and effect in urging the fire. On holding the flame of a lighted taper to the holes in the perforated zinc cone, Fig. 3, it will show the air forcibly drawn in through them, thus accounting for the increased quantity entering the fire. This additional supply may be called the induced current, and on this will be found to depend the great value and effect produced by the jet, whether it be of steam, air, or water."

The tuyere of a blast furnace establishes the same result when properly prepared. The tuyere patented by Ransom Cook, much used in the United States, furnishes a good example.

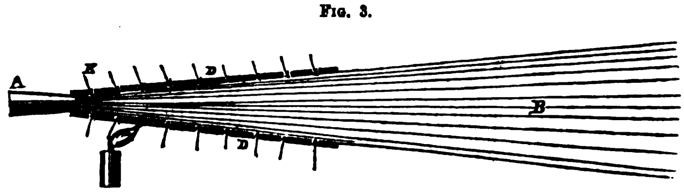
"The following will further illustrate the effect of the induced current. Let Fig. 4 represent a tin cylindrical vessel, about 5 inches long and 3 inches diameter. A is the mouth-piece through which the air may be blown from the lungs. B is a cone of the perforated zinc plate, fixed in and passing through the cylinder. C is an open space through which the air will enter to supply the induced current, to be drawn in through the perforations in the cone. On blowing smartly into the mouthpiece A, and holding the lighted taper above the open C, the flame will be rapidly deflected, as pointed out by the arrows, thus showing the great additional volume of air which was entering, in aid of that impelled through the mouth-piece. If however the open space C, be closed, the inefficiency of the blast will be strikingly evident.

The following is a familiar mode of showing the great amount of the induced current, as compared with what is supplied by the direct jet. Let A, Fig. 5, represent a tin tube of 4 feet long and 3 inches diameter. If the nozzle of the bellows be presented to the end of this tube, as shown at B, and the air be forced into it, on a lighted taper being held to its end, the direction of the flame will indicate the induced current entering the tube, as marked by the arrows. Now, to prove the inadequacy of the jet when deprived of the induced currents, let the tin plate C, Fig. 6, be placed against the end of the tube, leaving a hole in the centre of the plate sufficient for the introduction of the nozzle of the bellows. The result will be remarkable, conveying the effect of an almost want of power in the action of the bellows. This will be the more apparent if we hold a taper at the further end of the tube, or a distance from it, to indicate the force of the blast."

In continuation our author gives the succeeding examples, to show that the power of the jet is due to the pure air supplied by an induced current.

"The following are additional illustrations of the reality and importance of the induced current of air. We are all familiar with the boys' experi-

FIG. 3.



ment of balancing a pea in the air by blowing through the stem of a tobacco pipe. Thus let A, Fig. 7, represent the pipe stem held vertically, and C the pea. On blowing through the pipe, the pea having been first balanced on its end, it will be forced upwards, and sustained in the air several inches above it, as shown in the figure. In this case, no one doubts that the pea is not only projected into the air, but held in its position by the force of the jet and breath from the lungs; yet such is not the fact. The experiment will be more effective if made on a larger scale, thus:—Let A, Figs. 8 and 9, represent the mouth-piece of a tin tube, having an orifice for the exit of the air of about one-eighth of an inch. If then, holding the tube vertically, we place on its upper end the round cork ball C, of about ¾ or 1 inch diameter, the blast issuing from the lungs will project it 10 or 12 inches into the air, as shown in the figure.

Here, as in the case of the pea, it would be thought that the cork ball was sustained in its position by the sole force of the jet of air. So long as the jet is forced vertically upwards, there might be reasonable grounds for attributing the sustained position of the ball to the mere force of the jet. When, however, the ball is projected at a considerable angle as in Fig. 10, it is manifest there must be some other force in operation which prevents its falling over, as the ball could not be sustained at such an angle by the mere jet, since it must either be projected as a ball from a cannon, or it must fall downwards by virtue of its gravity. The induced current, however, illustrated in Figs. 9 and 10, then comes in aid of its support on whatever side it may be projected, sustaining its inclined position as shown by the arrows. This is further evident by observing that, as the intermittent current of the blast varies, the ball will return at a corresponding angle to the orifice from which it had been propelled.

Again, if the preventor tube D, Fig. 11, be placed on the mouthpiece, the effect of the jet will be so reduced as to be scarcely sufficient to move the ball.

In further illustration of the value of the induced current, let the experiment be made with steam instead of air. Let Fig. 12 represent a jet of steam, say at 10 lb. pressure, issuing at A from a tube of an orifice of 1-10th of an inch. The steam will then be projected to a distance of 3 to 4 feet. Let Fig. 13 represent the same jet with the preventor tin cone B placed on it, as in former experiments, by which the approach of any induced current will be prevented. The result will be, that the force will be insignificant, the steam having apparently lost its force, as shown at C. If then, as before, we remove the preventor cone and replace it with one of the perforated zinc, the force of the jet will appear to be restored, as in Fig. 14, where if the flame of a taper be held over the orifices it will be drawn into them to supply the induced current, as shown when the jet was made with air.

The value of the induced current is fully exemplified in the jets of the ordinary Argand gas burner, as also in the common blowpipe. In this latter case, if the pipe be used from the lungs, it is manifest it could have no value in promoting combustion, since, the carbonic acid and vapour issuing from it could not increase, or even sustain the combustion by which such powerful and intense heat is produced. We have, then, no

FIG. 4.

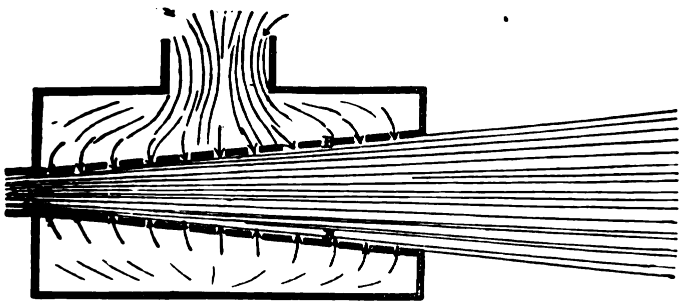


FIG. 5.

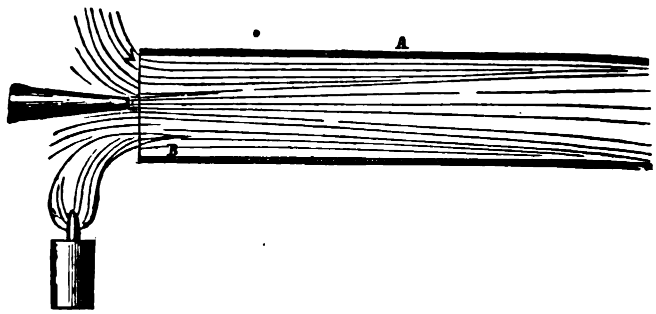


FIG. 6.

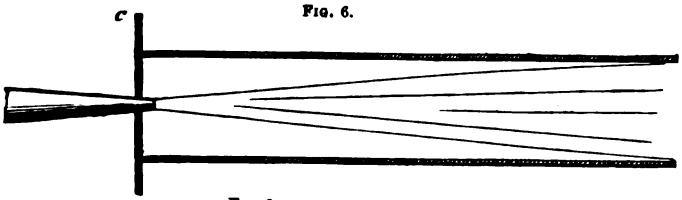


FIG. 12.

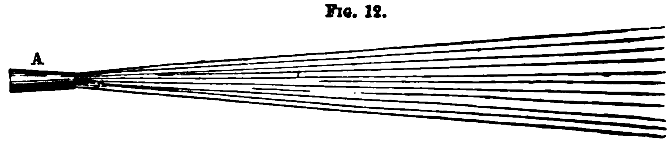


FIG. 8.

FIG. 9.

FIG. 13.

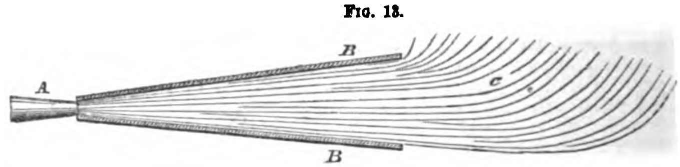


FIG. 7.

FIG. 14.

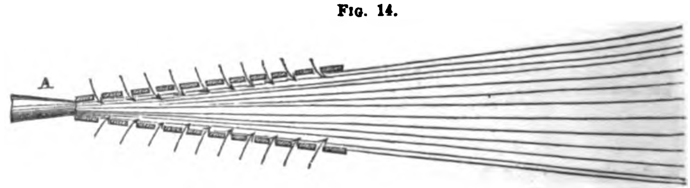


FIG. 15.

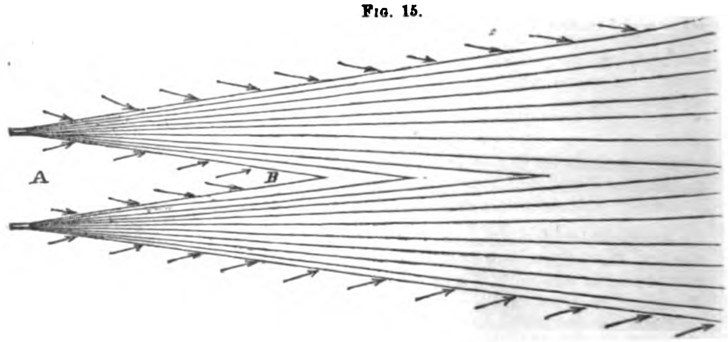


FIG. 10.

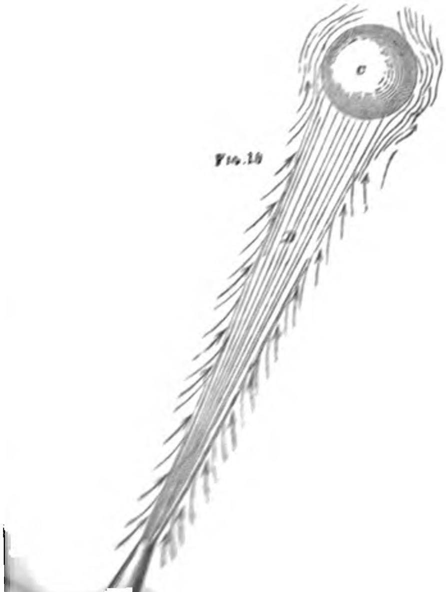


FIG. 11.

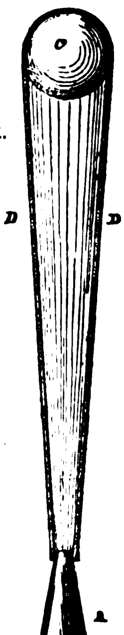
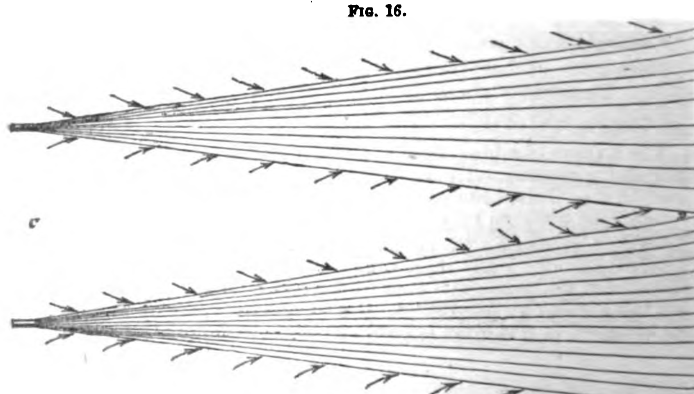


FIG. 16.



alternative, but to attribute the generation of that heat to the pure air drawn in by the induced current."

We have now fairly and fully laid the sound demonstrations and practical proofs furnished by Mr. Williams before our readers. His views on the jet, as well as on vaporisation, condensation, and explosionsare newand true; we endorse them. In the work before us the foundation is laid of a sound theory with respect to heat in its relations to water and steam; it is time that false doctrines and theories were laid aside, and a superstructure raised that will endure. The subject being of paramount importance, is sure to meet with the careful attention of engineers and men of science, to whom we would again commend the careful perusal of this valuable and original work.

The Iron Manufacture of Great Britain. By W. Truran, C.E. Second edition, revised by J. Arthur Phillips and William H. Dorman, C.E. 4to. London: Spon. 1862.

It is now seven years since the appearance of the first edition of the late Mr. Truran's well-known work, which was at the time noticed at some length in this Journal (vol. xviii. p. 319, and xix. 149.) The present posthumous edition is from a manuscript nearly completed by the author at the time of his death in Australia, he having in fact almost re-written the book, and increased the number of plates from twenty-three to eighty-four. The manuscript has been edited by the two gentlemen whose names are given in the title-page, who have endeavoured to follow out the author's aim as nearly as possible. The following extract from the preface will show the just estimate which the editors have formed of the work:—

"The great experience of Mr. Truran as an Iron Metallurgist, and the untiring industry with which during many years he collected notes and sketches of every kind of apparatus connected with the manufacture, is a sufficient guarantee for the perfect accuracy of the smallest practical details, while as an able draughtsman he has left behind him a series of beautifully executed drawings of the furnaces and machinery he describes, These drawings, which have been carefully re-produced by Mr. Newbery. give a greatly increased value to the present over the former edition; and it is not too much to say that this work now forms the most complete and practical treatise on the Metallurgy of Iron to be found in the English language.

"With respect to the opinions held by the author relative to the subject of waste heat and the advantageous application of the unconsumed gases issuing from the blast furnace, we may remark that the experience of the last few years does not appear to entirely bear out the conclusions to which he had arrived.

"It must however be remembered that Mr. Truran was essentially a practical man, and that the great value of his work is rather as a record of the exact state of this industry at the time at which he wrote, than as a scientific treatise affording information explanatory of the physical and chemical agencies which play such an important part in this branch of our manufactures.

"With some of his observations of a theoretical nature we cannot ourselves entirely agree, but there can be no doubt that his remarks on the influence exerted by the area of the tunnel-head on the working and yield of furnaces are of much practical importance, and that the attention of ironmasters cannot be too carefully directed to this subject."

The work is brought out in very handsome style, and the clearness and fidelity of the numerous lithographic illustrations much enhance its value. We shall take an early opportunity of noticing it more fully.

Orthographic Projections of Descriptive Geometry. By S. Edward Warren, C.E. 1860.

A Manual of Elementary Geometrical Drawing. By the same Author. 1861. New York: John Wiley; and London, Trübner and Co.

The author of these books is Professor of Geometrical Drawing in the Rennselaer Polytechnic Institute, Troy, New York, and appears to have devoted much study to his special subject, upon which he enters in the spirit of an enthusiast. The first and larger work is of somewhat ambitious scope, aiming at no less than an original methodical arrangement of the entire subject.

"In comparing the wants of the thoroughly trained draftsman—and every architect, engineer, master machinist, etc., should be a competent draftsman—as made known by several years' experience in teaching the various branches of graphical science, with the means of instruction afforded by the few existing works, in English, on descriptive geometry, these works have seemed defective both in the quantity of matter presented, and in their system—or apparent lack of system—of arrangement. But in view of the above named deficiences, the great value of descriptive geometry to architects, engineers, masons and machinists, as well as to mere draftsmen, as a technical graphic language, capable of expressing with unequalled brevity the true size and relative position of all parts of a geometrical magnitude, or assemblage of magnitudes, impels me to offer the following pages as the result of a careful noting of the matters suggested by many repetitions of the course in descriptive geometry in the class-room. The writer has deemed it a fortunate circumstance to be enabled to deal with a subject whose precise nature and sphere have not been determined by universal usage, especially in view of his citizenship in a nation which, being in many respects a compeer of the maturer nations of the old world, while it is yet in its own early youth, promises to be in a position to determine the usage just alluded to."

Accordingly, we have upwards of 400 8vo. pages, and a profusion of plates, devoted to the treatment of the matter *in extenso*, in a regular order based on a simple and sound scheme of classification. The author's general conception, and the faithfulness with which he has worked out its details, claim high commendation. At the same time it would have added much to the value of the work had simpler language been used. The English reader is placed somewhat out of his element among "tangencies," "nappes," "gorges," "graphical constructions," "second generations," and "revolved positions." We concede that Mr. Warren does not write for the Old World mainly, or in the first instance; and also that the task of generalising and reducing into system will sometimes require aids from language. But we conceive that if the verbiage of the volume before us were brought down to a plainer standard, the author's meaning would come out with much more clearness and force.

The smaller volume is what its name implies, and something more. Instruction is given in the rudiments of geometrical projection, and also of shadows, in isometrical drawing, and in the drawing of structures and machines. These instructions are accompanied with explanations, very useful to the young draughtsman, of all the details represented, so as to inform him of the principle, object, and actual working of every part, and teach him thoroughly to master the idea as well as to acquire the mechanical facility of picturing the form on paper. The work is liberally illustrated with neat lithographic plates.

STAINED GLASS IN THE INTERNATIONAL EXHIBITION, 1862.

Hardly is there a substance that contributes in so important a degree as glass to the progression of the arts in their development of the most refined and beautiful forms and materials, and to the comfort and necessities of all classes. The imperishability of this material has also secured to us inviolate the works of some of the greatest ancient masters of the art, and inspires even the artist of the present age with the grandest conceptions, and induces to a glorious emulation. To whatever more recent discovery we may be indebted for a more economic material, it is certain that the use of glass is traceable back so far as 2000 B.C., when the Egyptians not only made glass but understood its colouration, by means of fluxion with metallic oxides. Thus, in some of the oldest mummies, we find glass present in the form of beads and other conceits, for the decoration and ornamentation of their gods. The Portland vase from Nineveh is made of blue glass figured in white enamel, the date of which manufacture is given as 700 B.C. A most interesting analysis has been given by M. Bontemps to the Paris Academy of Sciences of the glass found at Pompeii and Herculaneum, manufactured about A.D. 79. The colour is bluish green, and approximates to an extraordinary degree to the constituent and component parts of the ordinary glass of our own time.

Glass from Pompeii.		*Ordinary Glass.*	
Silica	69·43	Silica	72·50
Lime	7·24	Lime	13·10
Soda	17·31	Soda	13·00
Alumina	3·55	Alumina	1·00
Oxide of iron	1·15	Oxides of iron and manganese	0·40
Oxide of manganese	0·39		
Oxide of copper	a trace		
	99·07		100·00

Glass was not used for the purpose of glazing until long after its discovery; mosaics and enamels were the first uses to which it was applied. The mosaics were of a very elaborate character, and consisted for the most part of filaments fused together, rather than a combination of geometrical forms. Next came the geometrical mosaics, wrought with surroundings of foliage, figures &c. Baron Rothschild exhibits a beautiful specimen of this class in the (Loan) Museum at South Kensington. In the enamelling of glass the Byzantine artists seem to have excelled, but it was long after Phœnicia became celebrated for, and Rome had introduced glass, in its brilliancy and beauty, that it was utilised by its adoption for ornamental and artistic glazing; and for this purpose it was first introduced into monasteries and churches. Bede, in his history of Wearmouth, in Durham, says "about the year 674 the abbot Benedict brought over an artist from beyond the seas to glaze the windows of the church and monastery of Wearmouth." France, in the sixteenth century, established extensive manufactories of window-glass, and conferred considerable privileges on the workmen employed: but it was not before the reign of Elizabeth that we produced window-glass in any quantity. Germany has in former years sustained a considerable reputation for its production of window-glass, but is now much below par. In order to criticise fairly or appreciate duly the productions of the various exhibitors in the present Exhibition, we should know certainly something of the manufacture, and the object each exhibitor has in view. To this end we would make a few remarks upon the manufacture of glass for window glazing, so far as the art of glass staining or painting is concerned. It is incorrectly supposed that of all stained glass extant that of the early period is the finest. This is not the fact; but the retrogression for some few centuries of the art, whether from economical notions or neglect, has led to this belief that the falling off reached its climax at the end of the seventeenth century, but no progress worthy of mention in the reproductive art took place until of late years. Now however it can be shown that we manufacture glass in no way inferior to the finest productions of the early ages. Two of our exhibitors, Messrs. Hartley, of Sunderland, and Messrs. Powell, of Whitefriars, are large manufacturers, and both in their specialities have done great and incalculable service in the reproduction of the finer details of this art. It would be most unfair to judge of Messrs. Hartley's (No. 6726, Class 34) glass from the design of the large circular windows at the east and western ends of the nave, this having nothing really to do with the speciality the exhibitors have in view; and, much as one could have wished so prominent a space to have displayed a design worthy the material, yet it has nothing whatever to do with the quality of the glass, which is not exhibited as a window, but is evidently intended to display the great, indeed wonderful, brilliancy and beauty of the glass manufactured by this firm; who also introduce some new colours, among which is a beautiful blue, where copper takes the place of cobalt. It is but justice to Messrs. Hartley to say that some of the most brilliant of the productions of many of the exhibitors is due to the successful production by them of an excellent quality of stained glass at prices that have not failed to increase very considerably its consumption. To Messrs. Powell (6737) much is due, not only for the manufacture of their glass for the artist, and their most excellent quarry glass, but in their efforts in glass painting, their windows, although subject to criticism on some points, sufficiently indicate their success in this department. This firm has the award of a medal.

The varieties of glass employed for these purposes are four in number:—1. The glass which is coloured through its substance, called pot metal. 2. That which is coloured only on the outside, called flashed glass. 3. That which is stained after the first process of manufacture is completed. 4. The rolled glass; and, lastly, the ordinary sheet-glass, which is to receive a process different from the foregoing, and requires the aid of the artist to produce its chromatic effects by the art of glass *painting;* this rests with the artist, whose colours are made to adhere to the glass by the aid of fluxes, which at a comparatively low temperature bring the silica into a state of fusion, and fix it, with its colouring materials, to the glass to be operated upon. Here, then, it is plain, that the art has many branches, upon each of which its ultimate beauty depends: 1st, upon the original glass manufacturer; 2nd, the chemist who compounds the fluxes; 3rd, the designer, so far as the cartoon is concerned; 4th, the artist, or painter, who needs to know most thoroughly the effect of the fire upon his work; and lastly, there is involved the necessity for great care and judgment in the management of the kilns and other incidentals, which may render justly the work of the artist, or affect it most unfavourably.

Hardly has architecture so beautiful an accessory as stained glass. Our ancient cathedrals and churches owe much of their magnificence and impressiveness to their glorious stained-glass windows, through which pour the soft streaming bejewelled rays in the bright sunlight, or the subdued and divine effects of the paler orb.

In the display of Messrs. Warrington (6744), who have received honourable mention, we find an attempt to illustrate the various periods of the art of glass-staining that falls far short of the evident intention of the exhibitors. Through the medium of their diversity of production we can trace plainly the styles of the various periods; but they have failed in some of the most important characteristics as illustrative of the periods to which they refer, either in the lineaments of the features, in the drapery of the figures, the eyes (which mark style and period), or the brilliancy and force attaching themselves in various degrees to these details. In some one or other of these particulars the work falls short, though altogether the firm deserve great credit for their attempt to render the illustration.

Messrs. Ward and Hughes (6741), who also have received honourable mention, exhibit the true inspiration of the artist; their figures are truthfully and beautifully rendered; their glass is most brilliant and harmonious in its effect, and the feeling displayed throughout is of an elevated order.

Mr. Charles Gibbs (6724) exhibits much that is to be admired; and the ornamental part of a window exhibited by him more especially deserves great praise for beauty and brilliancy of material and excellence, combined with richness of design. Honourable mention has been awarded to these productions. The last-named exhibitor has a namesake, whose attempt at reproducing the glass of the thirteenth century is a miserable failure.

Messrs. Hardman's works (6725), which have been recognised by the award of a medal, display the usual excellence of the productions of that eminent firm. The Emett Memorial Window excels in many respects their larger windows, which nevertheless display great merit.

Messrs. Lavers and Barraud (6745), who have a reputation for undoubted progress in the art, receive a medal; their works are of the very best kind. Their window for Lavenham Church displays great skill—the groups are beautifully drawn and painted, and full of religious feeling. We cannot pass by their heads of Authur and Guinevere without a word of praise justly due to these fine paintings.

Messrs. Ballantyne and Son (6711) should not have their work brought to the standard of ancient glass paintings; it is a style of their own, and suitable for certain purposes and positions. As transparencies they are not without merit, though their introduction into ecclesiastical buildings would be a great error in judgment. The thirteenth century work of Messrs. Powell is deserving of all praise, and the window in the Cinquecento style is an admirable production, especially so far as the figure of St. Paul is concerned. Some few defects in the design might be pointed out, but altogether their productions are of a most praiseworthy character. Messrs. O'Connor and Co. (6755) exhibit a great variety, but although the recipients of a medal, we cannot be persuaded out of the notion of the general poverty and inferiority of their selection.

Messrs. Heaton, Butler, and Bayne (6727) exhibit some very fine windows; the most prominent feature of their display is however their fine heraldic work. The figure of Moses, in the window for St. Alban's Abbey, is fine both in conception and execution; and great harmony of colour prevails in their work throughout, and deserves fully the distinction they have received as medallists.

Of Messrs. Clayton and Bell (6718) we need but say that they well sustain their reputation for high artistic skill and feeling in their glass painting; one thing strikes us however as wanting, which is, a higher degree of colour, the absence of which tends to an appearance of poverty in their productions. Messrs. Chance and Co. (6716) have boldly entered the field of glass painting, and have as boldly introduced a new disposition—we cannot say harmony—of colour, which is as eccentric as the design. It is difficult to criticise eccentricities, and it is placed where there are not many passing critics to offend.

Messrs. Rees and Baker (6740) exhibit a window, in which a most unsuccessful attempt has been made to introduce perspective and other effects, which does not speak much for their experience in the established principles of the art of glass painting. Messrs. Field and Allan (6721) are deservedly awarded a medal for a beautiful specimen of fifteenth century work.

Altogether, this department of the International Exhibition well sustains a reputation for progress, and proves, as in our advance in ceramic wares, that noble emulation will redeem in a short period a loss that the mourning of ages would but confirm. All praise then is due to those enterprising firms and individuals who have so nobly, and in many cases so disinterestedly persevered in the reproductive arts.

MACHINERY IN THE INTERNATIONAL EXHIBITION, 1862.

(*Continued from page* 289.)

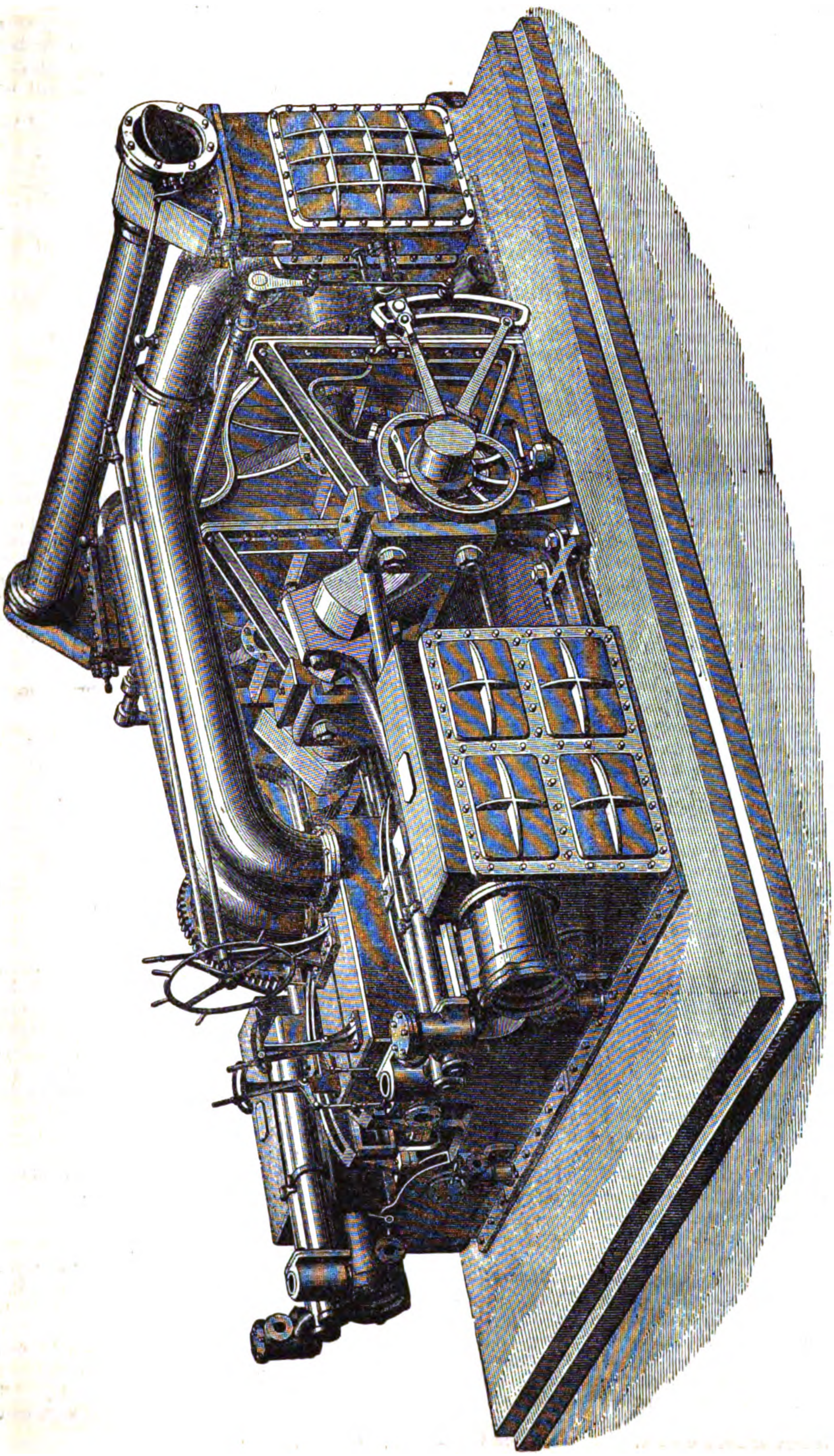


FIG. 12.—Ravenhill, Salkeld, and Co.'s Marine Engine.

Messrs. JOHN PENN and SON, Greenwich, exhibit a pair of *Horizontal Marine Engines* (1955, Class 8), of 600 nominal horse power. These engines are constructed on the trunk principle, working through both ends of the cylinders; the pistons in the centre of the length of the trunk; the connecting rod works on a gudgeon fixed in the trunk, the action being thereby direct from the piston to the crank; the air pumps and condensers at the opposite end—the former actuated from a rod moved by the piston to which it is attached, and passing through the cylinder cover, the same being the case with the rods that drive the feed pumps, placed close to the condensers, and taking their water directly from the hot wells. The air pumps consist merely of a solid piston working in a cylinder open at both ends, and placed within chambers, separated by a mid diaphragm, beneath the horizontal valve plates above. The valves are multiple and circular. The steam and eduction valves are simple cap slides of large size, with considerable lap. The valve gear consists, for each engine, of two eccentrics and link motion; the vibrating link is hollow or slotted, and the arrangements for handling the engines are very simply brought up to a single starting wheel, placed with its plane athwartships, and upon the top of the condensers; close by it are the levers acting upon the throttle valves and those by which small subsidiary valves placed on the upper sides of the cylinders are manipulated, by which the cylinders can be breathed and blown through, before starting, as well as the condensers. The steam and eduction valves stand on edge, or upon the sides of the cylinders. The discharging steam passes directly through polished copper pipes over the top of the engines to the top of the condensers. These are provided with expansion glands at the condenser ends. The main shaft is in one piece, 12 inches diameter at the necks. The cranks are balanced by blocks of cast-iron secured by straps. The main strains in engines of this class being reduced to push and pull in the line of the axis of the cylinders, in which direction ample strength is provided in the framing, no great transverse stiffness is needed, or found, in the lower frame or bed plates. The outer end of the crank shaft, at the first length of the screw shaft, is provided with a worm wheel of cast-iron and endless screw, for the purpose of turning round the engines when steam is not up. The boilers, four in number, have a heating surface of about 11,000 square feet. These engines are intended for a first-class frigate in the Spanish navy. The workmanship of these engines is perfect, as is usual in the productions of this eminent firm.

Messrs. Ravenhill, Salkeld and Co., of Ratcliff and Blackwall, exhibit (1962, Class 8), working models of a pair of *Horizontal Marine Engines* of 500 horse-power for screw propellers (Fig. 12). The cylinders are 71 inches diameter, 3 feet stroke, and are fitted with double piston-rods placed diagonally in the pistons, so as to pass the one above and the other beneath the shaft to the cross-heads. The guides are placed on the condenser framing, from which cross-heads connecting-rods return to the crank shaft.

The exhibitors were, it is believed, the first to introduce the double piston-rod engine into the British Navy; engines of 300 horse nominal power so fitted having been made by them in the year 1845, since which time they have fitted no less than forty-five ships with them. The slide valves are three-ported, and worked by the ordinary link-motion. The air-pumps are worked direct from the piston, and are placed outside of the connecting-rods at each end of the engines, so that their stuffing-boxes are at all times accessible whilst the engines are in motion. The foot and delivering-valves are placed at the extreme ends of the condenser framing, and are at once within reach by the removal of the doors. The connecting shaft is carried in three bearings, the main glands of which are of wrought-iron made to clip the framing. These models are very beautifully executed.

Messrs. Ravenhill, Salkeld, and Co. exhibit also a working model of the marine engines of the Holyhead royal mail packets, Leinster and Connaught. These engines are an admirable example of the class of mercantile marine engines, and of the application of the oscillating cylinder to the largest class of engines. The nominal power of these engines is 720 horse-power. The cylinders are 8 feet 2 inches diameter. The stroke is 6 feet 6 inches. The working pressure in boilers is 20 lbs. per square inch, and with an indicated horse-power=4751 horse-power=nearly 6·6 times the nominal power, these vessels attained an average speed at the official trials at Stokes Bay of eighteen knots or twenty-one statute miles per hour; the engines working at the rate of twenty-five to twenty-six strokes per minute. The average speed in all weathers of the two vessels on the station during the first six months of the new postal service, ending 31st March, 1861, between Holyhead and Kingstown, was 15·451 knots, or a little under eighteen statute miles per hour. The extreme length of the Leinster and Connaught is 350 feet; the breadth 35 feet; the mean draught 12 feet 9 inches; and the area of midship immersed section about 328 square feet. The boilers are eight, tubular, with 40 furnaces, and 4176 tubes, or a total of 4¾ miles of tubing, and expose a heating surface of 16,800 square feet. The consumption of fuel is about three lbs. per indicated horse-power per hour; the boilers are not fitted with superheating apparatus, nor are the engines fitted with any expansive gear, but steam is cut off by the slide valves at about ⅞ths of the stroke. The average vacuum is 25 inches. The shafts are wrought-iron—none of steel. The paddles are upon the feathering principle, and are one of the largest examples of this construction, the floatboards being 5 feet in depth. The outer paddle-shaft bearings are inside the paddle-boxes, and hence are very accessible. To Messrs. Ravenhill, Salkeld, and Co. honourable mention has been awarded for their models of oscillating engines.

THE TUNNEL THROUGH MOUNT CENIS.

The great enterprise of Sir Isambard Brunel of constructing the tunnel under the Thames, has nowhere been imitated on such a gigantic scale as in the case of the tunnel through Mount Cenis, which will open a new and shorter communication between the North of Europe and Italy. It is, in fact, such an undertaking as could hardly have been ever achieved if some recent mechanical and engineering improvements had not come to its aid. The entire length of this tunnel is estimated at about 12,220 metres. Its situation is between the railway station of Susa and St. Jean de Maurienne, west of the present highway from Susa over Mount Cenis by the Col de Fréjus, at an elevation of 1338 metres or about 4100 feet above the level of the Mediterranean. The southern opening of the tunnel lies about 6½ leagues west of Susa, near the hamlet of Bardonèche: hence the tunnel ascends by a gradient of ½ per 1000 until the middle of the mountain, and then descends towards the northern opening of the tunnel, near the village of Mondone, with a gradient of 23 per 1000. On account of the great height of the mountain, no vertical shaft was possible. The present postal road passes Mount Cenis at an elevation of 6354 feet, and the height of the Col de Fréjus is 9168 Paris feet or 2978 metres.

This stupendous work was began on the 31st August, 1857. At the present moment the excavations extend to 740 metres on the north, and to 950 metres on the south side, and consequently 10,530 metres are yet to be bored. Up to a late period the mining operations were performed by the ordinary method of manual labour, but now new boring apparatus has been adopted on both sides of the tunnel, and the work progresses daily at the rate of four or five feet. Still it is evident that ten years will hardly suffice to complete the work. The cost of this gigantic undertaking is estimated at sixty millions of francs, but probably this sum will be much exceeded. France has to contribute twelve millions of francs, but has not done so hitherto. If present circumstances continue, it is to be feared that the works will be stopped.

The work of boring is done by machines, which are moved by air compressed by hydraulic pressure. The water necessary for this purpose is obtained in the following way. The water which constantly pours down the slopes of the Alps, and which forms the chief supply of the little river of Bardonèche, is collected in channels and large reservoirs, and thence conducted by large tubes to a building, in which there are ten iron tanks in the shape of steam-boilers, each of which is furnished with a vertical tube of two feet diameter and fifty metres high. While the water is conducted from the main tube into these ten secondary ones, the air is conducted by a ventill apparatus, of which each tube has one, the air and water is so conducted that the tanks are completely filled with air, and the tubes with water. The columns of water in the tubes now compress the air, with a force of 22,000 lbs., which causes the air to issue from the reservoir with great force. A strong metallic tube eight or nine inches wide is conducted into the tunnel, close to the boring apparatus, where four tubes of india-rubber, secured by screws, bring it in four cylinders placed horizontally, from whence the rotatory apparatus, which moves the boring instrument, is fed. This rotatory apparatus moves eight steel gimlets, each three feet long, which placed at an angle of 45° penetrate, pushing and boring into the rock. As the borers make 200 strokes each minute, the noise is terrible. The air cylinder, the borer, and the men at work are placed on an iron framework, which can be moved upon wheels rolling on iron rails. Ventilation, as well as the removal of dust, is effected by the opening of spiral air-valves fixed on the iron tubes. The boring apparatus, made at the manufactory of Cockerill at Sèraing, are 9 feet long by 10 to 12 inches high. Each machine perforates the rock, according to its solidity, to the depth of 2 feet, and a width of 1½ inch. On each surface of 6 square metres, four holes, 2 feet long and 3 inches wide, and seventy or eighty holes of the same length, but of less width, are made. After all the holes have been drilled, which generally occupies six hours, the iron framework, with the boring apparatus, is drawn backward in the shaft about 100 metres, and it is closed by a strong wooden gate, for avoiding the projection of stones when the mine is exploded. The method resorted to here is the usual one of gunpowder and a conducting train, but the four large holes in the middle are not loaded. After the firing of the mine the smoke of gunpowder is expelled by means of the ventilating apparatus, and the débris of rocks carried in small carts, on a lateral rail, to the large waggons at the entrance of the tunnel, and thence conveyed to the general repository of rock debris. The collecting and removing of the rock débris takes also six hours, and thus the blasting can only be done twice a-day. There are two rails in the tunnel, between which is a conduit for the efflux of the water. It is altogether supported by a vault, that at the north end made of hewn stones, on the south side of bricks. Outside are the reservoirs and the building for the machines to compress the air, a mechanical workshop furnished with a turbine, a large building for the officers, and a manufactory of gas for lighting the tunnel and the buildings.

IMPROVEMENTS IN PARIS.

Restoration of the Palais des Tuileries.—The works of restoration at the Tuileries are progressing. At present the foundations on the south side of the building are carried off, which present many difficulties, on account of the river close by. It was required to go down sixteen metres to find solid ground, five metres lower than the old foundations. The cut is finished on the whole extent of the works, except on the S.E. angle. All the other excavations are completed, and the beton has been cast on which the masonry is to be placed.

Theatre of the Prince Imperial.—This theatre, situated in the square of the Arts et Métiers, will soon be finished. The front is near its completion. It consists, on the ground floor, of five round arcades, made of alternate voussoirs and triglyphs. Four of these arcades lead to a vestibule of two rows of pillars, where are the bureaux, and in the rear the staircase of the first galleries. The fifth arcade leads to a passage for the servants to leave, &c. The first floor is lighted by five large arched windows, the piers of which are ornamented by pillars which support the remainder of the pediment. Above rises the attic, pierced by six openings arranged in a centre, and above is the pediment.

Enlargement of the Hospital St. Louis.—The Board of Public Aid (*assistance publique*) has undertaken very important works, amongst which the above is not the least. It is intended to erect a new building for baths. It is situate in the garden of the hospital. Its plan forms the figure **T**, of which the lateral lines are to be occupied by the baths, and the central building is to form the passage to the hydrotherapeutic rooms. The entrance-door leads to this passage, on which open on both sides all the rooms of the establishment. To the left is the bath for the men. The walls are covered with marble up to the slopes of the windows, and the remainder is made of Portland cement, the vault of Fayence, to avoid injury by the saline or sulphurous vapour. The baths are of enamelled cast-iron, and the doors of galvanised sheet-iron. To the right is a similar hall for the females. In an adjacent room are the iron safes, inserted in the wall, in which the linen of the bathers is dried. Beyond are rooms for keeping the linen, the washhouse, with washing-machine and drying-machine, moved by steam. There are also rooms for douche baths, for running baths, vapour baths, fumigations, and ferruginous baths.

The New Opera House.—The works of this new theatre are pushed on with the greatest activity, notwithstanding the springs which have been met with. Excavations are made in several places, and in some the brickwork reaches already the level of the ground, as is the case on the boulevards. In some localities the removal of the materials is going on, in which six steam engines are employed. The piles are then driven in, and the beton spread. The cement, mortar, and beton are conveyed on platforms above the lower workshop, where they are lowered into waggons, which convey them to the places where the works are going on.

Squares projected in the Suburbs.—It is intended to build squares in some of the new arrondissements, like those which, it is asserted, have given such favourable results in the interior of Paris, in a sanitary respect. Excavations have been undertaken in the 14th arrondissement, Montrouge and Plaisance; in the 20th, Charonne, Belleville; at Batignolles, Grenelle, &c. Surveys have been made for two extensive promenades in the south and north of Paris. On the other side the transformation of the outer boulevard, on the right bank of the Seine, is being proceeded with.

The Cement used in the construction of the Bridge over the Vistula.—When the building of the bridge over the Vistula, near Dantzic, was begun, we had no hydraulic materials; and it was resolved to make for ourselves the cement we were in need of, and a workshop was constructed for that purpose. We shall state briefly the processes which were resorted to. We took two sorts of marl found in the neighbourhood, which were thus mixed, and their analysis yielded the following results:—

Carbonate of lime	64
Silica	30
Clay	4
Oxide of iron	4
Potash (soda)	1

The marl was exposed to freezing, and was intimately mixed in two large mills; it was then formed into small bricks and dried. The baking process was done in four tub furnaces, after the system of Rumford, of the following dimensions:—

Height of the mouth of the furnace ... metres	10·00
Diameter of the furnace	2·60
Diameter of the mouth	1·25
Height of the furnace, which is also that of the grate	2·60

Two men attended the furnaces. The filling was done every six hours. The cement was drawn from below, and the pieces too much or too little roasted were carefully separated. Every furnace roasted 60 hectolitres of small bricks, and consumed 11 hectolitres of Newcastle coal. The cost for the making and pounding was about 25 francs for the cubic metre. The further preparation was done by eight mills, with movable plates, each of which contained a couple of vertical moulds; the plate made 22 revolutions per minutes; a tap of water served for making the cement on the mill, by adding a little sand for mixing. Each mill produced 13½ cubic metres of mortar per diem, consisting of 1 part of cement, 1¼ part of sand, making by the volume $1\frac{1000}{1118}$. When beton was to be made, two drums were used, making eleven revolutions per minute, and mortar and stones were thrown into it; each drum made 68 cubic metres per diem; the engine working at three atmospheres, without condensation or stop, and consuming 18 hectolitres of coal. The experiments made for the sake of testing the strength of this cement under pressure showed that the resistance, which had been only 10 kilogrammes on the square centimetre after a fortnight, increased to 40 kilog. in a month, and became that of 100 in six or eight months, and after one year amounted to 150 kilogrammes on the square centimetre.—*Deutsche Bauzeitung.*

Scientific Balloon Ascent.—A scientific balloon ascent for meteorological investigations is shortly to be made in Prussia, under the direction of the Berlin Academy, on the plan of the successful ascents of Mr. Glaisher, which have excited very great interest amongst learned societies abroad. A new balloon for military purposes, which can be made to ascend or descend by a peculiar apparatus attached to the car, is stated to have been made by the French aeronaut, M. Goddard.

CLASSIFIED LIST OF PATENTS SEALED IN SEPT. 1862.

1402 Milward, J. F.—Breech-loading firearms (com.)—May 10
626 Deane, J.—Revolving firearms—March 8
642 Spence, W.—Projectiles (com.)—March 10
1108 Newton, W. E.—Cannon and other ordnance (com.)—April 16
743 Waller, T.—Breech-loading firearms (com.)—March 17
780 Mathew, B. H.—Firearms and cartridges—March 21
821 Beaumont, W.—Sights for rifles—March 25
1663 Whitworth, J.—Shells—June 2
872 Boucher, J.—Rifle ordnance and firearms—March 29
873 Parfrey, Y.—Breech loading firearms—March 29
983 Harris, A.—Manufacture of gun barrels—April 7
1051 Johnson, J. H.—Firearms (com.)—April 11
1098 Leek, W. F.—Projectiles—April 16
1208 Richards, G.—Ordnance—April 25

670 Johnson, J.—Steam boilers—March 12
570 Whitemore, J., and Davis, F.—Apparatus for supplying water to steam boilers—March 1
831 Johnson, J.—Apparatus for cleaning flues of steam boilers (com.)—March 26
876 Townsend, C., Young, J., and Hawkins, J.—Means of removing incrustation in steam boilers—March 29
814 Topham, J.—Apparatus for removing the sediment in steam boilers—March 24

979 Thompson, B.—Steam engines—April 5
641 Parker, W., Bateman, G. H.—Steam engines—March 10
1061 Park, J.—Steam engines—April 14
788 Humphreys, J.—Steam engines—March 21
833 Parker, J.—Steam engines (com.)—March 26
925 Kay, C., and Hartley, W.—Steam engines—April 4
691 Henry, M.—Stuffing boxes (com.)—March 13
1967 Child, O. W.—Composition for shaft journal boxes (com.)—July 8
940 Bower, J.—Metallic pistons—April 3
805 Holliday, W.—Flexible valves—March 22
1008 Farrow, S.—Steam valves—April 9
1839 Bousfield, G.—Steam engine valves (com.)—June 21
769 Brooman, R. A.—Rotary engines (com.)—March 19
646 Barclay, A.—Traction engines—March 10
622 Blair.—Rotary engines—March 8
594 Guy, G. T.—Electro magnetic motive power engines—March 5

616 Restell, R.—Apparatus for connecting and disconnecting cars and engines on railways—March 7
764 A'Beckett, A. M.—Railway signal apparatus—March 12
709 Muir, M., McIlwham, J.—Railway sleepers and chairs—March 14
1074 Brooman, A.—Railway cars (com.)—April 14
930 Blackburn, B.—Lubricators for axles—April 2
935 Leopard, W.—Railway brake—April 2
1011 Ashburn, J.—Permanent way—April 16
1795 Hasetina, G.—Roofs to railway cars (com.)—June 17
943 Toogood, M. R.—Railway crossings—April 3

782 Bouser, W.—Ships' fire hearth and cooking apparatus—March 17
770 Brooman, R. A.—Apparatus for drawing in and paying out chain cables, &c. (com.)—March 19
1844 Ponsonby, H.—Topsail sheet bits—June 23
865 Owen, A.—Means in varying the pitch of screw propellors—March 28
1104 Warren, F. P.—Steering vessels—April 16
1601 Harrison, J. F.—Coating ships' bottoms—May 28
937 Rebour, G.—Ship logs—April 3
730 Lord, W., and Gilbart, F.—Apparatus for raising and lowering ships' boats—March 17
931 Hunter, S.—Anchors—April 2

787 Hart, J.—Means for generating steam—March 21
988 Watremez, J., and Kloth, A.—Apparatus for indicating a deficiency of water in steam generators—April 7

619 Williamson, A. W.—Apparatus for generating steam—March 8
1884 Hunt, W., and Pochin, D.—Condensing apparatus—June 27
1149 Parkes, A.—Surface condensers—April 19
825 Morewoode, E.—Means of shaping iron—March 25
913 Smith, H.—Apparatus for casting iron—April 1
763 Radcliff, R., and Shipman, J.—Hardening wire and crinoline steel—March 8
966 Newton, W.—Manufacture of iron and steel (com.)—April 4
1294 Griffiths, T. F.—Shaping sheet iron—May 2

854 De Barry, R.—Machine for manufacture of cigars (com.)—March 27
864 Nation, B.—Machine for manufacture of boxes and cases—March 28
883 Hart, B.—Machine for cutting cork (com.)—March 29
1019 Theyson, R.—Machine for cutting cork—April 9
892 Hook, W.—Machine for folding envelopes and paper—March 31
911 Turner, W.—Bread making machines—April 1
917 Hartley, E.—Rolling or straightening metal shafts, spindles, &c.—April 1
920 Platt, J.—Machinery for applying motive power April 1
942 Hunter, G.—Machinery for stone cutting—April 3
1032 Petrie, J.—Blowing machine—April 15
557 Dodds, M.—Machines for moulding and cutting iron or other malleable metals—March 1
561 Hague, S.—Machine for raising hammers and stamping hot or cold metals—March 1
647 Piret, J.—Lubricating apparatus—March 10
726 Pendlebury, J. and T.—Form of lubricator—March 15
782 Siebe, D. E.—Machine for producing cold—March 21
859 Smith, M., Coventry, A.—Lathes and machines for turning and cutting screws—March 27
1078 Fell, G., and Haynes, W.—Machine for manufacture of leather—April 15
1109 Stanton, John—Machine for stamping metal washers &c.—April 16
806 Hartshorne, G., Ward, G., Wooley, W.—Machine for punching metal plates, &c. March 22
848 Edwards, R.—Machine for pulverising and washing mineral substances &c.—March 27
701 Quinard, A.—Machine for manufacture of horse shoe nails—March 18
766 Sampson, M.—Machine for cutting tobacco &c.—March 19

604 Barker, J.—Apparatus for casting drums, pullies, and other gear—March 6
717 McAdam, W.—Block pulleys, weights, &c. for windows—March 15
721 De la Haye de Barbezieres, S. M.—Construction of horse shoes—March 15
723 Hamilton, G.—Tumbler locks—March 15
805 Holiday, W.—Press plates—March 22
1029 Christoph, L., Hawksworth, W., and Harding, G. P.—Drawing metals—April 10
1165 Matthews, S. P.—Vices—April 21
1668 Jebhardt, J. J. H.—Fastenings for bags &c. (com.)—June 2
1767 Lancelott, J.—Manufacture of ornamental chains—June 14

765 Wilson, R.—Hydraulic presses—March 19
1017 Newton, W. E.—Apparatus for raising and forcing water &c. (com.)—April 9
652 Nadal, J.—Portable fountain—March 11
628 Guyet, J.—Water meters—March 8
746 Memmons, M.—Cooling and filtering apparatus (com.)—March 19
734 Weems, J. and W.—Apparatus for indicating the quantity and pressure, and in regulating the discharge of fluids—March 17
731 Mongreuil, L.—Cold vapour generator—March 17

1379 Fowler, J., and King, J.—Steam apparatus for tilling ground—May 8
612 Fowler, J., Greig, D., and Noddings, R.—Apparatus for tilling ground—March 7
658 Hall, C.—Implements for breaking up the soil—March 11
718 Hunter, J.—Reaping machines—March 15
1845 Haseltine, G.—Machines for mowing, reaping, &c. (com.)—June 23
836 Roby, R.—Haymaking machines—March 26
707 Bousfield.—Machines for digging the earth for agricultural purposes (com.)—March 14
773 Samuelson, R.—Chain harrows—March 20
875 Morris, T.—Machine for breaking land—March 29
879 Ransome, R.—Thrashing machine—March 31
925 Warren, S.—Transmitting power for agricultural machines—April 2
908 Clark, W.—Manufacture of manure (com.)—April 1
592 Cottam, G. and R.—Horticultural buildings &c.—March 14

614 Wright, R.—Heating and clarifying saccharine fluids—March 7
564 Robertson, P.—Improvements in yeast, and manufacture of ammonical salts, and a substitute for animal charcoal—March 1
1879 Johnson, J. H.—Electro voltaic platework for medical and other purposes (com.)—June 26
1896 Beslay, C.—Means of galvanising or coating metals by electro chemical agency—June 28
1127 Abel, C. D.—Alloy containing cadmium (com.)—April 17
815 Morewood, C.—Process of coating metals—March 24
919 Madge, H. J.—Process of coating metals—April 1
760 Brooman, R.—Manufacture of barytes and barytic products (com.)—March 18
880 Patterson, W.—Manufacture of iodine—March 29
813 Fleet, B.—Manufacture of soda water—March 24
1244 Glidden, W.—Process of restoring phosphatic guano (com.)—April 29
830 De la Peyrouse, Leo.—Preservation of animal substances—March 26
742 Gossage, W.—Manufacture of soda and potash—March 17
671 Conyers, W.—Means of currying leather—March 12
724 Robey, J.—Refining of sugar—March 15
832 Fryer, A.—Refining of sugar—March 25

842 Newton, A.—Apparatus for separating fibres of wood, flax, &c. (com.)—March 27
828 Clissold, W.—Carding engines—March 26
884 Platt, J.—Carding engines—March 29
1031 Platt, J., Richardson, W., and Holland, W.—Carding engines—April 10
793 Abercrombie, D.—Power looms—March 22
739 Cantauld, J. M.—Power looms—March 17
906 Couchoud, P.—Loom for the manufacture of chenille &c.—April 1
817 Stewart, J.—Manufacture of cards for weaving (com)—March 24
1152 Coombe, J.—Machine for hackling flax, &c.—April 21
563 Potts, A.—Machine for scutching flax &c.—March 18
576 Schofield, J.—Weaving looms—March 3
797 Lord, Edward—Machine for preparing cotton—March 22

617 Wood, T. H.—Apparatus for manufacture of artificial fuel—March 7
796 Fontenay, T.—Smoke consuming furnaces
684 Hunter, J.—Apparatus for removing slag from furnaces—March 13
710 Turner, W.—Baking ovens—March 14
673 Gondole, P.—Baking oven—March 12
807 Henry, M.—Kilns and ovens (com.)—March 22

984 Welch, W.—Register stoves and fire grates—April 7
928 Holcroft.—Blast furnaces—April 2
824 Guibal, T.—Ventilators for mines and furnaces—March 21
566 Jennings, J. G.—Chimneys—March 1

578 Tillam, T.—Means of purifying gas—March 3
664 Normandy, A. R. Le Mire de—Means of connecting gas and other pipes—March 12
692 Brooman, R.—Apparatus for regulating the flow of gas (com.)—March 13
978 Field, E.—Apparatus for regulating the flow of gaseous and other fluids—March 20
785 Newall, J.—Means of supplying gas to railway cars, steamboats, omnibuses, &c.—March 21
869 Smith, R.—Wet gas meters—March 28
562 Ragon, A. E.—Electric alarums (com.)—March 1
749 Banks, J.—Electric magnetic telegraph printing apparatus—March 18
708 Paterson, A.—Electric telegraph cables.—March 14

582 Conisbee, W.—Colour printing-machines for letter-press or block-printing—Mar. 3
771 Cumming, J.—Apparatus for distributing and setting up type—March 19
915 Caslon, W., and Fagg, G.—Casting printing types—April 1
1147 Parkes, A.—Rollers for surface-printing, &c.—April 19
1490 Ames, N.—Self-feeding card printing-press—May 16
955 Bakewell, F. C.—Letter printing-machine (com.)—April 4

767 Brooman, R. A.—Printing and painting on glass, ceramic wares; also on metallic substances (com.)—March 19

1247 Caley, J. W., and T. G.—Textile fabric—April 29
613 Ball, T. and W., Wilkins, J.—Manufacture of warp fabrics—March 7
623 Patterson, W., Sanderson, W. A. and R.—Finishing woven fabrics—March 8
683 Cunningham, J. and R.—Ornamental fabric—March 13
725 Wickstone, W.—Manufacture of piled fabrics—March 15
758 Slack, S.—Manufacture of stockings, &c. in circular knitting-machines—March 18
768 Brooman, R. A.—Lace embroidery, &c. (com.)—March 19
816 Henson, W.—Knitting machines—March 24
946 Wilson, D.—Cotton presses—April 3
783 Kay, R.—Printing calico—March 21
852 Cornellan, J.—Treating open cocoons of silk—March 27
944 Kemp, W., and Cowley, I.—Pile fabrics—April 3
899 Schmolle, B.—Crinolines—March 31
716 Smadja, J.—Bustles and crinolines—March 5
775 Hill, A.—Fastening for stays—March 20

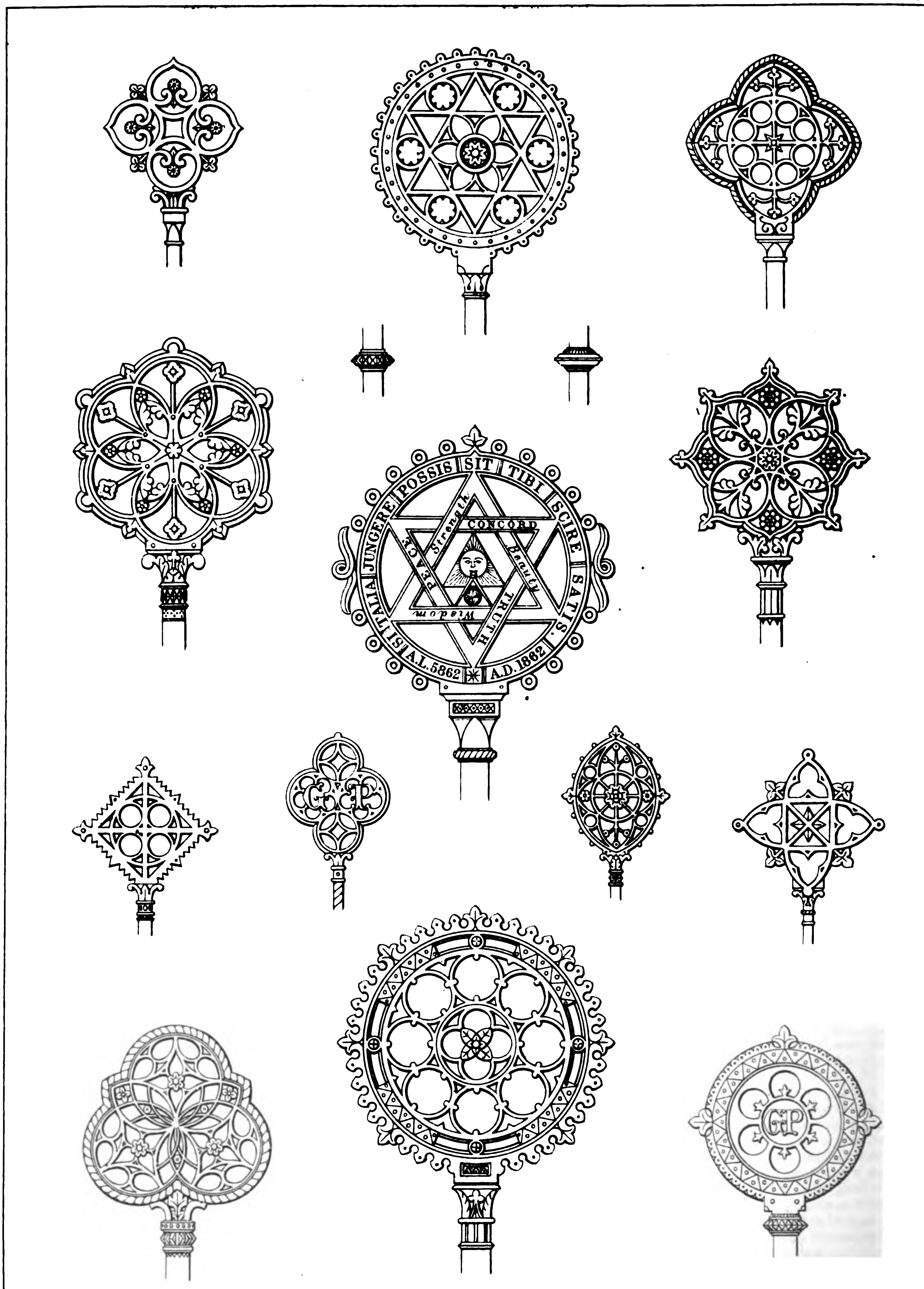
1162 Callebant, C.—Sewing machines.
2040 Newton, A. V.—Sewing-machines (com.)—March 16
738 Bousfield, G.—Cranks for driving sewing-machines (com)—March 17
901 Clements, J. M.—Sewing machines—March 31

621 Edmondson, G.—Washing machines—March 8
889 Young, R.—Apparatus for washing and drying grain—March 31
625 Platt, J., and Richardson, W.—Machine for cleaning cotton from seeds—March 8
1261 Newton, W. E.—Machines for picking and cleaning wool &c. (com.)—April 29

597 Somervill, J., and R. M., and Blanc, M. Manufacture of boots and shoes—March 5
600 Bastock, J. Manufacture of boots and shoes—March 5
687 Wadsworth, James Moveable heels for boots shoes—March 13
728 Stocker, S., and K. Metal boot-heels, tips, and horse-shoes—March 17
1612 Boisset, P., and Antognini B, Manufacture of boots and shoes—May 29

645 Nosworthy W. S. Pianofortes—March 19
886 Clinton, J. Flutes—March 31
1245 Samson, G. K. Valves for wind musical instruments—April 29
798 Davis J. Wind musical instruments—March 22

715 Petit, G. B. Apparatus for heating water &c.—March 15
799 Gladstone, R.—Tipping waggons—March 22
934 Clark, W. Apparatus for manifold writing (com.)—April 2
941 Newton, J Construction of breakwater piers &c.—April 3
1044 Mathias, J. Apparatus for pressing and ironing straw hats—April 11
777 Smith, E.—Apparatus for cutting stone—March 20
802 Jennings, J.—Manufacture of biscuits
808 Brierly, H.—Clasps for reversible belts &c.—March 24
835 Munn, H.—Mangles—March 26
950 Hassell, T., and Burke, M.—Invalid chairs &c.—April 3
1089 Holland, H.—Manufacture of joints in umbrellas &c.—April 11
949 Richards, W. A.—Bag locks, fastenings &c.—April 3
951 Woodall, J. F.—Ventilating carriages &c.—April 4
1419 Pope, J.—Apparatus for lowering and loading coals &c.—May 12
1812 Wood, J.—Manufacture of driving straps or bands &c.—June 19
703 Birkbeck, G.—Trusses (com.)—March 14
706 Gabler, L., and Zingler, M.—Manufacture of articles in ivory and bone—March 14
711 Coles, A. and W.—Trusses for cases of hernia—March 15
714 Kottula, N. Manufacture of combined soaps—March 15
1395 Oxley J.—Apparatus for mashing &c.—May 9
1491 Thompson, N.—Stoppers for bottles, jars, &c.—May 16
1604 Saunders, H., and Miles, H. J.—Venetian blinds—May 28
607 Shipley, G. J.—Bridle heads, reins, and bits,—March 7
640 Brooman, R.—Photography (com.)—March 10
948 Mann, A.—Photographic apparatus—April 3
648 Calow J. T.—Safety mining apparatus applicable to hoists—March 10
657 Camp, E. G.—Brushes—March 11
659 Wilson, T. B., and W.—Apparatus for splitting cane—March 11
939 Morton R.—Refrigerators—April 3
1218 Kirk, A. C.—Refrigerators—April 25
568 Martin, L., and Penfold, O.—Candle lamp—March 1
631 Palmer, W.—Manufacture of candles—March 8
938 Helme, W.—Fire lighters—April 3
1282 Fielden, H.—Lamps and signals for lighthouses &c.—April 30
932 Moore, T.—Fishing tackle—April 2
579 Bedborough, A.—Pillar letter boxes and bags—March 3
588 Schafer, P., and T.—Portmanteaus &c—March 4
2161 White, H.—Shirt collars—July 30
1107 Newton, W. E.—Setting artificial teeth (com.)—April 16
662 Davis, G.—Attaching artificial teeth (com.)—March 11
1757 Longbottom, A.—Artificial stone—June 13
656 Keraubret, O., and J.—Ornaments for buildings—March 11
860 Birkbeck, H.—Imitation mosaics (com.)—March 27
907 Gontard, C. P.—Watches—April 1
924 Scratton, G.—Window blinds—April 2
894 Lord, W. B.—Hame slip—March 31
891 Tyler, W.—Composition for feeding dogs, poultry, &c.—March 21
847 Telhausen, F.—Cigar tubes &c. (com.)—March 27



J. Drayton Wyatt, del^t J.R. Jobbins

ORNAMENTAL KEYBOWS IN THE INTERNATIONAL EXHIBITION, 1862.

Designed by J. Drayton Wyatt, Arch^t.

ORNAMENTAL KEYBOWS IN THE INTERNATIONAL EXHIBITION, 1862.

(*With Engravings.*)

The various designs which are illustrated in our plate complete the series commenced last month, and as the same principle of manufacture has been applied throughout, it is needless to add anything, by way of description, to what was then given. It will be remarked, however, that in the present plate the subjects are larger and more elaborate, also that the centre one is a strictly *masonic* design, in which an attempt has been made to combine several of the symbols and mottoes used among the craft in a complete and symmetrical manner.

THE PROPOSED RESTORATION OF ST. DAVID'S CATHEDRAL.

From the remote and truly secluded situation of this cathedral, it is a building which has been but seldom visited by the architectural tourist, independently of which, the dilapidated and forlorn condition into which it has from various causes been allowed to merge, offers a marked contrast to the most ill-fated of our English structures, which, however badly they may have been treated, have not been suffered to need substantial repair by reason of the imminent peril to which their walls are now exposed through the unchecked ravages of wind and weather during successive generations, as is the case at St. David's. In point of architectural interest, too, though it must undoubtedly yield to the greater pretensions of many others, there is a vast amount of curious and excellent detail, which, from this very fact of its having been left comparatively intact, is invested with a pecular interest.

Some years ago the History and Antiquities of St. David's formed the subject of an elaborate and well illustrated work, compiled by Messrs. Jones and Freeman; and this book has unquestionably assisted, if not in a great measure raised, the movement which is now in operation, with a view to the preservation and gradual restoration of this valuable architectural specimen. A report on the subject has been recently laid before the cathedral authorities by Mr. Scott, and we shall presently briefly extract from such portions as indicate the peculiar necessities of the case, and the mode in which it is recommended that they shall be met. It is perhaps desirable however that some introductory allusion should be made to the history of the cathedral itself. One of the most curious of these is, that apparently no traces remain in the existing structure of the *original* building. The earliest portion of the present cathedral dates back to about the year 1180, when Bishop de Leia appears to have commenced upon a plan exactly co-extensive with the existing building, with the exception of the chapels eastward of the choir and transepts. This period of rebuilding was one of especial importance in the history of Mediæval architecture, being the exact juncture at which the Romanesque or round-arched style was in a state of transition into the pointed-arched style now vernacularly known as Gothic; being, of all periods of our old architecture, the one which is most strongly characterised by energetic effort and rapid advance. It was just before this that the Church of St. Cross, near Winchester, had been erected, which is a most marked type of this great transition. Simultaneously with the work at St. David's, the rebuilding of the eastern portions of Canterbury Cathedral was being brought to a conclusion in a manner which establishes it as one of the great landmarks of church architecture; at the same time, also, Archbishop Roger, of York, and Bishop Pudsey, of Durham, were carrying on the same great work of art reformation in the North; while, in the South, the rebuilding of the Abbey of Glastonbury was in progress—a work which evinces a very direct relationship to that at St. David's.

The whole of the building as erected at this period was, so far as we can tell, prepared to be vaulted with stone, chiefly on the principle designated by Professor Willis as "sexpartite" vaulting; although it would not appear that any part of the vaulting was actually carried into execution. It is not known how long the work, commenced in 1180, occupied in its completion, or indeed whether it ever was completed at all. Unfortunately, in 1220, a sad catastrophe occurred to the new work, in the fall of the central tower, in which it would appear that the choir and transept suffered severe injury. The piers and arches which support the tower afford distinct evidences of the reconstruction after this catastrophe; the western arch, with its two piers, belonging to Leia's work, while the three remaining arches are the result of the reconstruction.

The choir, it may be assumed, owes its general design as now exhibited, to the reconstruction after 1220, and the same probably extended to a considerable degree to the eastern sides of the transepts. About this time, too, that extensive addition of chapels, which subsequently so much altered the eastern portion of the church, would seem to have been commenced, and the aisles of the choir were prolonged far to the eastward, and connected towards their extremities by a cross aisle, having on its eastern side arches opening into (or prepared to open into) a lady-chapel; by which arrangement a void space, open to the sky, was inclosed between this cross aisle and the east end of the choir, to avoid interference with the light of the east window. This scheme, though a peculiar one, is not an isolated example; a similar plan having been carried out at the east end of Gloucester Cathedral, as well as in the Abbey Church of Tewkesbury, and the Priory Church at Great Malvern.

Bishop Gower, who held the see from 1328 to 1347, seems to have been one of the greatest builders of his time, and he set about a general work of assimilation of the somewhat discordant elements of which his cathedral consisted. The entire aisles of the cathedral, whether of the nave, the choir, or the eastern chapels, appear to have been in a greater or less degree reconstructed and remodelled by him. Those of the nave were altered, and one, the South, entirely rebuilt, with many other decided changes of various kinds, including the erection of the rood-screen, and the introduction of a considerable number of rich and beautiful monuments into the cathedral. In the succeeding century, and the beginning of the one that followed it, a number of minor alterations were made; but the most important works were the conversion of the void space beyond the east end of the choir into an exquisite chapel, by Bishop Lloyd—though the improvement was dearly purchased at the loss of the east window—and the reconstruction of the roofs generally, including the gorgeous roof over the nave, &c.; thus giving to the church, in the main, its present form, subsequent changes belonging more to the history of its degradation than its construction. This general outline will suffice as a key to the past, and will help our references, in regard to the future, as embodied in the report to which we have alluded.

The first great case of dilapidation instanced by Mr. Scott relates to the tower, which is placed, as usual, at the intersection of the four arms of the cross, and of which we have already stated that after the fall of the first tower, in 1220, the two eastern piers, with three of the arches, were rebuilt; but the western piers, with one of the arches (subject to some increase of strength), were allowed to remain. This might have been set down from the first as a dangerous expedient, and so it has proved. The old portions which remained have been constantly crushing and giving way, and the older and newer parts have become disunited to a most marked degree, which other causes have tended to increase; so that the present condition of the tower is in the highest degree alarming, more especially since, in consequence of the fact that of its four supports two are sound, while the other two are wholly untrustworthy, an ominous crack is visible up the north and south sides. To remedy this great failure, it is proposed to construct an efficient system of shoring, such as would be capable, if necessary, of sustaining the entire load which now rests upon the damaged piers. The general course to be followed would be this:—1st. To bind together the walls of the upper stage of the tower with massive ties of iron, aided by stays of timber, so as to render it impossible for the walls to spread: then to construct incompressible foundations, upon which the shoring is to rest. 2nd. To contrive and frame the shoring necessary for the purposes just stated. The operation of reconstruction would be done very gradually, 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 on, and capable of being shifted from time to time as the work rises.

The nave has suffered materially from the sinking of the west side of the tower, and this has occasioned a westerly movement throughout the whole of the nave arcade and clerestory, throwing all the pillars out of the perpendicular, and crippling and damaging the arches and many other parts. Mr. Scott "fears that it would be useless to attempt to rectify either of these displacements, and that the utmost which can be done will be to prevent further movement, and to repair the direct injury which has been sustained by the stonework." Externally, the nave requires much repair and restoration, as well as the completion of its cleaning from whitewash. The clerestory, too, has been sadly mutilated; and, of its windows, some have been walled up, some altered from their original forms, and the parapet has been entirely renewed in the most uncouth manner. The north wall is buttressed by huge and unsightly masses of stonework. Some of these would appear to be connected with the ancient cloister of the college, and the question of their treatment must, for this reason, depend upon circumstances. The west end has been entirely rebuilt, and that with very little regard to its original design. This old design can in some measure be recovered by the help of prints, &c., and Mr. Scott therefore proposes to reproduce it so far as it is possible, but retaining, with some modification as to their forms, some of the present constructive features. Passing by some minor facts alluded to in the report, we read concerning the choir, that its "interior stonework is not in very bad condition," though "the arcades are at present walled up, in consequence of the unroofing of the aisles. . . . . The south aisle of the choir is partly a ruin, and partly converted into a porch, or thrown into the modern church, which has been formed out of the south transept." This will have to be brought back to its original form, re-roofed and restored. The aisles will have to be newly floored, but the eastern arm itself has a fine old pavement of encaustic tiles, which will of course be preserved. In one of the altar-steps is a singular relic of ancient ritual usage—viz., the mortice which originally received the lectern for the Gospels and Epistles; such instances are now rarely to be found. The original east windows were in two ranges; a beautiful triplet below, and a group of windows (now lost) above; the former was walled up by Bishop Vaughan, and the latter was, in the 15th or 16th century, converted into a window of the style of that period, and this, being now quite decayed, will require renewal. There is a building, adjoining the north transept, which contains on the ground-floor the chapel of St. Thomas; and above, the chapter-house, and another still higher chamber. This building is mainly of the 14th century, and was of very excellent design, though now reduced to a miserable condition.

From an examination of the internal fittings it appears that the stone screen of the choir (the work of Bishop Gower, and in part his monument) is in a fair state of repair. The choir stalls also (the work of Bishop Tulley) are in a tolerable state of preservation; while the bishop's throne, as well as the eastern screen dividing the presbytery from the choir proper, demand extensive repairs, and the renewal of some portions. This latter screen, it may be noted, is remarkable for being unique in its position. The choir is now filled with the unseemly pews so common till lately in all our cathedrals, and these will necessarily be replaced by entirely new and more suitable fittings.

There are some questions open to consideration as to matters involving a certain degree of departure from the forms in which sundry portions of the building have come down to us. Thus, all the parts of the building have been either vaulted with stone or prepared for such vaulting. In a great majority of instances this has never been carried into execution; and the question arises whether, in a restoration of the building it would be right and expedient to carry out this intention of the builders, or, if the walls are insufficient for its support, whether the intended forms may not be carried out in oak. Against either of these proposals there are, as regards the choir, objections; in the one case insuperable, and in the other of considerable force. As regards the nave, the objection is twofold: first, the walls are not in a condition to support stone vaulting; and, secondly, the existing roof is so beautiful as to render the idea of any change absurd. The present choir roof, though not particularly firm, possesses some beauty and historical interest, besides being susceptible of reparation, while the addition of stone vaulting would be a rash experiment, and there is also an uncertainty as to the design of the once-intended vaulting. Such objections do not, however, occur as regards the transepts, where the roofs are worthless, and the walls will not carry stone vaulting, so that there appears no objection to completing the original design in oak, since its indications are clear. In one instance in the cathedral, the system of placing timber vaulting upon stone springers has been carried out by the *old*, though not the *original* builders, and that is in the vaulting within the tower.

The estimate as to the cost of the works enumerated in the report is from £27,500 to £30,000, according to the mode of carrying out certain parts, which have been left open to consideration.

MODERN ARTILLERY.

Few departments, if any, in the International Exhibition of 1862 show so marked and rapid an advance in inventive genius and constructive skill as those devoted to the appliances of war, not only as seen in the plated vessels, deemed until recently practically invulnerable, but more especially in the terrible ordnance and ammunition with which the artillerists have taken up the challenge of the armourers.

The once famous Lancaster gun, with its oval spiral bore, is exhibited, it may almost be said, as an obsolete engine, having an interest chiefly historical; and showing the first general application of rifling to large guns in the British service. The substitution of bolts for round shot, the successful use of percussion shells, and the singular advantages found in special modes of constructing the front and rear of a projectile, all take their rise from the adoption of rifled ordnance.

Captain Blakeley's gun is conspicuous for its peculiar form of rifling. It is also deserving of notice as an early application of the system of building large guns by means of hoops placed over an inner tube. It has been asserted that the idea originated in America; but be this as it may, to Captain Blakeley appears due the prominent advocacy and working out in this country of a principle which, with certain modifications has been adopted generally in the manufacture of our heavy ordnance. We must however except the ponderous Mersey gun of 10-inch calibre, which, with a charge of 20 lbs. of powder and a 136 lb. round shot, shattered, at 210 yards range, a 4½-inch iron plate, the fragments of which are displayed beside it. This gun, forged out of the solid, is itself eclipsed by the monstrous piece of ordnance from the same makers, of which such successful trial was made at Shoeburyness in September.

Attention however, both within and without the Exhibition, mainly centres on two groups of guns and missiles; those exhibited by the War Department, and those of the Manchester Ordnance Company,—the Armstrong and the Whitworth.

The principle adopted in the Armstrong ordnance and projectiles is sufficiently well known. The bore is cylindrical, and rifled with spiral grooves. The projectile has a coating of lead, and this metal being driven into the grooves on the discharge of the piece, the required spin is thus given. In speaking of the projectile it is impossible to omit to mention the concussion and time fuses, with which the shells made at the Royal Laboratory at Woolwich are fitted. These shells and fuses are shown in section under a sheet of plate glass, with explanatory diagrams. The principle is very ingenious and beautiful. The rupture of a piece of metal within the fuse is occasioned by the shock of firing. This liberates the detonating mechanism, or fires the time fuse, as the case may be. In the former case, the shell bursts on striking an object; in the latter case, the explosion takes place any required number of seconds after firing, as regulated by the aid of a graduated scale on the fuse. It is, perhaps, scarcely necessary to add that these fuses are applicable to shell fired from any description of rifled gun, and that their merits have therefore no essential connection with what is known as the "Armstrong system." The guns turned out from the Royal Factory at Woolwich are admirable specimens of workmanship; and as not only the undoubted abilities of the inventor, but all the scientific and material resources at the disposal of the Government, have been lavished on the improvement of the arm, it is reasonable to conclude that it is as efficient in all respects as ordnance made on this peculiar system ever will be. We must also suppose that the authorities of the War Office felt pretty well satisfied before ordering upwards of 4,000 guns to be made on the Armstrong principle.

But however pleasant it may be to take the most favourable view of a weapon in the construction of which such vast sums have been expended, and for which a special drill has been introduced into the service, the facts can no longer be disguised. The Armstrong gun and projectile have serious inherent imperfections; have proved unequal to the contest with the armour plates, if success is to be measured by practically useful results; and in precision, range, and penetration have on every fair trial shown a marked inferiority to the Whitworth gun and projectile.

Such difficulties have been found to oppose the successful construction and satisfactory working of breech-loaders after Sir William Armstrong's pattern, that after all the care devoted to it the naval gun must be regarded as a failure. In military service the liability of the lead coating to strip, and thus endanger troops over whose heads it may be necessary to fire, is a serious drawback, which seems to be scarcely compensated by the circumstance that the scattering of the lead also increases the execution among the enemy. This evil is found to prevail chiefly when the lead coating is soldered on after Sir W. Armstrong's method. When attached by undercutting, on Mr. Bashley Britten's plan, the danger of stripping is considered to be much abated.

In the contest with the Armour plates, the Armstrong gun cannot be considered to have come off with triumph. Within the limits of weight ordinarily assigned to ship's guns, no Armstrong ordnance has effected anything against the "Warrior target," even with solid projectiles. So completely, indeed, had the plates foiled the rifled gun, that the opinion was expressed but a few months since by a high authority, that the massively plated sides of such vessels as the Warrior and Black Prince could, at a short range, be more effectively assailed by round shot from enormous smooth-bore guns than by bolts from rifled ordnance. For any given calibre and charge of powder the round shot, having less weight than the bolt, is more readily set in motion, and therefore issues from the muzzle of the gun with greater initial velocity. This velocity indeed is rapidly reduced, while that of the bolt is but slowly retarded, so that the bolt retains great penetrating power at ranges at which the force of the round shot is entirely spent. But at 200 yards the round shot strikes the target with about the same momentum as the bolt, and with greater velocity. It was therefore thought that at such short ranges the most destructive missile would be the spherical shot. In this hasty inference no account seems to have been taken of the form and material of the front of the projectile; the tendency of spherical shot to glance from a surface struck obliquely; or the comparative fitness of round cast-iron and sharp-edged steel for perforating iron-plate. The idea of the moment was, that under certain circumstances it would be necessary to abandon the improvements of science, and fall back upon the hazardous and costly expedient of monstrous smooth-bore guns, with tremendous charges of powder. That such artillery would readily destroy any plated vessel that could be induced to anchor within a furlong of the battery, there can be no question; and until the experiments at Shoeburyness in September last, it seems to have been presumed that equally destructive results could not be obtained with rifled ordnance of moderate calibre. To shell, vessels protected with even 2½-inch plates were considered invulnerable, unless under a plunging or vertical fire directed on their decks. The Armstrong shells having always failed to penetrate the plated targets, this point at least was regarded as settled.

In the Autumn of lost year a 12 ton smooth-bore gun, with a charge of 50 lb. of powder, and a 156 lb. round shot was used against the "Warrior target" at 200 yards, and did considerable damage. But the effect of these heavy charges upon the gun itself were very discouraging, and augured but ill for the 20 ton gun then projected, as to the performances of which the most sanguine predictions had been hazarded. This 12 ton gun had been built up with external hoops of coiled wrought iron, after the method already alluded to, and practised for years by Mr. Whitworth and other artillerists; although by a curious misnomer it has sometimes been spoken of as the "Armstrong coil system."

In the Whitworth gun, rifle grooves and the consequent occasion for a lead-coated projectile are avoided. The bore is hexagonal, with the requisite twist, and the shot or bolt is made truly to fit the bore. The form and proportions of the projectile, and the rate of spin best suited to each calibre, have been arrived at by means of careful and exhaustive experiment. This rate of spin is in every case rapid as compared with those adopted in the Armstrong gun. The projectile as well as the gun being finished in a lathe, the axis of the former always accurately corresponds with that of the latter, so as to secure perfect smoothness and steadiness of motion as the bolt issues from the gun. Instead of the projectile being retarded by the clinging of a lead coating in grooves, the friction is reduced to a minimum; and in the breech-loading 12-pounder the bolt, close though the fit is, can be trundled from the breech right out at the muzzle by a thrust with a stick. This mechanical exactness of finish sufficiently accounts for a greater initial velocity in the Whitworth as compared with the Armstrong projectile. The same cause, coupled with the greater rapidity of spin, fully explains the altogether unrivalled precision of shooting of the Whitworth gun; and it is doubtless mainly to these properties that the remarkable advantage in range which it has been proved to possess over the Armstrong gun is attributable. But the flight of the Whitworth bolt is also assisted by the manner in which it is tapered towards its rear, for much the same reason that the sailing of a vessel is improved by reducing the hull towards the stern.

But length of range and precision are not the sole qualities to seek in artillery. The destructive power of the projectile itself is a most material point. In this respect the solid shot of Mr. Whitworth have now for a long time held an uncontested superiority. His flat-headed hardened bolts are found, after passing through several feet of water, to retain sufficient penetration to go through the unprotected bottom of a ship. Above water they riddle the thickest iron-plates hitherto employed for ship armour, and this even when they strike obliquely. The 5½-inch calibre bolt that pierced the plated side of the Trusty, in May 1860, is exhibited among other projectiles, and really looks not much the worse for the encounter.

But the performances at Sheoeburyness in September last throw all that had been previously effected into the shade. A Whitworth flat steel-fronted shell, weighing (with its bursting charge of 2½ lb. powder) 70 lb., was fired with only 12 lb. of powder at a target representing the side of a plated vessel. The outer plate was of 4-inch iron, behind which was a strong oak box, plated at the back with 2-inch iron. The range was 200 yards. The shell went through the 4-inch plate, and exploded behind it, shattering the box to pieces. The production of a shell of such moderate calibre, capable of piercing the thickest armour-plate, and exploding by detonation *after penetration*, must be regarded as the greatest triumph yet achieved by any artillerist. At 600 yards the 130 lb. Whitworth shell pierced the target and backing, exploded inside the framework with destructive effect, setting the supports on fire. The charge was 25 lb. of powder. When it is remembered that these shell will pierce water; that they will not glance from iron even at very oblique angles; that they retain great power of penetration at ranges of upwards of 1000 yards, and that they require but light charges of powder (compared with the monstrous and inefficient guns hitherto advocated), it will be seen that the importance of the invention can hardly be overrated.

We are not of those who would argue that because much has been accomplished, more should be required. It is surely enough that the Whitworth ordnance has effected with moderate calibres what the most formidable guns in the service, though overstrained, have failed to achieve; and shelled a target previously deemed invulnerable to hollow projectiles. However deeply committed the country may be to further expenditure on the Armstrong gun, it would be a disastrous economy to intrust our defences any longer to a second-rate and baffled weapon, leaving its terrible rival to become the prize of some watchful and emulous neighbour.

INTERNATIONAL EXHIBITION, 1862.—JURY REPORT.
CLASS VIII.—MACHINERY IN GENERAL.

Subdivision I.—Prime Movers,

SECTION I.—BOILERS, FURNACES, &c.

With a few exceptions, the actual boilers exhibited (as distinguished from drawings and models) belong to traction engines, or to portable or semi-portable steam-engines; and those boilers are marked on the whole by efforts made with greater or less success to economize space, and to facilitate cleansing and repairs by means of improved arrangements of the heating surface, or otherwise. The following examples may be cited:—Bray's traction-engine (United Kingdom—1805), Ransomes and Sims' portable steam-engine (United Kingdom—1961), J. Taylor and Co.'s traction-engine (United Kingdom—2004), Tuxford and Son's engines (United Kingdom—2195), J. F. Cail and Co.'s engine (France—1144), Farcot and Son's condensing steam-engine (France—1152), Hediard's boiler (France—1131), Laurens and Thomas' boiler (France—1151), Zambeaux's portable boiler (France—1137), Albaret and Co.'s portable steam-engine (France—1207), Henschel and Son's boiler-tubes (Hesse-Cassel—434).

Many of the boilers are provided with the means of superheating steam, either by passing it through tubes in the smoke-box, or by enclosing the steam-chest in a smoke-box or flue.

In the engine exhibited by Mr. Wenham (United Kingdom—2019), the steam, after having performed part of its work in a smaller or high-pressure cylinder, is supplied with heat while in the act of expanding during its passage from that cylinder to the larger or low-pressure cylinder. This application of heat to steam is at once sound in principle and successful in practice.

The most new and unusual in form of the boilers exhibited is that by Mr. Harrison (United Kingdom—1877), which is an American invention. It consists of a number of hollow cast-iron globes, all equal and similar, connected with each other through cylindrical necks or short tubes, the whole being bound together, in a rectangular arrangement, with wrought-iron bolts. A boiler of any required size can at once be made by building and bolting together the proper number of globes and necks. The water and steam are inside, the fire outside.

M. Grimaldi (Italy—1001) exhibits a cylindrical boiler, containing either flues or tubes for the flame, and turning slowly about a horizontal axis, so as to bring every part of the surface in contact with the liquid water and with the steam alternately, in order to increase the efficiency of the surface in raising steam, and prevent over-heating and corrosion.

The boilers shown by Mr. H. Cater (United Kingdom—1814), (presenting a peculiar arrangement of tubes), although they were set up too late to be the subject of an award, may here be mentioned, as being at work in the boiler-yard of the western annexe, with satisfactory results.

The following articles fall especially under the head of furnaces and their appendages:—

An apparatus for promoting perfect combustion and preventing smoke, by using very small jets of steam to blow streams of air into the furnace, is exhibited by Mr. D. K. Clarke (United Kingdom—1822). Its practical success has been well-established. It is at work in the boiler-yard.

Siegburg's improved grate (Prussia—1320), and Schulz, Knaudt, and Co.'s fire-box (Prussia—1318).

In M. Hubazy's portable engine (Austria—569) the furnace is adapted for the burning of straw, a most useful contrivance where other fuel is scarce.

The apparatus of M. Steenstrup (Norway—213) is intended for the prevention of rust in boilers. The exhibitor takes advantage of the chemical affinity of chloride of calcium for water, so as to dry completely the rust already formed, which consequently falls to powder and detaches itself from the boiler.

The "Hydratmo-Purificateur," or water-softening apparatus, exhibited by M. Durenne (France—1163), purifies water from salts of lime by the aid of its property of depositing such salts when raised to a high temperature. A rectangular case contains, one above another, a series of horizontal trays or platforms, heated by means of the waste steam of the engine, which enters at the bottom of the case, and slowly ascends. The water to be purified is introduced at the top, and trickles from tray to tray, becoming heated by the condensation of the steam, and depositing parts of its salts of lime on each tray, until it is discharged at the bottom of the apparatus, completely softened, and at a high temperature; so that the heat of the steam employed is not wasted. By opening the front of the case the trays are taken out, from time to time, and cleansed. The practical working of this apparatus is most efficient.

Mr. Siemens' regenerative furnace (United Kingdom—1987) is well known through descriptions which have appeared in the Transactions of the Institution of Mechanical Engineers, and the Reports of the British Association for the Advancement of Science.

Section II.—Land Steam-Engines.

Of the land steam-engines, some are fixed, or semi-fixed, some portable, and some are road locomotives, or "traction-engines."

Amongst the fixed and semi-fixed engines, although a few good examples of beam-engines and vertical-engines are to be found, the horizontal construction generally prevails; probably owing to the ease and convenience with which all parts are accessible. In some cases, as in the machinery of Messrs. Manlove, Alliott, and Co. (United Kingdom—1924) and Messrs. Whitmore and Son (United Kingdom—2023), a horizontal engine is used to drive a vertical shaft directly, which is a good arrangement for corn-mills and centrifugal machines.

Many of the steam-engines are employed to drive machinery belonging properly to other classes; and in such cases it is the steam-engine alone that falls under the consideration of the Jury of Class VIII.

In other cases the steam-engine drives some piece of mechanism, such as a hoist, a crane, a pump, a blowing-machine, &c., belonging to a different subdivision of Class VIII., and in such cases any explanation which may be required of the machinery so driven will be found in the proper subdivision of this report.

With respect to the steam-engines in the present Exhibition, as compared with those of 1851, it may be observed that they show an increased employment of high-pressure, great expansion and superheating, an increased use of surface condensation (generally effected by means of a great number of small horizontal tubes), a tendency towards simplicity in the framing and main moving parts, a general abandonment of devices that are more curious than useful, and a higher perfection of workmanship and finish; all of which improvements combine to produce greater economy of fuel, power, and repairs.

Setting aside merit of a kind that does not require special explanation, such as simplicity, good workmanship, practical success, &c., the following remarks may be made as to those engines which present new and unusual features:—

Manlove, Alliott, and Co. (United Kingdom—1924) exhibit a pair of horizontal engines for working centrifugal machines, which are placed with their cylinders bottom to bottom on one frame; so that the tendency to strain the frame, which arises from the inertia of the moving parts, may be balanced by making the pistons move in opposite directions.

The double-cylinder expansive engine, in various modifications, is numerously represented. In the engine of Mr. Wenham (United Kingdom—2019) the steam is superheated in its passage from the small to the large cylinder (See Section I.) In Messrs. May and Co.'s engine (United Kingdom—1927) the dead-points are done away with by placing the cranks of the large and small cylinders at right angles to each other; the steam being exhausted from the small cylinder into a wrought-iron reservoir, jacketed with high-pressure steam from the boiler.

In one of the engines exhibited by Carrett, Marshall, and Co. (United Kingdom—1813) the dead-point is passed (though its effect is not wholly done away with) by placing the cranks of the small and large cylinders not directly opposite each other, but at a very obtuse angle. (This arrangement has also been employed in Craddock's engine.) The opposite, or nearly opposite motion of the large and small pistons is well known to be favourable to balance of inertia, and also to a good distribution of the steam, by enabling it to pass in the most direct manner from either end of the small cylinder into the adjoining end of the large cylinder. In the drawing of M. Delandtsheer's engine (Belgium—265), the cranks for the large and small cylinders are exactly opposite in direction, and the dead-points are done away with by combining a pair of engines with cranks at right angles to each other in the usual way.

The end-to-end double-cylinder arrangement is exemplified in the engine of M. Scribe (Belgium—278), and in a model in the United Kingdom division, which is not numbered nor mentioned in the catalogue.*

For producing variable expansion, the system most frequently employed is the ordinary link motion; and next in order as to frequency, the link motion with a separate expansion-valve driven by a third eccentric. In Messrs. Ferrabee's engine (United Kingdom—1852) the expansion-valve is driven by a straight-link motion of its own, worked by means of two eccentrics on a shaft, which is made to turn at double the speed of the engine-shaft by means of a pair of toothed-wheels.

In many cases also, and especially in the foreign engines, the variable expansion is produced by means of the compound slide, regulated in some cases by hand, and in others by the governor; and amongst the latter class may be specified the engines of the Magdeburg-Hamburg Steam Navigation Company (Prussia—1312), the Sprottau Iron Works (Prussia—1321), Farcot and Co. (France—1152), C. T. Porter (United States—29). In Messrs. Farcot's engine, the action of the governor upon the variable expansion is very exact and perfect, owing mainly to the construction of the governor, in which, by a peculiar mode of suspension and counterpoise, there is obtained a sufficiently accurate practical approximation to the theoretic accuracy of the parabolic governor, but without its complexity and liability to derangement. (For details, see the report of M. Tresca to the Société d'Encouragement pour l'Industrie Nationale, published in their Bulletin for 1861.) In the governor of Mr. Porter's engine a similar result is obtained by using light balls and a high speed with a heavy vertical load to balance the great centrifugal force. The figure and movement of the side-valve in this engine are of a peculiar kind, suited to open and close rapidly with a comparatively small travel.

The pumping-engines of Mr. Steele (United States—38) and

* Exhibited by Mr. E. E. Allen.

of Mr. Worthington (United States—28) are remarkable as being engines of rapid stroke without fly-wheels. In the former there is a single cylinder, whose slide-valve is moved when the piston is at its dead-points, by an apparatus which is in fact equivalent to a small auxiliary steam-cylinder. In the latter there are a pair of equal cylinders, working at half a stroke behind each other, the slide-valve of each cylinder being shifted by the piston of the other.

In M. Scheutz's rotatory steam-engine (Sweden—273) the advantages of simplicity and compactness, which the rotatory engine is admitted to possess, are combined with the power of working expansively in a very perfect manner; while at the same time the disadvantages of engines of that class are to a great extent overcome; for the pressures at the shaft are balanced, the sliding vanes or pistons are relieved of pressare while they are passing the stops; and the steam-tight bearings, when worn, can all be tightened at one operation, in consequence of the conical form of the casing.

The North Moor Iron Foundry (United Kingdom—1948) exhibit a steam-turbine which has been found to work efficiently, and which is convenient for driving fans, the fan and turbine being fixed on the same shaft. M. Bourdon (France—1156) has a turbine driven by a current of water, which is itself driven by a steam jet.

Of the single-acting Cornish engine one example only appears, represented by the model of Messrs. Harvey and Co. (United Kingdom—1880).

The traction engines to which awards have been made by this Jury are those exhibited by Bray's Traction Engine Company (United Kingdom—1805), J. Taylor and Co. (United Kingdom—2004), Tuxford and Sons (United Kingdom—2195). It is well known that, although steam-carriages for common roads are of old date, traction-engines, or road-locomotives, are of recent introduction. All the three engines above-mentioned work well in practice.

Mr. Bray's is capable of acting as a portable steam-engine, a steam-crane, or a fire-engine, at will; the rim of each of its two driving-wheels is furnished with blades or spades, which can be pushed out or drawn in, according to the steepness of the road and state of its surface and the load to be drawn, so as to give just the required hold and no more. Messrs. Taylor's is marked by the merit of great simplicity. It has two driving-wheels, six feet in diameter, without blades. Messrs. Tuxford's has a single roller instead of driving-wheels; its engine is well protected against injury by dirt, and the engine-driver and steersman are together.*

Section III.—Marine Steam-engines.

The general remarks as to progress since 1851, which have been made in Section II., as to land engines, are applicable to marine engines also. The improvements in workmanship are even more striking.

A very large number of marine engines exhibited possess merit of a high order, as this Jury have testified by their awards. They have also indicated briefly in the reasons given for the awards, the particular kind of merit by which each engine is most distinguished.

Of the marine steam-engines, by far the greater number are horizontal screw engines; the reason probably being that such is the arrangement best suited for ships of war, and that the engines of ships of war can more easily be spared for purposes of exhibition than those of merchant ships.

The horizontal engines are numbered as follows:—United Kingdom, 1891, 1902, 1926, 1955, 1964, 2632 (model), 1897, 1962 (model); France, 1132, 1195; Sweden, 274. In this form of engine the space is more limited than in any other, and difficulties are thus caused which the skill of the engineer is exerted to overcome in various ways. Hence arise great varieties in the details of the designs of horizontal engines. For example, the engines of Humphrys and Tennant (United Kingdom—1891) are marked by simplicity and accesibility; the action is direct, the stroke and connecting-rod short, and the cylinder of large diameter. In other examples a longer stroke and connecting-rod are obtained in various ways: in those of Maudslay, Sons, and Field (United Kingdom—1926), Ravenhill, Salkeld, and Co. (United Kingdom—1962), Nouvelle Société des Forges et Chantiers (France 1195), A. W. Frestadius (Sweden—274), and others, by double piston-rods; in that of E. Nillus (France—1132), by double piston-rods, connected with trunks in the air-pump, a construction which is also used in Britain; in that of G. Rennie and Sons (United Kingdom—1964), by trunks in the cylinders: in that of J. Penn and Sons (United Kingdom—1955) by trunks passing completely through the cylinders, &c.

A peculiar arrangement of a duplex horizontal trunk-engine, in which the inside of the trunk is made available as cylinder-space by the aid of a fixed piston, is represented by a model in the British division of the Western Annexe, which is not mentioned in the Catalogue. (Exhibited by Mr. E. E. Allen.) The engine of M. Frestadius (Sweden—274) has concentric double cylinders.

Amongst oblique screw engines may be mentioned those shown in the drawings of Armengaud (France—1181), and of Randolph, Eider, and Co. (United Kingdom—1960), the latter of which arrived to late to be adjudicated upon.

As examples of the vertical inverted-cylinder screw-engine, so well suited for merchant ships, the engines of Morrison and Co. (United Kingdom—1936), Tod and M'Gregor (United Kingdom—2009), and Richardson and Sons (United Kingdom—1965) may be noticed, as well as a model exhibited by Humphrys and Tennant (United Kingdom—1891), which will be again mentioned further on. The first three of these have surface condensers, the first two with horizontal, and the third with vertical tubes. The first two are very compact and convenient in their arrangement; the third may be regarded either as a working model or a pair of small engines. The steam, before entering the surface condenser, gives out much of its heat to the feed-water, which traverses a set of tubes surrounded by the exhaust steam.

The engines of Maudslay and Co. are accompanied by a very complete and well-executed set of moving models of marine engines, of a great variety of kinds, both paddle and screw.

The engines of Humphrys and Tennant are accompanied by moving models of themselves, and also of a pair of vertical screw engines, noted for their efficiency and economy in practice, being those of the Mooltan, these are double-cylindered expansive engines, each small cylinder being directly on the top of its large cylinder.

Paddle-engines are represented by working models exhibited by Maudslay, Sons, and Field (United Kingdom—1926); J. Penn and Sons (United Kingdom—1955) and Ravenhill, Salkeld, and Co. (United Kingdom—1962); and by the drawing of Messrs. R. Napier and Sons (United Kingdom—1939). The model of Messrs. Ravenhill has feathering paddles and oblique cylinders; while that of Messrs. Penn has oscillating cylinders. The only pair of full-sized paddle engines are exhibited by Messrs. Escher, Wyss, and Co. (Switzerland—104).

The valve gear and expansion gear of the marine engines are very various. For reversing, the link motion is used in almost every case: an exception is found in the engine of the Mediterranean Company above referred to (France—1195), where the engine is reversed by a piece of wheelwork, which when acted upon by hand causes each eccentric to reverse its position on the shaft that caries it. In Humphrys and Tennant's engines an improvement in the construction of the link has been carried out, by making it of a single bar embraced by a slider, instead of a pair of bars with a slider between them.

In some examples, the link motion is used for expansive working; but in most, the cut-off is effected by means of a separate expansion valve, the mechanism for working which presents a great variety of designs.

Amongst various peculiarities of arrangement, may be noted that of the pair of horizontal screw engines of Messrs. Rennie, in which the cylinders are at opposite sides of the shaft; each cylinder is directly opposite the air-pump of the other; and each cylinder exhausts directly into the condenser by its side, so that exhaust-pipes bridging over the shaft are dispensed with.

The horizontal trunk marine screw-engines of Messrs Penn, being exhibited by a member of this Jury, could not be made the subject of an award. They are accompanied by a model

* Mr. Yarrow's steam-carriage (United Kingdom—2033) was included in Class VIII. of the Catalogue, although its place would have more properly been in Class V. (see Jury Directory, page 63). The Jury of Class VIII. examined it, and formed a very favourable opinion of its merit, so far as that could be ascertained by mere inspection. They were at first desirous of having its performance practically tested on some road near the Exhibition; but they were induced to desist from considering it further by the belief that it was about to be transferred to the class to which it properly belonged. Unfortunately that belief was erroneous; and the steam-carriage in qustion has not been the subject of any award.

already referred to, and by separate parts of engines, showing great perfection of material and workmanship.

Section IV.—Windmills.

The windwill of Wentworth and Jarvis (United States—54) is chiefly remarkable for its regulator, which consists of a pair of slightly diverging vanes, forming a sort of tail behind the cap of the windmill, and so connected with the sails, that when the vanes, by the increased impulse of the wind, are pressed closer together, the sails are turned into a position that exposes less surface to the wind.

Section V.—Water-wheels and Turbines.

The conditions to be fulfilled in order that the efficiency of a turbine, or water-wheel of any other kind, may be the greatest possible, are that the water shall begin to act on the wheel without shock, and shall leave it with no more velocity than is necessary in order to prevent the wheel from being choked with back water. All the turbines to which honours have been awarded by this Jury are capable of fulfilling those conditions when properly managed.

Turbines have been classed according to the general direction of the flow by which the water is carried through the wheel, independently of the whirling motion which is first impressed on the water by the guide blades, and afterwards taken away during the action of the water on the wheel. According to this mode of classification those of the North Moor Foundry Company (Schiele's) (United Kingdom—1948) and of Fontaine & Brault (France—1173) are "parallel-flow" turbines, because the general flow of the water is parallel to the axis; and that of Williamson Brothers (Thomson's) (United Kingdon—2026), is an "inward-flow" turbine, because the general flow is towards the axis. In order that the conditions of greatest efficiency may be fulfilled with different loads, the mode of varying the quantity of water supplied ought to be such as to change as little as possible the speed of the whirling component of its motion. This is effected in parallel-flow turbines by supplying the water through a ring of orifices, a greater or less number of which are completely closed when the supply is to be varied, so that all the orifices which are open are fully open. In the inward-flow turbine or "vortex-wheel," the same object is obtained by varying the obliquity of the guide-blades.

The drawing of M. Sagebien (France—1154) represents a water-wheel which on theoretical grounds may be considered advantageous for low falls; but the Jury had not, during their proceedings, sufficient data to enable them to make an award upon it.

Section VI.—Water-pressure Engines.

The water-pressure engines of Sir W. G. Armstrong and Co. (United Kingdom—1785) are capable of working and standing still at intervals without waste of power or of water. This (in the absence of a reservoir) is effected by the aid of the "accumulator," being a cylinder like that of a hydraulic press, having a plunger loaded according to the pressure to be maintained, and being large enough to contain the store of water which collects when the machinery is at rest, and to supply the surplus of water required when the machinery is moving. One of the engines consists chiefly of a cylinder and piston of long stroke for working a hydraulic crane through pulleys and chain-tackle; another is an engine for producing rotatory motion at high speeds, with three oscillating cylinders, having plungers which act upon three cranks, making angles of 120° with each other. This engine is characterised by the use of "relief clacks;" those are valves which upon the occurrence of any tendency to excessive increase or diminution of pressure in the cylinder, permit water to flow back from the cylinder into the supply pipe, or from the discharge-pipe into the cylinder, as the case may be, and thus prevent shocks without wasting water.

Carrett, Marshall, and Co. (United Kingdom—1813) exhibit a double-acting water-pressure engine specially adapted to the blowing of organs, in which the piston moves with a uniform speed, and there is no fly-wheel.

The water-wheel exhibited by Mr. E. O. Richard (Canada—119) is really a kind of rotatory water-pressure engine.

Section VII.—Vacuum-power Engine.

The Jury could find no engines to which the above description seemed to be applicable.

Section VIII.—Electro-Magnetic Motive Power Engines.

Some engines of this kind were exhibited, in which much ingenuity was displayed; but inasmuch as the Jury had no opportunity of ascertaining the convenience and efficiency of those machines while working, either by inspection or from the information of others, they did not conceive themselves warranted in making any award upon them. It is well known that certain electro-magnetic engines are at present in extensive practical use for driving small machinery in which the cost of motive power is unimportant; but no specimen of those engines was exhibited. The electro-magnetic engine of D. McCallum (United Kingdom—1916) was carefully searched for, but not found.

Section IX.—Miscellaneous Prime Movers.

The gas-engines of C. W. Siemens (United Kingdom—1987), and Lenoir and Co. (France—1188) are driven by the combustion of a mixture of coal-gas and air so proportioned as not to be dangerously explosive; the mixture is fired at each stroke by an electric spark. From the report of M. Tresca on Lenoir's engine, it appears that this engine is not economical of fuel as compared with a steam-engine, but that it is very convenient and useful for driving machinery in situations where a steam-engine cannot be employed. Siemen's engine is provided with a regenerator for saving a great part of the heat which would otherwise be discharged with the waste gases; and there are theoretical grounds for expecting it to be economical; but precise experimental and practical data as to its economy and efficiency do not yet exist.

The engine of E. B. Neill (United Kingdom—1943), and an engine of the United States without a number, are both hot-air engines of a kind invented by Captain Ericsson. Those exhibited by C. H. Dennison (United States—82), and that of Schwarzkopf (Prussia—1319), are also hot-air engines. No advantage in point of economy over the steam-engine is claimed for any of these, their proper use being, like that of the electro-magnetic engine and the gas-engine, to furnish a convenient motive power for small machines where a steam-engine cannot be employed. As the working of these engines within the Exhibition building would have been inconsistent with the regulation which prohibits the lighting of fires in it, the Jury, in order to satisfy themselves that the engines worked in a smooth, steady, and manageable way, obtained from Her Majesty's Commissioners permission for the exhibitors to remove them for a time from the building, and set them to work outside. The results were satisfactory in the case of the two American engines; but the Prussian engine was unfortunately prevented, by accidental circumstances, from being set to work until after the proceedings of the Jury were closed, so that they could not make any award upon it. It was afterwards, however, set to work in the boiler-yard; when it moved smoothly and steadily, and was easily started and stopped. Both the American engines take in at each stroke a fresh supply of air, which is afterwards discharged; Schwarzkopf's engine retains the same air permanently, and transfers it back and forward between the hot and cold end of a receiver alternately.

W. J. Macquorn Rankine, *Reporter.*

Subdivision II.—Separate Parts of Machines, Specimens of Workmanship, Miscellaneous Pieces of Mechanism.

Section I.—Heavy Castings or Forgings in the rough; Castings or Forgings, plain, intricate, or beatiful, in the rough.

As compared with articles under these heads exhibited in 1851, we consider there is a decided improvement; few however are exhibited in this class as abstract specimens, but are for the most part portions of machines: there are nevertheless some excellent specimens of forgings of very large dimensions, and which owe their excellence in finish and soundness, mainly, to the facility afforded in their construction by the application of the Nasmyth and other steam hammers: some of the large forged shafts are put together in longitudinal segments, which is another reason for their soundness. A complete revolution in the manufacture of large forgings has been effected by the steam hammer. The castings of large marine engine cylinders and other parts, the crank shafts, cross heads, connecting rods, &c. in wrought-iron, as shown in the present Exhibition, are such as never were produced of equally good quality on any former occasion.

Fr. Krupp, Essen (Prussia—1308).—This exhibition includes the largest block of steel in the Exhibition; also some excellent specimens of cast-steel axle-trees, and other first-rate specimens of steel manufacture. Medal awarded for excellent workmanship and material, practical success, general excellence.

Hörder Mining and Forging Company (Prussia—1258).—Wheel-forgings, locomotive tires of puddled steel, wrought-iron telegraph poles, &c. Honourable mention, very good work.

Petrarsa Royal Works (Italy—1058.) A large wrought-iron shaft for screw propeller, very good specimen of plain forging. Honourable mention.

Under the above heads, the Jury wish to call attention to a beautifully forged and finished cross-head for a marine engine, being one of a pair for the "Agincourt," 1350 horse power, also a connecting rod of similar powers by Messrs. Maudslay, Sons, and Field. The above is not separately designated in the catalogue.

Also to a double-crank shaft for engines of 1250 horse power, by Messrs. Penn and Son, of Greenwich, excellent both as a forging and a finished piece of work; and to the casting of a cylinder, which is exhibited in the state in which it left the sand, and without having had any subsequent workmanship bestowed upon it. A most beautiful specimen of loam casting. The above are not separately designated in the catalogue.

Section II.—Specimens of Turning in Metals.

The preliminary remarks of the last section apply with equal force to the different portions of steam-engines and machinery in general, inasmuch as by the improved construction of slide lathes planing, slotting, and grooving machines, work is produced of the most superior description.

In the construction of all machines and machinery by the best makers, the great aim evidently now is, to introduce such forms as can be obtained by power tools, without the use of the hand-chisel and file, and the result is, increased elegance and simplicity combined with great economy. It is necessary to point out where these results are most striking, as the awards of the Jurors have already shown their appreciation of them.

One specimen alone of turning and finishing in glass is shown, and this is both practical and new.

J. Chedgey, Southwark (United Kingdom—1820), Glass-rollers, pumps, and pipes turned and bored.

New manufacture and good work. The only articles of the kind in the Exhibition. Here is exhibited a household mangle with glass bed and rollers. Medal awarded.

Section III.—Specimens in Filing, and finished work in Metals, such as Surfaces, Irregular Figures, etc.

Broughton Copper Company, Manchester (United Kingdom—1808), Copper and brass work valves, &c., copper rollers for calico printers, and brass tubes for locomotive engines of very superior quality and workmanship are exhibited by this firm. Medal awarded.

Eadie and Spencer, Glasgow (United Kingdom—1843), Iron tubes for boilers. Medal awarded for good workmanship.

Imperial Iron Tube Company, Birmingham (United Kingdom—1894), Metal tubes. Medal awarded for good workmanship.

Newton, Keates, and Co., Liverpool (United Kingdom—1944) Copper and brass articles for engineers. Medal awarded for good workmanship.

J. Russell and Sons, Wednesbury (United Kingdom—1975), Tubes and fittings, most excellent specimens. Medal awarded for good workmanship.

Stephenson Tube Company, Birmingham (United Kingdom—1994), Seamless metal tubes, rollers, &c. This firm have a most interesting exhibition; and claim great advantages as regards toughness of material from the combination of phosphorus in the manufacture of their metal. The Jurors speak in high terms of the whole exhibition. Medal awarded.

A. Everett and Sons, Birmingham (United Kingdom—1848.) Brass, copper, and iron articles, tubes, &c. Honourable mention)

Lloyd and Lloyd (United Kingdom—1912), Wrought-iron tubes and fittings. Honourable mention. Some excellent specimens of workmanship are here exhibited in forgings of wrought-iron junctions for gas, having a great number of outlets on the same piece.

Russell and Co., London and Manchester (United Kingdom—1974), Wrought-iron tubes, &c. Honourable mention.

Section IV.—Valves, Cocks, Pistons, Governors, Driving Bands, &c.

Most excellent articles are exhibited under these heads and by a large number of exhibitors. The valves and cocks are both good in design, and constructed of materials well suited to the purpose. Metallic pistons are now exhibited having great facility of accurate adjustment against the sides of the cylinders, so as not to cause more friction than is absolutely necessary for preventing the passage of steam, and of very simple construction, and not liable to derangement. Governors are in great variety, but in most cases they partake of the objections to the ordinary ball and pendulum governor,—viz., that they do not give a proportionate amount of steam for a varying load, with a maintenance of uniform speed; still in some cases this desideratum is obtained, and the examples are noted and described under their respective numbers. A decided improvement in driving bands is shown, both as regards materials and mode of construction, in leather, india-rubber, &c.

Valves and Cocks.

Baines and Drake, Glasgow (U.K., 1788).—Engine and boiler mountings. Honourable mention.

J. Beck, Southwark (U.K., 1796).—Valves and cocks. These include some very conveniently arranged angle-placed valves as cocks, and the work and finish are very good, Honourable mention.

E. T. Bellhouse and Co., Manchester (U.K., 1797).—Brass fittings. Honourable mention.

J. J. Silbermann, Paris (France—1162).—Air-pump valve. Honourable mention.

F. Allen, jun. (U.S., 29).—As inventor of slide-valves, valve gear, and expansive gear, exhibited by C. T. Porter. By a peculiar arrangement of levers actuating on a slide cut-off valve at the back of the ordinary steam and exhaust valve, a very simple mode of expansion is obtained with great variation. Medal awarded.

S. Leoni, St. Paul's-street, N. (U.K., 1909).—Taps, steam-cocks, bearings for machinery. These have not yet been sufficiently tested to prove their superiority, but appear to work with little friction. The substance "Adamas" consists of silicate of magnesia, calcined, moulded, and baked to any required shape, and appears to possess peculiar anti-friction properties.

Driving Bands.

North British Rubber Company, Edinburgh (U.K., 1947).—Driving-belts, &c. These are said to be very durable, and have more adhesion than leather. Medal awarded for practical utility and success.

C. A. Preller (U.K., 1959).—Untanned leather driving-belts, &c. In the leather bands made from ordinary leather, where extra strength is required, this is obtained by one or more thicknesses stitched together; which is objectionable, inasmuch as in passing over pulleys of small diameter the different layers are at different degrees of tension, and increased wear and friction are the result: this is avoided in a great measure in the driving-bands exhibited by Mr. Preller, who obtains great increased strength by his peculiar manner of preparing the leather, giving extra strength and suppleness, and thus rendering the double strap in most cases unnecessary, and, when actually required, the objection is not so great as with leather prepared in the ordinary way, on account of the thinness and suppleness of the former. Medal awarded for good workmanship and new manufacture.

Webb and Son, Stowmarket (U.K., 2017)—Leather driving-belts, buckets, hose, &c. A very creditable and useful exhibition. Medal awarded for good workmanship.

C. J. Edwards and Son, London (U.K., 1845).—Leather bands, hose, and fire-buckets. Medal awarded for good workmanship.

Hepburn and Sons, Bermondsey (U.K., 1882).—Machine belts and other articles of leather. Honourable mention.

J. Holgate and Co., Southwark (U.K., 1885).—Leather mill-bands and hose-pipes. Honourable mention.

Nobes and Hunter, Borough (U.K., 1945).—Leather bands, hose, buckets, &c. Honourable mention.

W. Pottir, Blackfriars-road (U.K., 1957).—Gut wheel-bands. Honourable mention.

M. J. Bleyenheuft, Eupen (Prussia, 1287*a*).—Leather machine-straps, buckets, hose, &c. Medal for good workmanship.

J. H. Bleyenheuft (Prussia, 1287).—Leather machine-straps, cord, hose, &c. Honourable mention.

W. Ruland, Bonn (Prussia, 1316).—Leather for machine-straps. Honourable mention.

Farcot and Sons, Port St. Owen (France, 1152).—Governors with crossed arms, arranged so as to overcome in some measure the objection to the ordinary ball-governor, by making it more accurate for varying amount of load upon the engine. Medal awarded.

A. B. Albaret and Co. (France, 1207).—This consists of a fly-wheel mounted on a movable centre, which enables it to be set at different angles with regard to the line of its own axis: when revolving, the tendency is to move to a position at right angles with its axis, and in so doing to act up the throttle-valve.

Governors.

C. T. Porter (United States—29) exhibits a governor having double-elbow arms, the tendency of which is to raise a weight vertically upon the spindle. This governor is very sensitive, and mainly owes it to rapid rotation, which its peculiar construction requires. Mr. Porter also exhibits another governor particularly applicable for marine engines; this is also a centrifugal ball-governor, but the centrifugal force of the balls is met by a spiral spring, and is thus described by the exhibitor:—The novel feature in this governor, and that which gives it its value, is the initial compression of the spring: for example the spring is compressed two inches by the nut on the spindle. The circle in which the centres of the balls revolve is ten inches in diameter, expanding to one of fifteen inches diameter. This expanding motion of the balls produces a further compression of the spring of one inch, The balls are shown in the engraving half expanded, and the spring, if released, would be two and a half inches longer than it appears. It will be observed that the expansion of the balls adds fifty per cent. to the diameter of the circle which they at first described, and also fifty per cent. to the original compression of the spring. If, therefore, the centrifugal force of these balls and the resistance of the spring are in equilibrium in any position, they will be so also in every other position, the number of revolutions per minute remaining the same. The resistance varies, by the increase or decrease in the compression, precisely as the force varies by the expansion or contraction of the circle.

M. A. Soul (United Kingdom—1992) exhibits a governor which may be thus described:—A fly-wheel having a long boss with a spiral groove cut in it is placed upon a hollow spindle with a straight groove in it; inside said spindle is another which carries a pin as a driver to the fly-wheel; if the spindle or shaft overruns the fly-wheel, the interior spindle is moved in or out as the case may be, and the movement is communicated to the throttle-valve.

Schiele's governor, exhibited by the North Moor Foundry Company (United Kingdom—1948), acts by water-pressure upon a piston, given by a centrifugal pump. This governor can be made to exert great force, so as to be capable of acting directly upon the sluice or clow of a water-wheel or other large valve; under ordinary circumstances where great sensitiveness is required, an elastic diaphragm may be used instead of a piston.

J. Hick, *Reporter.*

(To be continued.)

THE EXAMINATIONS OF THE INSTITUTE OF BRITISH ARCHITECTS.

The last session of the Institute of British Architects was signalised by the adoption of more than one measure likely to produce permanent and important effects on the architectural profession. The immediate good results of the establishment of a recognised scale of charges, and of rules of professional practice, are likely to be considerable, for it is a matter of personal interest to every practising architect to know how much is fairly to be expected of him, and how much he is entitled to charge in accordance with the best opinions and most received customs.

The endeavour to regulate professional practice in these or in similar respects is peculiarly the duty of such a society as the Institute, and will be recognised by all as a worthy exercise of its functions. Yet the regulation of current transactions, though likely to be more valued by practical men than that diffusion of information on detached subjects by means of papers and discussions to which the proceedings of the institute have at some periods been confined, is not equal in real importance to such measures as will tend to alter and improve the character and tone of feeling and action of the entire profession. To diffuse information is something, to direct and control professional customs is something; but so to raise the whole standard of professional attainments, as to procure that architects as a body shall be better informed, more accomplished, and consequently more respected and increasingly influential, is to fulfil the highest office possible for a public society, and to confer the greatest benefit possible upon the constituents.

Viewed in this light the institution of the annual Voluntary Architectural Examinations, the first of which is announced as to be held in January next, is a step in advance of any thing yet attempted since the establishment of the Institute, at least as far as the scope and intention of the measure are concerned, and should the examinations answer the intentions of their promoters we have little doubt of their being recognised as instrumental in the inauguration of something like a new order of things.

Hitherto no systematic plan of education for an architect has existed, and no influential indication has even been given of the preliminary education which it is desirable that a youth should bring to the study of his profession, the books with which he should be familiar, or the amount of attainment which is essential to constitute him a respectably educated architect, or the further degree to which it is necessary he should pursue his studies before he can be ranked as accomplished.

Much of all this must always be left, as all has hitherto been left, to individual discrimination and judgment; but it is not on this account necessary or desirable that so influential a profession should continue without some authoritative declaration of opinion on these subjects, without any recognised standard of preliminary proficiency, and without any means of designating those who have sufficiently trained themselves to reach it. These deficiencies the plan now inaugurated professes to supply. No special mode of education is attempted or indicated, and even if desirable—upon which opinions are divided as matters stand—such a step would be premature; but a very clearly defined standard is fixed, up to which the education of the student ought to be carried, a method of indicating to some extent acquirements which surpass that standard is provided; and so much of the means of self-education as can be obtained from books is pointed out, a carefully prepared list of books having been issued by the council along with their programme.

So far as the influence of the Institute has extended, admission to the profession as represented by its members has been based upon respectability of character and practice,—the best and widest basis possible, and one which can never be departed from without disadvantage; but it is in the highest degree desirable that competence for the performance of its responsible and very varied duties should be secured in every possible way, and tested by a process more rigorous than can possibly be pursued in a society constituted like the Institute; and it is in every way desirable that those entering the profession should be youths of good previous education, and should studiously avail themselves of the opportunities at their command.

These aims the present scheme is calculated to reach. The ultimate success of its working will have to determine whether it shall remain a purely optional honourable distinction, or whether it shall ultimately become the groundwork of a diploma which shall be essential to practising architects. The feeling in influential quarters is strong against a diploma, and this scheme would have met with serious opposition—possibly with defeat—had it been proposed to associate with it any certificate of competence to practise, or other document such as might by possibility have been made use of as conferring the rank of an architect upon its holders. The probability is great, notwithstanding the jealous exclusion of all allusion to such an ultimate purpose, that eventually some test analogous to the examinations which must be passed before a member of the legal or of the medical profession can practise, will even be adopted, and will be legally enforced. Without fettering in the least the freedom of the individual artist in matters of art, such an examination will insure that the information which every architect ought to have on technical matters is not altogether wanting, and that the preliminary education, without which no man can creditably pursue a liberal profession, has not been omitted, and has not remained quite fruitless.

PAPERS ON HYDRAULIC ENGINEERING.*

By Samuel McElroy, C.E.

No. 2.—Distribution.

As a consequence of the use of water supply under pressure, lines of distribution service to the several points of consumption are provided, and are common in principle of use to both the intermittent and constant systems of service, which have been previously noticed.

From the reservoirs of storage or points of supply, by stand-pipes and otherwise, these lines, branching off in various directions, with various proportions of calibre and differences in material, have been applied to the solution of the problem of adequate delivery, adequate strength, and protection from the several contingencies of use; and have, therefore, involved not only the question of serious expenditure but various interesting questions of propriety in manner of construction, arrangement, and method of use,

A system of distribution comprises lines of feeding mains, service mains, special service pipes, and the various appurtenances connected with the details of delivery, and is controlled in character by the extent of service as to relative supply and demand, the conditions of service as to pressure, and by range of admissable expenditure.

Distribution is generally the most costly feature of any water supply. Its proportion, for instance, at Brooklyn, in an original contract total of $4,200,000, was not less than $1,750,000; and while this matter of cost is determined by the extent of the system the latter in turn chiefly determines the item of annual income, thereby regulating in an important way the propriety of this extent.

The materials which have been used at various periods and in various localities, and which may be noticed under a general head, are stone and brick conduits, earthenware pipes and pipes of glass, bitumenised paper, lead, wrought-iron, cast-iron, zinc, tin, and other metals, wood, and other materials, some of which will be discussed under special heads.

Arrangement.—The most perfect system in this respect is that which transmits the supply to its consumers with the least loss in pressure from frictional and other obstructions to its flow. To this end, a subdivision in supply districts is requisite for any system, properly controlled by lines of feeding mains of adequate calibre for free delivery and circulation; and for want of proper attention to this principle the value of many supplies has been seriously injured, under circumstances which render remedies difficult in application.

In a number of cases we find small and independent feeding mains, attached to service mains as low in calibre as two, three, and four inches. Not only does it result from this that the pressure on the house service is seriously vitiated, from a natural law in hydrodynamics, but in the important special use of a fire supply, instances abound where serious losses have resulted from a restricted discharge at the hydrants on this account. And as experience proves that a line of 4-inch pipes will not properly supply more than one fire-engine, except under an unusual pressure, it may be taken for granted, wherever fire-supply is an object, that all lines of this calibre should be short, and connected with larger mains, and that 6-inch mains should be assumed as the minimum for lines of general service. This principle was adopted as a rule in the arrangement of the Brooklyn distribution, the use of 4-inch pipe being restricted to hydrant branches. It is also adopted by the Croton Board for extensions of service.

Due attention to this arrangement of districts improves the operation and efficiency of the supply, admits greater extensions with less loss in head, and a much more simple and effective location of stop-cocks, which control delivery, accidents, and repairs, and which need, for this reason, particular care. The larger and more complete this framework of feeding mains around the special districts of service mains the better, within limits of reasonable cost, and subject to local contingencies of supply, pressure, demand, and extension; and for these, as thus determined, the calibres may range from eight, ten, and twelve inches, to sixteen, twenty, twenty-four, and thirty. Some of the Croton mains of this class are thirty-six inches in diameter. As an illustration of forethought on this subject, and a good example, the following extract is made from the Philadelphia Water-works Report of April 19, 1855:—

"The distribution of the old city proper, although arranged in 1819, before any other in this country, is very perfect, the system originally laid down having been strictly adhered to. The city is crossed upon the highest streets, running north and south, by two supply mains of twenty inches diameter each; and in the opposite direction, through the centre street, runs a main of thirty inches diameter: the whole plot is circumscribed by mains of sixteen inches diameter, reducing to twelve and ten inches, and is crossed north and south at intervals of about 1200 feet by mains of ten and twelve inches, these again are crossed east and west by several mains of sixteen, twelve, and ten inches diameter (all connected at proper intervals, and making a complete network of mains and feeders), supply the remainder of the distribution, which consists of six, four, and three inch pipes. The arrangement is quite complete, the only source of regret being that any pipes so small as three inches should have been used; but at the very early date when the distribution was devised and commenced, they were considered more than sufficient. Many new water-works, however, executed within a very short period, and long after those of the old city, have, notwithstanding the advice and experience of Fairmount Works, fallen into the same error, and are now suffering from the want of larger pipes and mains."

Usual Practice in Material.—Notwithstanding the varieties of material which may and have been applied to water distribution, the general modern practice has adopted the use of cast-iron mains for service. For house service pipes lead is generally used. These materials have several advantages and defects, which require special notice.

Cast Iron Pipes.—The strength and durability of this material; its facility for ready adaptation to the different forms of mains and their special appurtenances; facility in making joints, and in tapping for house service; in connexion with the influence of long established custom, comprise its chief advantages.

The ordinary form of joint in use, the "spigot and faucet," is that made with a hub at one end of the pipe, expanded to take another pipe, with a joint for gasket and lead packing, varying in width from ⅜ of an inch upwards, and averaging about 6 inches in length. These admit considerable expansion and contraction, and are therefore preferred to flanch joints, or to the conical joints originally introduced in London, and abandoned on account of frequent breakage from this cause. Special cases, however, frequently occur, where flanch joints may be used with economy, and fully guarded against objectionable rigidity.

It is found, however, that expansion affects the lead joint sensibly, causing it to "crawl" in its socket, particularly after the gasket is destroyed; to remedy which, in part, the hubs are cast with a countersunk bead, which tends to hold the lead in place.

In pipe lengths and sizes, improvements have been gradually made in foundry work, increasing the lengths from the old 30 inch sections of the Albany and other works, up to ordinary lengths of 9 feet, and more recent lengths of 12 and 15 feet, with much advantage in handling and economy in laying, since the expense at the joints is a serious item of cost, the lead alone, independent of labour, ranging in value from about 58 cents per joint for 6-inch pipe to $5·18 for 36-inch. Practically, at the foundries, there is but a slight difference in cost per ton between the shorter and longer lengths, except for very large diameters.

The usual test is that of 300 lb. per square inch under hydraulic pressure, in connexion with a hammer test, which may be made needlessly severe with a pipe under great tension. This is equivalent to a hydrostatic head of 690 feet, or about four times the usual pressure in waterworks practice—245 feet, as at Albany, when the upper district is connected with the lower; and 230 feet, as at Watertown, and a few similar cases, being exceptional instances in the United States, although exceeded in some European supplies. This test, however, has this fallacy, that it is applied only to the pipe castings, while the joints, as the true source of leakage, are laid without any trial, except that of actual use. There is an extreme and hurtful zeal in one case, with such a peculiar metal as cast-iron, which may be permanently injured before it shows any symptoms of yielding, and an oversight in the other extreme, as to the ordinary points of damage. Unquestionably, a considerable part of the loss of supply now attributed to house waste, is due to defective joints in the service.

Objections.—The objections to the use of cast-iron may be summed up in its cost, its defects in casting, its loss of length and other defects at the joints, the difficulty in breaking joints, and its liability to destruction, and discoloration of supply by oxides, and by tuberculation, which also restricts its delivery.

Cost.—The excessive weight of metal used for the qualities in ordinary application involves items of expense for transporting

* Continued from page 313

and handling material, freight, distributing on line of work, and labour in laying, as well as for value of material. To this is added the cost of jointing. The weights for pipes of 12 feet length may vary from 225 lb. for 4 inches diameter to 4600 for 36 inches diameter, and the following table will show the variation in standard, from two recent waterworks schedules:—

Cast Iron Pipes.—Standard Weight.

Length, and Class.		4 in.	6 in.	8 in.	10 in.	12 in.	16 in.	20 in.	24 in.	30 in.	36 in.
9 feet.	A	...	330	430	...	680	...	1600	...	3000	3600
9 ,,	B	...	360	500	...	820	...	1900	...	3700	
9½ ,,	A	...	347	453	...	716	...	1682	...	3160	
9½ ,,	B	...	378	525	...	864	...	2000	...	3900	
12 ,,	A	...	...	...	...	920	...	2100	...	3960	4750
12 ,,	B	...	...	...	...	1080	...	2500	...	4890	
12 ,,	(to lay)	225	368	480	750	...	1432	...	2511	3845	4607

In this case the A class is arranged for a practical head of about 100 feet, and the B class of about 150 feet, the lengths including the hubs; the weights given in the last line refer to a head of about 120 feet, and the length is exclusive of hubs. Including the value of the material, the cost of such pipes per lineal foot laid may vary from about 55 cents for 4-inch to about $9·50 for 36-inch, and readily aggregates a formidable sum. This item can only be modified in amount by any substitutes, and must always keep the distribution service in the front rank of expense. We may have occasion to allude to these modifications under another head.

Casting.—In foundry work, this metal is liable to defects from various causes. Unequal shrinkage, uneven thickness, blisters, sand holes, air cells, cold shuts, &c., may result from the spring of core bars, yielding at the ends, displacement of core coating, unequal rate of cooling, steam and air bubbles, the effects of local ebullition, and of floating sand, slag, dirt, &c. on the hot metal. For these and other obvious reasons in grade of metal, pipe castings should be made vertically, hub down, in loam moulds, and of a pure quality of iron. But their quality is generally inferior, although vertical castings are coming more fully into use.

Soft and impure iron is less strong and much more subject to oxidation and tuberculation, than better grades, although the relative cost of material operates strongly in favour of its use for waterworks by contractors, while the same consideration favours green sand castings in inclined and horizontal moulds.

Joints.—By the common method of jointing described, it follows that an increase in weight is required for the hubs, both on account of their enlargement, and for additional strength to resist the process of caulking; and whatever length of pipe is appropriated to the joint is a direct loss, varying from 5 to 7 inches on each pipe. Economy in movement and in jointing, therefore, urges the adoption of the longest practicable lengths. It is also evident, that reduction in number of joints must reduce the contingencies of leakage, so far as affected by the operation of expansion, contraction, or other general causes.

When it becomes necessary to take up a line of pipe, or a defective pipe, the lead must be melted by a hot fire from several hubs, to spring out one piece. This process is objectionable for several reasons, but is inevitable with this manner of jointing. Practically, all the tightness of a lead joint is included in the depth of an inch or so, which is expanded by the action of the caulking tool, the gasket serving no other purpose than a mould for the running lead, and frequently defective in this office. There is room then for question, whether the sleeves which are frequently used for jointing large pipes may not be commonly applied with advantage, since they may be easily and cheaply cast, save the losses in length at the hubs, are jointed with double-caulked faces, and may be cut away and replaced without the trouble, expense, and risk of a hot fire on the mains for several lengths. It may also be said that flanch joints save the losses in length, and as "face" or as "rust" joints may be made tight and durable. They are also cheaper, altogether, than hub joints, and are frequently used on large mains for special connexions. With occasional "slip joints," or with occasional pipes or flanches cast to admit expansion, their chief objection may be obviated.

The most perfect hub joint is that which is made with a full lead packing, caulked both on the outside and inside. This secures a smooth water-way, avoiding the use of gaskets, but can only be applied with convenience and certainty to pipes of large calibre. The 36-inch force mains of the Brooklyn pumping engines have 7-inch hubs, jointed in this way. In jointing, as in all other mechanical operations, good workmanship is essential to any method which may be adopted.

Oxidation.—The natural action of water on cast-iron pipes produces oxidation. It has been held that this effect is mainly controlled by the constitutents of the water in contact with the iron, different qualities having different effects; but it is much more certain that the constitutents of the iron determine the rapidity and extent of oxidation in connexion with those of the water, and as the most prominent cause. A walk through any pipe yard, after rain, very clearly shows how much more susceptible to this action some castings may be than others, probably from the same foundry; and it is evident, without argument in detail, that the differences in combination of material, and in method of casting, must essentially affect the liability to this action, and particularly with a class of castings which are impure, and rudely manufactured, at comparatively low prices.

From the thickness of pipe which the quality of metal, rather than the limit of resistance, renders obligatory in the foundry, the ordinary process of oxidation involves no immediate danger to the castings under pressure. Its chief objection is found in the impregnation and discoloration of the contents of the mains. Where the house taps are placed on the top of the mains, drawing their supply from the purest currents, and the supply is not subject to extraordinary agitation, oxidation may progress to a large extent, without making itself apparent in the house service; but if the hydrants are thrown open for fire purposes, or other causes of general agitation occur, disturbing the heavier particles in the mains, the evidences of their presence become at once and prominently sensible, and in some cases render the supply unfit for domestic use for a length of time. With unprotected mains, this is an evil which can be remedied only in degree, as to its palpable effects, while the process of destruction is as certain as it is slow. Unquestionably, different kinds of water will differ in degree of effect in oxidation, and different proportions of air in the same water have also their degrees of effect; but the prominent cause is attributable to the castings themselves, as being more or less impure, and therefore more or less subject to oxidation.

(*To be continued.*)

ON STAINED AND PAINTED GLASS.

By Apsley Pellatt.*

The adoption of painted windows was concurrent with the improvement in architecture, and especially in the introduction of the Early English and Gothic, which succeeded the Saxon and the Norman. From the twelfth to the thirteenth century the large expenditure, in England and on the Continent, on cathedrals, churches, and religious houses, induced a demand for decorated glass windows; and the early Archaic style was then generally introduced into windows, which were not only beautiful in themselves, but conferred a beauty upon the interior architectural decorations of these ecclesiastical buildings. At this period and for centuries subsequently, the Archaic style was adopted; it consisted of a perfect mosaic of rosettes, flowers, leaves, and other designs. The borders consisted of small pieces of variously coloured glass, secured by lead to the iron framework of the windows, in conformity with the outline of the design. In the centre, secured in a similar manner, were the medallions of a single figure or group of figures. The borders were usually harmonious and pleasing: the drawing of the figures was often grotesque, and in some cases almost amounting to caricature. The leading of the glass, being arranged to follow the outlines of the pattern, appears hard when viewed in close proximity; but, like the severe outlines of Raffaelesque subjects on china, when viewed at a proper distance this harshness nearly or wholly disappears. Many patrons still adhere to this severe Archaic style; while others, in keeping with the taste of the present time, admit a modification of more correct outlines of the figures. A good specimen of the coloured mosaic treatment, with its borders of a flowery kind, the lesser spandrils being fitted with a flowing ornament of various colours upon a red ground, is to be found in the circular window of the north transept of Lincoln Cathedral, as recently restored by Messrs. Ward and Hughes. The lower lights are in contrast with those above, on the grey or grisaille mosaic treatment, the chief parts of the white glass being shaded or worked with brown or black lines of enamel colours, intersected with small portions of coloured mosaics, the grey chiefly predominating.

The manufacture of coloured glass in small effigies, opaque mosaics, and vessels, dates as far back as the Egyptians, Phœnicians, Romans, &c. Its introduction for windows in the style termed Archaic was during the twelfth century. The art was considered not merely as decorative, but as a pictorial representation of Scripture history, aiding Christian teaching. The repose and solemn subdued effect of light passing through the varied coloured glass contributed to the character of the subject sought to be impressed upon the mind.

The first or Archaic style commenced at the latter end of the twelfth and beginning of the thirteenth century. Examples are to be found at St. Denis and Bruges, and in Canterbury, Lincoln, and Salisbury cathedrals. The second or Decorated style was introduced about the end of the thirteenth century. Good examples may be seen at Strasburg and Gloucester (recently releaded by Messrs. Ward and Hughes). The third or Perpendicular style, from 1380 to 1430. Another style the Cinque-cento, dates from 1500 to 1550, examples of which are chiefly to be found on the Continent,—viz., at Brussels, Liège, &c.; the examples of the Perpendicular being at Cologne, Winchester, York, and at St. Margaret's, Westminster.

In the Early English, such as the north transept of Lincoln Cathedral, the figures are less grotesque than in most other examples of that date. The figures were generally placed in medallions, canopies having not then been introduced. The next period, the Decorative, is marked by an extensive use of canopies: the drapery was more flowing and graceful, especially in the coloured mosaic and grisaille borders. About this period the yellow stain was introduced, which pleasing colour softened the white used in the earlier styles, and had a good effect when stained in portions, the cased red or blue being taken out to receive the yellow. The third, or Perpendicular, style is marked by its being more soft and silvery, and also more delicate and refined than the preceding; having no rounded or projecting cornices. The Cinque-cento style is of Italian origin, and more picturesque, being evidently influenced by the progression of oil painting. All these styles obeyed the spirit of their times; glass-painting agreeing with the state of the arts of each period, and in harmony with the architecture and the taste of its various epochs.

The principal difference between ancient and modern glass windows arises from the latter being brighter and of a higher key than the ancient, while it has less tone and richness, which, like the paintings of Titian and the old masters, may be viewed for any length of time without fatigue to the eye. Continental glass being thinner and of a higher key than the English, a fictitious surface and tone are obtained by enamel painting, which takes off the lurid glare, but deadens and too much lowers the tone: this ineffective imitation is easily detected. Modern windows of inferior materials, being charged with bright colour at a higher key, transmit too readily through the glass bright rays of different colours antagonistic to each other, which fatigue the eye and form an unpleasant contrast to ancient glass, or to that which has been recently made on the same principle, and which for want of a better term we shall call antique. Although homogeneous flint glass is so essential for chandeliers and household use, and especially for optical purposes, the reverse is required for coloured window glass, technically called pot-metal, to imitate that of the thirteenth century. Every colour of the spectrum,—viz., violet, indigo blue, green, yellow, and red, are produced in glass by the use of the oxides of the following metals,—viz., gold, silver, chromium, tin, copper, iron, manganese, cobalt, antimony, nickel, and uranium: carbon also produces yellow for pictorial purposes.

Window glass, although almost indestructible by time, whether coloured or of a greenish white, when long exposed to the action of the atmosphere, is liable to partial surface decomposition; and, if not too much decomposed, prevents advantageously the too free passage of the rays of light through it: old glass thus affected softens and blends the pictorial effect; and the colours remain sufficiently vivid and brilliant without fatiguing the eye. Modern amateurs and glass painters have had their attention drawn to the fact, that the agreeable blending and harmonising effect of ancient glass, although occasionally due to surface decomposition, owes its chief charm to the retention of the striæ and small bubbles in the body of the glass. The constituents of such glass have been perfectly vitrified, and the colours fully developed; but being less transparent than when thoroughly fined (like the ordinary clear-coloured glass), it becomes less dazzling and more subdued. To succeed in making striated and bubbly-coloured glass, having a horny or gelatinous appearance similar to the ancient, the fining process must be arrested during the latter part of the fusion by reducing the heat of the metal to a sufficient consistency for working before the bubbles and striæ are fully driven off: great attention is necessary on the part of the manufacturer to reduce the temperature of the furnace just at the right time to prevent the metal becoming too clear. This imitation of the ancients constitutes the chief improvement, since 1851, as as regards the vitrified material. Although these gelatinous striæ and bubbles are quite apparent on close inspection, they disappear when seen from a proper distance; a portion of the light becoming absorbed, but retaining the full richness of the colours. Pot-metal blues, greens, and rubies, &c., by this system of embodying in the mass the hindrances to the too free passage of the light, are far superior in effect to those of the ordinary, cheap, modern, clear, bright-coloured glass. No person of taste should require the latter, which will fail to produce what is termed the peculiar "dim religious light" of the ancients resembling the reposing colours of the spectrum. Blue is often used as a background to groups or single figures, as well as to the drapery and borders, and may therefore be considered the prevailing colour; and after this are ruby and green—all pot-metal colours.

About the year 1850, Messrs. Powell and Son commenced manufacturing antique glass of white and various pot-metal colours, a considerable portion of which, especially the blue and ruby, was equal to the best specimens of ancient glass of the thirteenth century. This was selected by Messrs. Ward and Hughes for the four windows painted by them, and erected in the Temple Church, London, about the years 1853 and 1854. Messrs. Hartley of Sunderland, and Messrs. Lloyd and Summerfield, of Birmingham, have also produced antique glass. This glass is striated, bubbly, and gelatinous, and sometimes the ruby is streaky. Pieces of dark and light ruby are occasionally leaded separately, and placed side by side, to give the effect of shading without the use of enamel colour. A national debt of gratitude is due to Mr. Charles Winston, author of a work on "Ancient Glass Painting," in two volumes, for his long, persevering, and successful efforts to revive the rich colours and low tone of ancient glass, the best specimens of which are to be seen in the four windows of the Temple Church, painted at his suggestion and under his superintendence.

If the colours in these windows equal the best of the ancient, of which there is little doubt, it is owing to the various specimens he caused to be analysed, and the synthetic experiments he made which enabled him to reproduce the glass, and furnish recipes gratuitously to the glass-maker. Foreign manufacturers have, no doubt, availed themselves, ere this, of Mr. Winston's liberality; and as wood fuel and open pots succeed best for glass dependent upon carbon as a colouring constitutent, no doubt they will ere long rival our productions of antique glass for windows. Messrs. Clayton and Bell, in their artistic treatment of the severe Early Archaic style; Messrs. Ward and Hughes, in their windows for St. Anne's Church, Westminster, of the style of the thirteenth century, the figures of which are treated in keeping with modern taste, similar to those in the Temple Church; Messrs. Powell and Son, in a window wholly of antique glass, of their own manufacture; likewise Messrs. Lavers and Barraud, Heaton, Preedy, and other artists, have availed themselves of English antique glass, much of which rivals the ancient in rich colour and low tone, and has a crispness and shellac appearance so well calculated to absorb the rays and retain the richness and beauty of the ancient colours. While, therefore, most of our Continental neighbours exhibit windows of inferior material, fully equal or superior in artistic merit to their painted windows of 1851, the English, availing themselves of the superiority of the antique glass, excel their exhibits of 1851. The Exhibition of 1862 may be considered so far as a triumph over that of 1851: the artistic progress has, however, been less than might have been anticipated.

The various attempts which have been made to imitate the richness and depth of the ancient material, by coating the glass with enamel paint, have produced no other effect than that of depriving it of its brilliancy, and, consequently, the glass paintings in which this expedient has been resorted to, of one of their chief distinguishing merits. In all the glass paintings of earlier date than the last quarter of the fourteenth century, until which period the glass was not over clear, substantial in appearance, or intense in colour, the artists seem to have relied for effect principally on the richness and depth of the colouring. In these works the means of representation may be said to have been reduced almost to the lowest degree. We are strongly impressed that the difference of effect between such ancient and modern glass does not depend on the state of the surface, but on the composition of the material; and this result has been strengthened by the result of some experiments recently made, by which the very great difference in the composition of modern glass of the thirteenth century is clearly demonstrated. The cheaper sorts of white and coloured glass, as alluded to in the Report of the Commissioners of 1851, counterfeit the ancient glass by coats of enamel colour, which only produces a misty and cloudy effect, merely blinding or shutting out a portion of light; but it cannot give the depth and richness of ancient colours. If varnish colour be used for such a purpose it will only serve a temporary object; and even if the enamel colours be burnt in, they are not always to be depended on, being liable to crack off by long exposure to the action of the atmosphere. Bertini and others obscure a portion of the back by roughing, or by a layer of white or neutral colour, so that little or no light may pass through the main figure of the subject, which rather resembles fresco than transparency. The latter is generally considered to be one of the essential conditions of glass painting. Brown enamel colours, more or less dense, are used for stippling and shading white or coloured pot-metal; but if too thickly laid on at one time will be liable to crack off in a few years: several coats and frequent firing are necessary to produce permanency in the various dark shades. Examples of coloured enamel painting, by Brackler, may be seen at Arundel Castle, the seat of the Duke of Norfolk. They are wholly enamel, and have no pot-metal colours; similar also to several glass paintings designed by West, and painted by Jervis, in the royal chapel at Windsor. These may be considered as simply semi-transparent pictures, wholly out of the category of what is generally known as stained or painted glass, by mosaic or grisaille treatment, for ecclesiastical purposes. Referring to former explanations on the striated gelatinous colours, called antique, used since 1851, as they were then shadowed out by Mr. Winston, and since produced by him and adopted by many of our English artists, but as yet feebly followed by Continental painters, it is somewhat remarkable, that while clearness of metal constitutes the greatest improvement in flint glass, the reverse should be the case for window glass; in fact, that while homogeneity should be the essential property of flint glass, impurity is equally necessary for the successful imitation of the ancient glass, in attaining the same depth of colouring, and the absorption of the rays to be found in the coloured glass of the thirteenth century: it, therefore, seems anomalous that the inferior fuel, for melting the materials, also that the metals, sand, and alkali possessed by the ancients, which were less pure than those used by the moderns, should have furnished greenish white, and pot-metal coloured glass, so exactly suited to produce the best effects for pictorial windows.

Resuming our remarks upon enamel painting, there was the brown painted smear, and stipple shading, also a darker enamel for lines and shadows by hatching, or repetition of lines, serving as shadow upon white or pot-metal colours. There are several methods of shading, some being smooth, employed in early examples, and the latter being darker, employed in the grisaille of larger works.

It may be asked, does the grotesque style of the past age harmonise with our present mode of thought? How far does the present Exhibition, considering the present advanced state of the fine arts, meet the requirements of the nineteenth century? We reply, it is the contrast between 1851 and 1862 that affirms the fact, that in most of the English exhibitors, and several of the foreign, the art of glass painting has advanced with the times both in style and artistic execution. It is, however, much to be regretted that few of the windows can fairly be seen to advantage, owing to too much interior light, and the exterior borrowed lights of the present building being so inferior. Continental glass artists generally adhered to the early grotesque style in imitation of the past age; and in that respect, in 1851, were superior to the English; and, with the exception of the beautiful windows painted by Bertini and his school, that style is still retained. Bertini's windows in 1851 and 1862 may be classed in the mixed style of the old mosaic, and the enamelled style of the nineteenth century. The excellence in design and execution of the former was generally admitted, although insufficient transparency was occasioned by the too great opacity of the principal central figure. The Madonna and Child of Bertini, of 1862, may be considered as one of the gems of this Exhibition.

The art of glass painting should have a special mode of treatment, impressed upon it by the nature of the material, as oil for canvas, and fresco for ceilings and walls. Glass being the medium through which the light passes, transparency must be its condition: different degrees of transparency are admissible: but when a large portion of the glass is so opaque as almost wholly to preclude the transmission of the rays, an essential condition is infringed. The style of the sixteenth century, or earlier periods, modified by the taste and feeling of the nineteenth century, should be supported by our designers and glass painters. With good original designs, improved antique glass, judiciously leaded, with a proper degree of transparency, first-rate drawing, good shadows, and well-arranged colours, forming, as a whole, a work of art, rich, harmonious, and impressive, patrons will not be wanting for the decoration of our ecclesiastical or domestic buildings. No doubt artists are influenced considerably by their patrons, each of whom may have his settled convictions as to style, &c. We should, however, endeavour to preserve the beauties and avoid the defects of the drawing of earlier ages; but no reason exists, why, as pottery, carving, statuary, and the fine arts, have generally advanced, glass painting should be impeded or restricted in its progress towards the perfection of the art.

MERITON'S IMPROVEMENTS IN MARINE BOILERS.

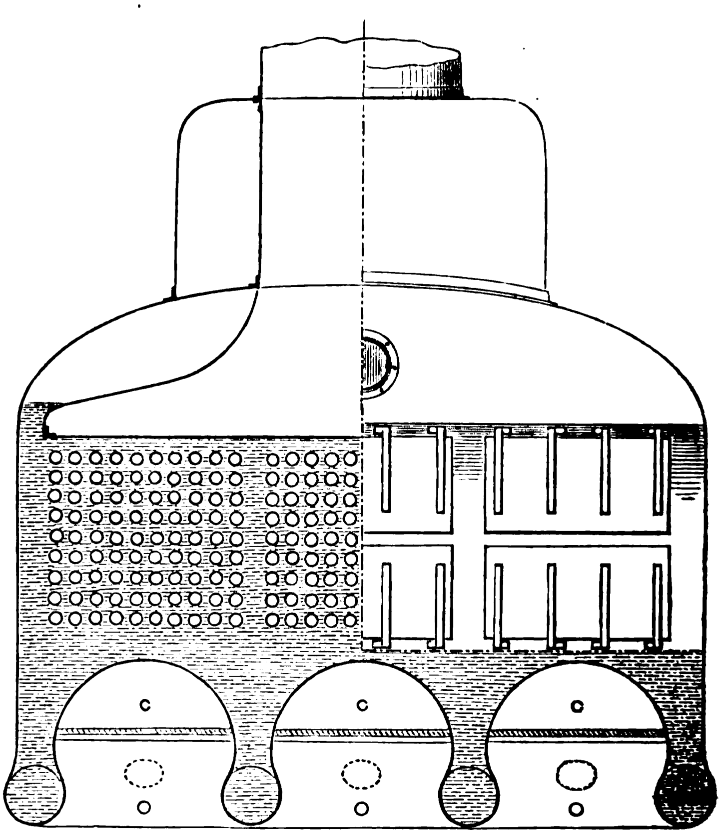


Fig. 1.

Mr. Meriton's improvements in marine and other steam boilers, consist chiefly in an arrangement which enables him to introduce at the back of the firegrate, in the up-take, a series

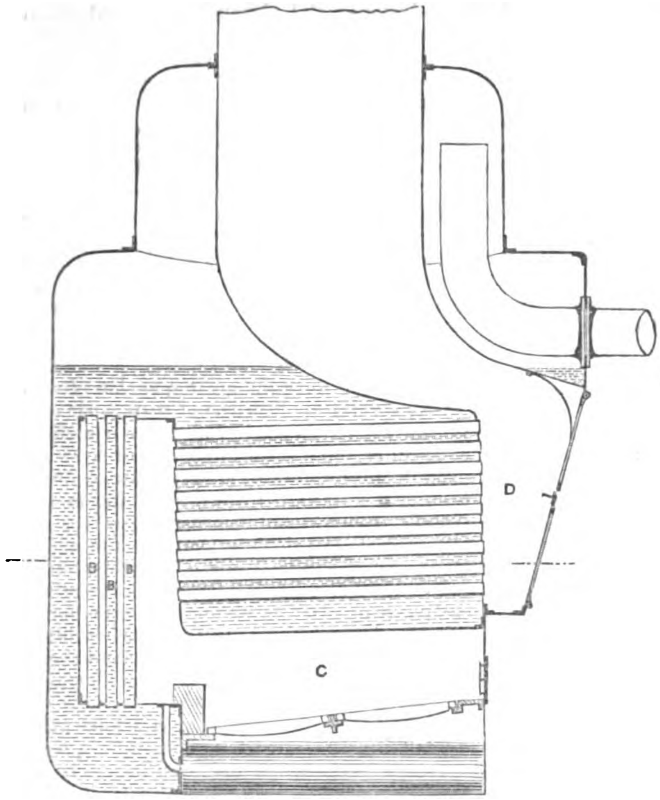


Fig. 2.

of vertical or inclined tubes of a circular, oval, or any convenient form, connecting the water-space at the top of the boiler with the water-space at bottom of boiler behind the bridge at back of

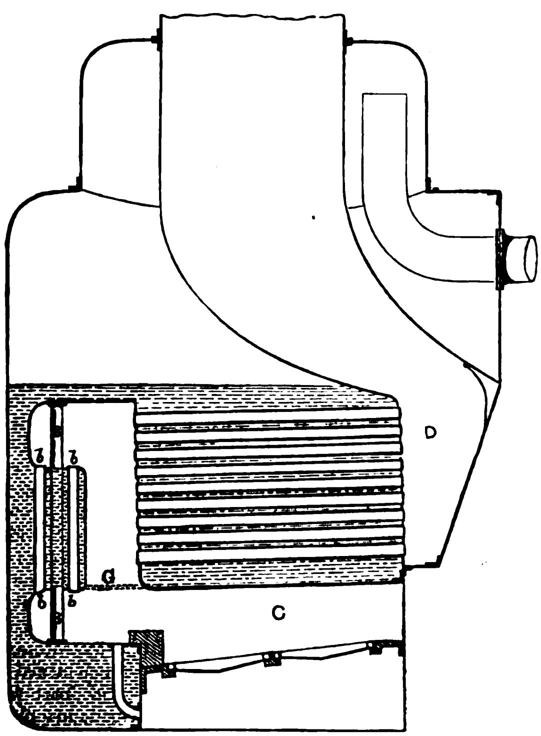


Fig. 4.

gratė, and thereby increasing the heating surface and consequent evaporative efficiency of the steam-boiler. By this arrangement he is also enabled to render the tubes and other parts of the boiler more accessible for the purpose of repairs and cleaning or

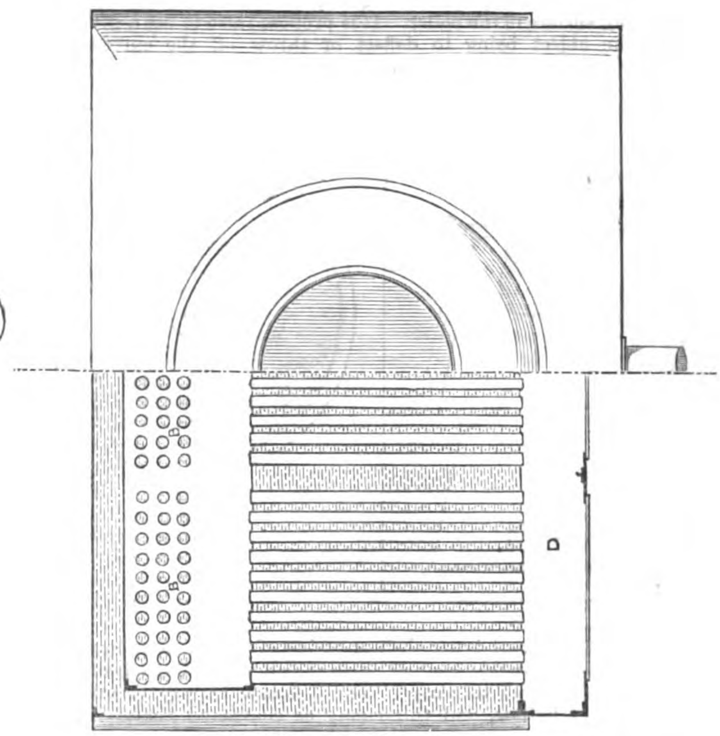


Fig. 3.

clearing operations, than other forms of boilers. The advantages claimed for these improvements being the facility with which boilers constructed upon this principle may be thoroughly repaired, and the parts most subject to wear may be renewed, without laying up the vessel for any length of time. Boilers constructed upon his principle, he states, may be used for a very much longer period without requiring lifting, than ordinary boilers.

In the engravings, Fig. 1, is a front elevation, with doors at one side removed; Fig. 2, a longitudinal section; and Fig. 3, a plan of an ordinary marine tubular boiler, to which Mr. Meriton's improvements are applied; and it will be seen that these improvements do not interfere with the present construction of boiler, but consist in introducing, as before stated, into the uptake A, a series of tubes BB, which may either be placed vertically, as shown in Fig. 2, or inclined at such angles as may be found desirable; and the tubes themselves may be made either circular in section, oval, or of any other suitable sectional form. The smoke and heated currents of air pass from the fire-boxes CC, around the tubes BB, and thence along the tubes placed as in ordinary marine tubular boilers, horizontally, into the smoke chamber D, and funnel. The manhole doors are so placed or disposed that access can be readily had to all the tubes and all the parts of the boiler, for the purpose of cleaning or repair.

Fig. 4 is a modification of Mr. Meriton's invention, also applied to a marine tubular boiler, of which it is a longitudinal section, in which the connection between the water-space at the top of the boiler and the water-space at bottom of boiler is maintained by a tube or tubes B; but the currents of heated air or gases are made to pass through the other tubes *b*, *b*, *b*, *b*, instead of around them, the boiler being constructed as shown, so that the tubes are in this instance surrounded by water—the currents of heated air and gases passing from the fire-boxes up through the tubes *b*, *b*, *b*, *b*, thence in a downward direction to the horizontal tubes, and to the smoke-chamber D and funnel. At G is a plate which prevents the currents of heated air and smoke passing direct to the horizontal tubes, and is at the same time so constructed that it can with facility be removed and replaced for cleaning or repairing the tubes or other parts of the boiler.

Fig. 5 is a sectional elevation, and Fig. 6 a plan of Mr. Meriton's invention as applied to an upright or vertical boiler. B B are the tubes communicating between or connecting the water-spaces above and below; these tubes also utilise to a very great extent the currents of heated air and gases, and materially increase the heating surface of the boiler. It is proposed also to use a deflector H, the object being to deflect or throw off the currents of heated air and gases so as to cause them to reverberate against

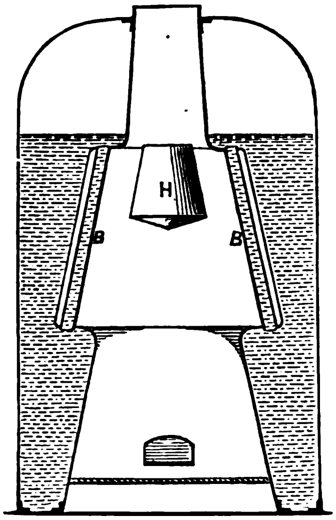


Fig. 5.

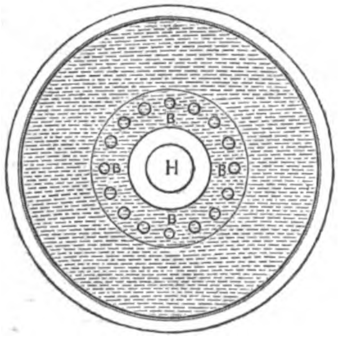


Fig. 6.

the tubes B B, and inner shell or casing of boiler, in order to get the greatest possible amount of heat before the heated air and gases are allowed to escape. The deflector H may be made of metal, and hollow, and tubes may be connected therewith, as indicated by the dotted lines, for the purpose of superheating or drying the steam.

SANITARY IMPROVEMENTS AND APPLIANCES AT THE INTERNATIONAL EXHIBITION.*

As a general result it does not appear that the actual thought stirring among men is, in sanitary contrivance, very great. The amount of education on the subject is still deficient, and all progress must be slow until the nation is brought up a little farther. There is, in fact, a desire for change—in some instances to the worse—from an ignorance of the part we have left behind. At the same time, the amount of knowledge is very unequally diffused in different parts of this country, as well as in different parts of Europe. In this country we seem to have attained a much more refined idea of that which is pleasant to the lungs; and we have a higher idea of purity of air, water, and food. But in different parts of England, Scotland, and Ireland the differences are also great, the improvements being the consequences rather of imitation than of public instruction. Men learn more by example than precept—an old maxim, most wonderfully illustrated in the Exhibition, and which is the very cause of its existence.

Sanitary reforms, such as they appear at the Exhibition, show that men are striving after materials with which to act, and also after forms in which to embody the well-known old ideas. New ideas of a purely sanitary kind we have absolutely none before us, although since 1851 the subject has grown widely. We know more of the condition of the air: we know more of the necessity of ventilation, and more of its difficulty; but the progress of our knowledge has not been seen in the Exhibition. Thus far we see a defect in it: the whole circle of human invention has not been exposed to view; and room is made for improvement in a future Exhibition. Although we have not shown all that has been done, we must not forget that much is still undone. We have not learnt the best mode of ventilation, nor solved the sewage problem. We have not decided on the best way of rendering all the food sold to the poor and to the rich perfectly free from noxious adulterations. We have not liberated ourselves from the fear of being poisoned by arsenic on the walls; nor, if this be poisonous when used on paper, have we decided if it is wise to live with other noxious metals around us ready to fall in powdery oxides as dust into our lungs. We have not solved the problem of the best pipe for supplying water, which with the purest supply shall still give us no lead or injurious metal, although one patent which has gone far towards this exists, but little used, and not exhibited. We have not learnt how to live in great communities, enjoying the advantages of social intercourse, without the disadvantages of many accumulated evils, in which we breathe with dislike. We have not solved the problem of smoke, of sulphur, and of arsenic in our towns, our manufactories, and especially our mines and metal works. We cannot warm and ventilate a small room so as to make it healthy and comfortable; and we cannot build a house suited to the wants and the wages of our population.

These are a few of the problems before us on which the nation's eyes have been more distinctly fixed; and the response in the Exhibition has not been so great as the intellect of the country led us naturally to expect.

VENTILATION.

There are several attempts to solve the great question of ventilation. Amongst these, several applications of wire-gauze and perforated zinc for ventilating rooms are included in our section. The general principle of all of these is the admission of fresh air diffused through a small opening, either by simply drawing down the windows, or by opening a slide valve: there is nothing in any of them calling for special remark; but generally they are all applications of a long-established principle made in the right direction. Cooke's apparatus claims to do more than this, but it was not demonstrated to the Jury. It is neat, and never intrusive, and must, like all gauze blinds, remove an immense amount of dust. Two other forms of ventilating apparatus are exhibited in the same place, which have higher claims to commend them. One is the glass-louvred ventilator of Mr. Moore (United Kingdom—2393), the very extensive introduction of which is sufficient proof of its simplicity and usefulness. The other is a concentric tube, exhibited by Mr. M'Kinnell (United Kingdom—2392), with its application to the ventilation of ships and dwellings. There are other applications of the same principle not in the Exhibition, but Mr. M'Kinnell's contrivance is an ingenious adaptation, and merits recompense. We preferred to select the glass-louvre of Mr. Moore and this ventilator of Mr. M'Kinnell for honourable mention; the former on account of its simplicity and general utility; the latter on account of its applicability under certain conditions to closed apartments and holds of ships. Mr. Moore's ventilator is of glass, and in the form of a Venetian blind. It opens or shuts by changing the angle of the laths of which it is composed, as a Venetian blind does, but it is not made to be raised or lowered.

There are several applications of the principle of warming part of the fresh air admitted into dwelling-houses by means of the waste heat behind the fireplace. They are all improvements more or less ingenious, and in the right direction; but the subject is comparatively new, and none of these applications are of such importance as to merit special recompense.

Mr. Watson, of Leeds, had long ago introduced his double tube or tube with a diaphragm, which under many circumstances, acts remarkably well; but instead of one branch having a current up and another down, it frequently happens that the air is found moving in both tubes in the same direction. Mr. Muir, of Glasgow, removed the difficulty to a great distance by having the square tube crossed twice diagonally, and so causing with almost every wind an inclination to produce a difference in the four currents. There are numerous situations in which it must supply abundant pure air at all times. These four tubes are stationary substitutes for the two cowls, one towards the wind, the other from it, and which must be moved according to the direction of the wind. There is however a natural difficulty inherent in the subject itself—that of causing two currents of air to run together so very closely. Mr. M'Kinnell puts one tube within the other, and this plan is said on high authority to be extremely beneficial in holds of ships. But when currents of air come so near each other, they must cause numberless eddies, and the impure air can only pass after being very much mixed with purer air, and thereby a much greater amount of heat is lost than is at all needful. Many praiseworthy attempts are made to purify the atmosphere of a room by merely bringing the air through perforated wire-gauze, zinc, or glass.

There are several inventions for causing the air to turn corners before entering a room,—that is, to cause it to enter in a zigzag manner. There may be some value in this, as the great violence of the wind is prevented, and rain is also kept out at the same

* From Report of Jury on Section B, Class X., International Exhibition.

time; but they promise little. No invention in ventilating will ever dispense with an abundant supply of pure air. Many have a good method, but are afraid to use the large quantity of air required.

Messrs. Doulton and Co. separate the flue of the ordinary fireplace into two parts with a zinc partition: the one is for the smoke: the other is connected with the upper part of the room by an opening, where Arnott's valve is usually put. This removes the warm and fouled air; the draught being caused by the heat of the parallel flue, as well as the heated air of the room. An Arnott's valve may be added. This of the Messrs. Doulton cannot be adapted to ordinary fireplaces, but it seems to be extremely promising for new houses.

The Military Commission of Vienna, appointed by the Government to inquire into the question of ventilation, has decided on using mechanical means; and a fan drives the air forward into the garrison hospital. A medal was awarded to the Imperial Royal Commission.

Mr. Zimara, of St. Petersburg (Russia—316), exhibits a stove which conducts the heated air and products of combustion through a numerous collection of earthenware tubes under the dwellings, and allies itself more with the old Roman method. It is a plan which in cold climates may be of the greatest advantage, although too heavy, cumbersome, and expensive for small houses, even there. By it the whole under-part of a house is in fact converted into a Dutch stove, which long retains its warmth. A medal was given to Mr. Zimara.

Mr. W. Pierce (United Kingdom—2395) is mentioned honourably for his mode of Huthuance's drying chamber for clothes.

None of the models at the Exhibition use the heat of the fire so as to warm the space between the walls, and to render it a drying-room for clothes. The model washing-houses are very valuable for the poor, but a commodious way of using the heat produced in their own fires at home is very much wanted. At present a great deal of the heat is expended in drying bricks and mortar that never ought to have been wet. This would be much better employed in warming the room itself, or even an intramural cavity, which would also give out some heat to the rooms. This, however, occupies space, which is not generally to be spared.

The great demand in this country is for warmth and dryness: give these, and we are ready to ventilate sufficiently; deny these, and the whole population instinctively prefers bad air to cold-giving air: therefore, if we ventilate sufficiently, we must warm

AS TO DRY "CLOSETS."

Mr. Spence had some time ago cured his own house in Pendleton, Manchester, of a sewer disease, by connecting the sewer with the house chimney; and he proposed to carry all the air of the sewers into chimneys, or into one great chimney which would supply the whole city, the effluvia to be disinfected by the smoke: this plan included the separation of surface-drainage. But the separation of surface-drainage would probably render the operation of purifying towns a profitable one, even with our present knowledge of the value of sewer water. Mr. Spence went so far as to propose one chimney for the whole of Manchester—a bold and (many will add) a fine idea. The ventilation of sewers and of water-closets by leading the effluvia into the air without disinfection is a most inefficient method of purifying air. It certainly removes the evil from our own houses, but it sends it to our neighbours, although in a more diluted state. If this were done by a whole community, we should have our towns no whit better than now—perhaps worse; because there are increased inducements given to evaporation. If the sewers are ventilated however, Dr. Stenhouse's mode, through charcoal, is decidedly the best.

Several have acted on the idea of disinfection, and produced dry closets which shall give no effluvia. G. Smith and Co., of Glasgow (United Kingdom—2401), have exhibited one which pours out sawdust from a perforated box every time the lid is closed. Mr. Owen, of Manchester, had some time before done the same with McDougall's disinfecting powder. The same substance is used by Messrs. Muir and Carrick in their dry water-closet; and Dr. Lloyd, of Anglesey, seems to prefer charcoal in that which he has been recommending: he seems to have been the first of the class, and made many models not brought to the Exhibition. There seems, in fact, to be a movement towards dry-closets, and an inclination to object to water-closets. This has arisen from the condition of the Thames chiefly; not unconnected also with the Clyde, as well as some small streams scattered up and down England. This feeling has produced several ingenious schemes, one from Dr. Joule, who for a while left his other important investigations, and contrived underground receptacles for sewage, which receptacles should be emptied by air-tight carts. Of these underground receptacles, one to every group of houses was considered not to be a return to the old cesspool method, which allowed one or more to each house; and they were to be in the towns, because the sewage, not being mixed with the water of towns, would not flow far, from its want of fluidity. The experience of Paris seems conclusive against this system, although, as Dr. Joule projected it, it is far superior to that which the Parisians are anxious to get rid of, although it is similar in kind. Mr. O. F. Glassford has long advised receptacles of a similar kind, but at greater distances: he draws the sewage from them into larger receptacles by pumping.

In Berlin and in Paris the system has been carried on more carefully than anywhere, and so-called closed vessels are used for the purpose. But it is scarcely possible to keep such vessels well closed. Disinfection by chloride of zinc is adopted for the cesspools, but whoever has watched the process must be satisfied of its failure. Nowhere does the emptying of ash-pits among us cause such a nuisance as the emptying of a disinfected cesspool in Paris, with several officials to watch its progress.

It is rather strange to see how easily men's minds are diverted on some points. We forget the great deliverance obtained by water-closets, and some are actually willing to go back again to a state of pain and misery for the sake of our rivers, instead of continuing the process begun, and bringing it to perfection. It needs but little ingenuity to reject all inventions made by those who have laboured for the benefit of mankind, and to return to a primitive state of filth and discomfort, as many contrivances now seem bent on driving us. We may consider it as certain that no plan will ever be devised for removing refuse from our houses equal to an underground flow, self-acting and out of sight. To wish more seems impossible: to perform this is known to be possible: to remove a few difficulties connected with its use in some places is all that we require to render the system perfect. The wants of society are becoming more numerous: there is no room above-ground for the mechanism by which these wants shall receive attention: the earth can cover up or destroy all that annoys us. It must, however, be confessed that there is a necessity for the dry system in many places where cold or dryness prevents a flow.

WATER SUPPLY.

Fortin-Hermann, Brothers (France—1189), have introduced several alterations into the system of water supply: amongst these is a mode of joining pipes. The two pipes are attached by an iron collar, rather loosely, so as to allow a collar of lead which is fixed on each to slip under the iron collar: the lead is then hammered inwards. By this means a certain flexibility is obtained in the joints, which is an extremely important consideration. The two pipes may be lifted up as one. When it is required to undo them the flexibility may be extended to rupture by one or two men leaping on the point of junction, the distant extremities of the pipes being supported. The water-taps are made so that they shut themselves by their simple weight: they are opened by merely lifting up the point, as there is no pressure of water. This pressure is removed by each being supplied with a small cistern, kept full by a ball and tap. The entrance to the water-tap on the causeways is made by one pipe sliding over another, so that when waggons pass over it the opening sinks with the pavement. A medal was awarded to Messrs. Fortin-Hermann. The *bouche sous trottoir* adopted by the city of Paris, placed flush with the level of the ground or pavement, replaces the standpipe. It is a hydrant, which is also used for gutter-washing and road-watering. The *bouche d'arrosage*, used for watering public roads, is also a step distinctly in advance of our usages in England, where water ought to be abundantly supplied for all purposes.

BRICKS AND EARTHENWARE.

Bricks generally do not come under Section B of Class X., but a perforated and highly-glazed specimen, made by Mr. Jennings (United Kingdom—2386), called for special attention. It is used at the Herbert Hospital for the purpose of preventing the rise of moisture into the other bricks of the building. It forms the first layer above the surface of the ground: by this means the surface can never convey its moisture to the bricks above this layer. It is perforated, and by this means allows free access of air to the space under the floor of the building. This brick is exceedingly strong; and it is believed by the inventor to increase in strength because of the perforations. We do know that a great amount of moisture may be raised from the moist earth by absorption,—an amount which may, and which does, entirely destroy the health and comfort of dwelling-houses, and, we may add, the houses themselves. The same effect is abundantly observable in houses built with very porous bricks or other porous materials. During wet weather a great amount of water is absorbed; and when warm weather comes it is evaporated, removing from the building a great deal of heat instead of contributing to comfort. In this land of frequent showers there is seldom an interval sufficiently long entirely to dry the bricks; and fires are used to prevent dampness, which might easily be prevented by using good building materials. We much need a brick for the whole building which shall resemble this made by Mr. Jennings in the compactness of its structure and the smoothness of its glaze. Another result would follow: the blackness of the rain falling in our smoky towns would not leave its traces: these black spots would be removed by showers rather than left by them, as we find to be the case where a smooth surface is exposed to the action of wind and rain together.

Mr. Jennings obtained a medal for his general improvement in arrangements for sanitary purposes. There are some specimens in the retiring-rooms of the Exhibition. There was a completeness in the arrangements and fittings which very much pleased the Jury.

EARTHENWARE PIPES AND VESSELS.

Messrs. Doulton and Co., of Lambeth (United Kingdom—2268), showed some very beautiful specimens of earthenware. Sewers were exhibited 3 ft. by 2 ft., and made in segments. The sewer is made with hollow walls, or two thin walls with a space between them. Each piece formed about the fourth part of the whole circumference, and is fitted on the others. When packed for carriage the hollow walls save a great deal of weight; and the segments being fitted on each other save a great amount of space, as one curve nearly corresponds to the other. This must effect a considerable saving in expense of carriage. The various parts are cemented; so that here there is some additional outlay in this respect; but for foreign shipments the packing and carriage must far outweigh the expense of cementing.

The principle has been applied to the formation of tubs and cisterns of earthenware. In this case the segments are dovetailed and cemented, very large vessels of earthenware may, in this manner, be made at a moderate expense. At the same time it is not at all improbable that by doing this we are cutting instead of unravelling a knot. It seems as if the manufacture of large earthenware vessels were rendered difficult rather by our ignorance, which it would be well to remove, than by natural obstructions; although a substitute for knowledge not yet attained must of necessity have some of the characteristics of the real knowledge itself, as in this fine specimen of Messrs. Doulton's pottery,

A medal was given to Messrs. Doulton; also to Miller and Hochstetter (Austria—1390), for earthenware pipes; and to A. Richter (Austria—1393).

PAINTS.

There is a considerable amount of attention paid to hydrocarbon paints by Dupont, of Cherbourg (France—1270), and by Ruolz and others. These paints are chiefly pitch or wax, or both. The difficulty, of course, is to remove the dark colour of the pitch. This is done in some cases with a good deal of success when the colours themselves are dark; and among these, especially, oxide of iron may be mentioned. M. Dupont uses it for wood and iron.

L. Machabée (France—1380) uses fat, wax, and pitch to cover pipes, as has been done in this country. These were shown by the Paris Commissioner; but the section did not seriously consider them, both because they were brought in hastily at the end, and because they seemed not intimately connected with the subject of inquiry.

WATER PIPES.

Water pipes of paper and asphalte have been made by several parties. A curious objection was found to occur in Switzerland: the paper was eaten by insects. Guicestre and Co. (France—1255) make them also of sand and pitch. M. Sebille, of Nantes, uses finely-ground slate, and makes a very fine tube. He shows the value to be in the simple mode of making a joining. The parts to be united are melted by a hot iron and put together. When a curve is to be made the pipes are merely warmed before a fire, and bent as desired. The pipes are prepared in moulds, into which the substance is put when soft, and, being pressed tightly, is left to cool. Pipes 3 inches in diameter inside can be made for 2¼d per metre, or, let us say, per yard. With a capital of £500, 10,000 metres can be made in a day, according to M. Sebille. When the pipe is very large, the ends have a piece of sheet-iron inserted into them. About one-fourth of the pipe is tar, and three-fourths of slate. The pressure which they stand is said to be 10 to 12 atmospheres. M. Sebille also shows tubes made of pitch and coarse sand and cinders, useful in conveying acids. In addition, there are tubes of lead coated with tin; the coating made when the tube is being drawn. This plan seems to have gained a good deal of consideration in France. In Manchester it was tried about fourteen years ago with great care. The coating was made when the lead was soft: melted tin was placed at the top of the core which determined the size of the bore, and the lead took up the tin when it was soft. Pipes were laid down in Salford, and specimens were examined after one, two, and three years. There was a manifest progress towards separation of the two metals even during the first year; and in the third year the spots were both numerous and large; the lead surface giving way more rapidly when the tin was removed. The manufacture was discontinued.

A medal was awarded to M. Sebille for his ingenious employment of bitumen, slate, and refuse materials.

THE CONSTRUCTION OF LIGHTING APPARATUS FOR LIGHTHOUSES.*

By Armand Masselin.

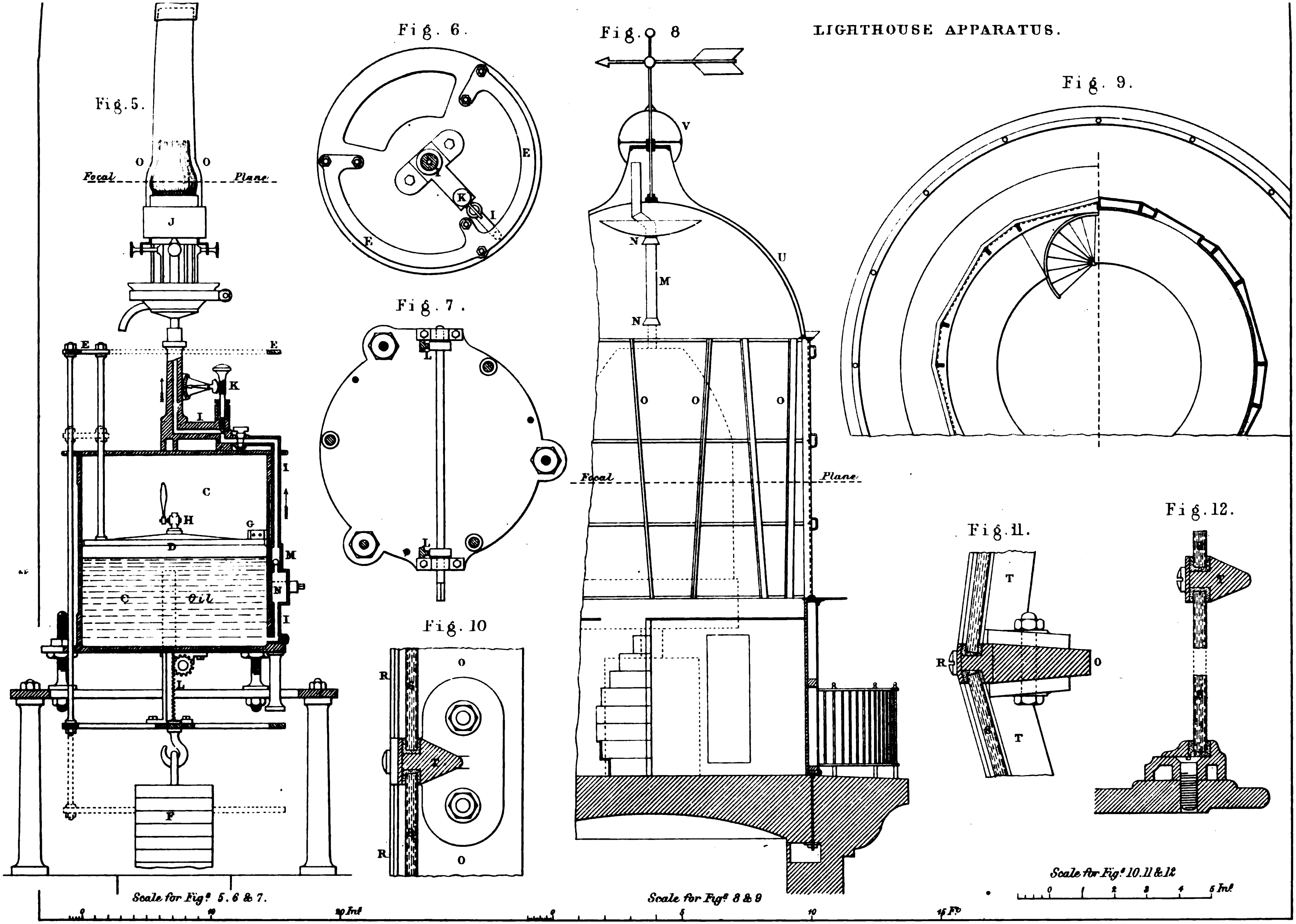
(With Engravings.)

The lamp necessarily forms a very important part of the lighthouse apparatus, in the efficiency of which, it is an essential element. The lamps generally used in the larger dioptric lights are of the class known as mechanical lamps, in which the oil is forced from a reservoir into the burner by means of a pump worked by clockwork driven by a weight. Although this construction of lamp is simple enough, it requires that the keepers should be trained to its use, and should have a thorough knowledge of the way of taking it to pieces for cleaning and then putting it together again, before they are sent to their respective lighthouses. As this precaution was not at first universally adopted in lighthouses, complaints were made against the mechanical lamp; and in consequence lamps of the simplest possible construction but inefficient in action came into use in this country, consisting simply of a side reservoir communciating by a tube with the burner, the level of oil in both being the same. The consequent absence of overflow prevented a high flame from being obtained, and greatly impaired the efficiency of the light, which doubtless considerably retarded the adoption of the dioptric system. Pressure lamps were also made more lately, consisting of a large cylindrical oil reservoir containing a piston fitted with a cupped-leather packing, the pressure being obtained by a number of small weights arranged round the piston, whereby the oil was forced through a side tube into the burner. These lamps however presented many inconveniences: the pressure could not be conveniently varied, since the addition of one weight tended to cant the piston out of its horizontal position and allow the oil to escape at the opposite side. The cylinder being made only of sheet brass, and therefore not perfectly cylindrical, a considerable difference of diameter between the piston and cylinder was required; and when the oil became rather warm, the leather got so soft that it was liable to turn over and render the lamp useless. The piston being entirely submerged lost a portion of its weight, and whenever the pressure had to be varied, the weights taken out were covered with oil, and there was a great waste by the oil being spilled: there was also a liability to leakage from the body of the lamp being made of several parts soldered together.

The conditions the lamps are required to fulfil are:—a constant and even supply of oil to the burner, equal to fully four times the consumption; simplicity of construction, so that any unskilled mechanic can take the lamp to pieces and put it together again; freedom from liability to derangement; and an accurate fit of the various parts, so that all duplicate parts will fit equally well.

* Concluded from page 297.

LIGHTHOUSE APPARATUS.



To meet these requirements the writer designed the construction of lamp shown in the vertical section Fig. 5, Plate 24, which has fully answered the purpose. The brass cylinder C, containing the oil for the lamp, is cast solid in one piece with the bottom, and bored out truly cylindrical, and is fitted with a turned piston D, having a cupped-leather packing; the three piston rods are connected at top to a wrought-iron ring E, seen in the plan of the top of the cylinder Fig. 6, to which are attached the side rods passing down outside the cylinder to the wrought-iron ring below, which carries the weight F. The piston is steadied against any small lateral oscillation by six leather guides G fixed round its circumference; and any air underneath is let out through the centre vent cock H. The oil is forced out at the bottom of the cylinder through the upright tube I leading to the burner J, the quantity being accurately adjusted by a conical regulating valve K, having an index on the screwed handle which shows the quantity of oil supplied to the burner per minute or per hour. When the piston has descended to the bottom of the cylinder, it is wound up again by the racks and pinions LL, Fig. 7, shown attached to the bottom of the cylinder, and the oil is prevented from being drawn down from the burner by a check valve consisting of a small ball M situated in the feed-pipe I. The burner remains therefore constantly fully supplied with oil; and the time occupied by winding up the weight being only a few seconds, the overflow of oil is not visibly affected. As impurities from the charring of the wicks, and especially a quantity of flue or dust from the cotton wicks, are constantly brought into the cylinder by the overflow oil, and afterwards drawn under the piston, these would find their way up through the feed tube I into the burner J, which would cause a stoppage of the supply of oil to the wicks. To prevent this, a fine wire sieve N is placed in a box in the feed tube I, which arrests any impurities in the oil, and can be opened and cleaned out occasionally in the day-time when required. Should the sieve get stopped up during the night while the lamp is burning, it can be changed in less than a minute, which does not interfere with the working of the lamp. Each wick is provided with two oil tubes, whereby a constant supply of oil to each wick is obtained, instead of all the wicks being fed by a single exterior tube, as in the previous lamps.

In order to produce a proper illumination of the horizon by this light, it is essential that the full height of flame should be kept up, maintaining the flame correctly in the focus of the apparatus, without which the best optical apparatus would be imperfect in action. For this purpose the overflow of oil must never be less than three or four times the actual consumption; otherwise the wicks will burn down to the edge of the burner, and the intense heat produced would very soon destroy the burner itself. Moreover, when the supply of oil is too small, the heat of the flame has time to act on the small overflow, and considerably deteriorates the quality of the oil; and the overflow being all returned into the reservoir, the quantity of deteriorated oil in the reservoir increases, until it is impossible to maintain a good flame.

The proper shape, diameter, and position of the shoulder or contraction O, Fig. 5, in the glass chimney used for the lamp is of special importance, since this has a direct influence upon the shape and height of the flame, and consequently upon the intensity of the light produced. Too sudden a contraction of the glass causes the flame to be reduced in height, especially that of the outer wick, and no efficient flame can be obtained unless all the wicks give a flame of equal height. Too large or too high a shoulder of the glass prevents a rapid combustion, and consequently prevents a bright flame from being obtained, and a long flickering one is the result. An adjustable damper is placed over the glass; and above this a continuous pipe of about 6 feet in length from the burner is required to produce a sufficiently rapid draught to support the combustion. When the lamp is lighted at first, the wicks are kept low for some time, and gradually made to rise for about twenty minutes, until they rise about ½ inch to ⅜ inch above the burner; then by a slight adjustment of the wicks to obtain equal height of flame, and the occasional shutting or opening of the damper P, Figs. 1 and 2, Pl. 22, a most intensely bright and high flame is obtained and kept up during the whole of the night. The diameter of the burner and flame of a first order lamp is 3½ inches, and with proper management the flame is kept up constantly to a nearly uniform height of 4 inches.

The oil used in lamps for lighthouses is the refined colza oil or rape-seed oil, which is the only oil fit for the purpose, and is much superior to the sperm oil formerly used, and is also cheaper. It burns with a brighter flame and does not cause so much deposit on the wicks, which therefore burn much longer without requiring to be trimmed. It also requires far more intense cold to thicken it than other oils, and there is therefore much less need for the small auxiliary frost lamp used in frosty weather for warming the oil in the main lamp. The thickness of the wicks is another point to be attended to, as a thin wick gives a brighter flame than a thick one under the same circumstances. When a lamp is in proper condition, supplied with proper materials, and in the hands of a moderately careful attendant, the flame can be kept up for fully seventeen hours to its full size, untouched, without requiring to have the wicks trimmed. The quantity of oil consumed in a dioptric light during a given period is thus to a certain extent a test of the efficiency of the light, as it indicates the height of flame kept up during that time.

The construction of the apparatus for producing the revolution in revolving lights is shown in Fig. 2, which represents a revolving light recently constructed by Messrs. Chance, for Russia.

The revolving platform D carrying the optical apparatus is mounted on a large cast-iron pedestal E, within which is placed the clockwork G, for producing the revolving motion. The revolving platform D is carried on twelve gun-metal rollers HH, centred on a live roller frame I, running round a fixed centre shaft J, on the top of the pedestal. The roller paths on the top of the pedestal E, and the underside of the revolving platform D, are of steel; and the rollers H are fitted on their spindles with washers of different thickness, to allow of slightly varying their positions from time to time, in order to avoid grooving the paths by running constantly in one line. The driving motion is communicated from the clockwork G by a pinion gearing into an internal toothed wheel K on the underside of the platform D. Formerly a simple spur wheel worked by the pinion was used, but it was found that the motion was never steady enough in this mode of driving, on account of the small number of teeth in contact and the backlash between them: but with an internal wheel the number of teeth in gear at a time is much greater, and the motion is rendered much more smooth and regular. The clockwork G is driven by a heavy weight, and the speed is regulated by a pair of flies on the flywheel L, which are adjusted to the proper angle for controlling the motion to the required speed. The whole of this improved arrangement of clockwork and pedestal was devised by Messrs. Stevenson of Edinburgh, for the service of the Northern Lights, where its constant use for many years has proved its great superiority over the arrangements adopted in all other revolving lights.

The optical apparatus itself is of an octagonal shape, as shown in the part plan, Fig. 4, and the frame is constructed entirely of gun-metal. The catadioptric prisms BB composing the upper and lower portions of the light are fixed in the eight gun-metal standards of the frame; but the lenses A forming the central portion are carried in separate frames, bolted to the standards, with a slight clearance left at the top, to prevent the risk of any weight coming on the rings of glass forming the lenses, which being in close contact with one another would give way under the least pressure. At the bottom the prisms B are omitted in one side to allow of access to the lamp C, which is erected upon a stand on the service table, as shown in Figs. 1 and 2. A copper ventilating tube M extends up above the lamp into the neck of the cowl, Fig. 8, Plate 24, on the plan introduced into the lighthouse service by Professor Faraday. The inverted funnels N placed at different levels in the ventilating tube afford a free escape to any accidental downward gust of wind, and thus prevent any risk of the lamp being blown out; and it is found by experience that the wind may blow in suddenly at the cowl, but the effect never reaches the lamp. The draught of the heated air in the tube M also draws off through the funnels a quantity of the air of the lightroom, thereby preventing condensation of the moist air upon the glazing of the room, which would otherwise interfere greatly with the efficiency of the light. A short length of the tube at the bottom containing the damper P, Figs. 1 and 2, is made to slide upwards, to allow of removing the glass chimney, but so as not to weigh on the glass, or fall when the glass is taken out.

The lantern, within which the whole of the lighting apparatus is contained, is shown in the part vertical section Fig. 8. It is of an octagonal shape, as shown in the part plan, Fig. 9, and is 13 feet diameter, formed of cast-iron panels with the joints planed to the proper bevil, so as to fit solid together. The standards O supporting the dome of the lantern, and forming the framing for the plate glass panes, are inclined alternately right and left, which adds greatly to the stiffness of the structure, while the light is not entirely intercepted in any vertical plane, as would be the case if the standards were vertical. The standards are of wrought-iron, of a bevil section, as shown enlarged in Fig. 11; to prevent corrosion by the action of the sea air they are protected along the outer edge with a gun-metal facing R, grooved to receive the plate glass panes S, which are then secured in their places by thin covering strips of gun-metal screwed on outside. Two sets of gun-metal astragals T, Figs. 10 and 12, to support the glazing, are fixed horizontally between the standards, at the level of the joints between the refracting lenses and reflecting prisms of the optical apparatus, so as not to stop any of the rays emanating from the light.

The glazing S of the lantern consists of panes of plate glass about ⅜ inch thick, the edges of which are ground and the arrises bevilled to prevent breakage in fixing or in any possible shaking of the lantern in a violent gale. Small strips of lead are placed between the glass and the gun-metal frames, and the interstices are filled up with putty. The glass lies entirely within gun-metal frames, and there is no difficulty in replacing a broken pane at any time. To guard against an accidental stoppage of the light through breakage of a pane in a gale, or by sea-birds flying against the glass, storm panes are provided, made of a copper frame glazed with thick glass, which are kept always ready in the light-room, and can be fixed in a few minutes in place of a broken pane. The copper dome U, Fig. 8, forming the roof of the lantern, is made double, with an air space between; and the cowl V at its summit revolves with the weathercock, to turn the openings always from the wind, allowing a free escape for the heated air from the ventilating tube of the lamp.

The efficiency of a dioptric light depends entirely upon the proper adjustment of the various optical elements which compose it. The vertical divergence of the rays of light depends on the dimensions of the flame of the lamp, and seldom exceeds an angle of 5 degrees, which is amply sufficient for all practical purposes. For an angle of vertical divergence equal to one fourth of the dip of the horizon illuminates half the whole distance from the horizon to the lighthouse; and an angle of vertical divergence equal to the dip of the horizon illuminates three fourths of that distance. Within a mile or two from the lighthouse however an angle of vertical divergence equal to the dip of the horizon illuminates only a small fraction of a mile, showing how little is gained by increasing the vertical divergence at the sacrifice of brilliancy at the horizon. Thus, for a tower of 100 feet height, about 1-6th of a degree (9′ 45″) is the amount of the dip of the horizon, and a further angle of the same amount illuminates the sea from the horizon towards the land for a length of 8½ nautical miles, the total range of the light being in this case 11¾ miles. For a tower of 200 feet height the dip is about 1-4th of a degree (13′ 46″), and a further angle of the same amount illuminates from the horizon a distance of 12 miles out of a range of 16 miles. These figures show that a vertical divergence equal to the dip of the horizon is quite sufficient to illuminate the sea from the horizon up to within a moderate range of the tower.

The efficiency of the light depends also upon its being correctly adapted in direction and divergence to the particular elevation it is intended to occupy, otherwise a portion of the brightest rays may pass above the horizon and consequently be lost, instead of being of service at and within the horizon. The dioptric system also affords peculiar facility for directing the light upon any particular point where it is more especially required. For instance: a light may be required merely as a sea light, for the purpose of signalling to mariners their approach to the land; in that case the most intense light of the whole apparatus is directed towards the horizon. Or a light may be required to illuminate the horizon, but most particularly the sea in the neighbourhood of the land, the approaches of a harbour, or some particular local danger; in that case the light of some portions of the apparatus is directed towards the horizon, and the light of the other portions is deflected towards the point requiring special illumination.

A specimen of one face of the optical apparatus, containing the lenses and prisms of a revolving light, was exhibited from Messrs. Chance's glass works; and also a specimen of the pressure lamp used for the most powerful lights; and, in the course of the discussion which followed the reading of the paper,

Mr. Masselin stated that the old mechanical lamps were complicated in construction, and the clockwork for working the oil pumps had to be got into a confined space, being more like watch-work than clockwork, and requiring a skilled mechanic properly trained to manage it; and as lighthouses were generally situated at a distance from any town, it was a serious objection to have any liability of requiring to send away to get the necessary repairs done. The pressure lamps now used were of simple construction, and stronger in all the parts, as shown by the specimen exhibited; they had no machinery about them requiring attention, and there was therefore no liability of the light ever failing from the lamp getting out of order. Of course clockwork was still required for making the lights revolve, but this was so much stronger and larger that it was not liable to get out of order, and admitted of easy repair.

Each wick was raised independently of the rest by a separate screw, and all were turned up to exactly the same level, standing about ⅜-inch above the burner, of which about ¼-inch became blackened by the flame, leaving ⅛-inch steeped in the overflow of oil standing above the burner.

The entire burner, together with the glass chimney, was readily removed by simply unfastening two screws, and it could then be immediately replaced by a fresh burner, which was kept always ready at hand in the lightroom; but such a case never occurred in practice while the light was burniag at night, because the supply of oil was maintained constantly greater than the consumption, insuring an abundant overflow, which prevented the wicks from burning down to the burner. The light was now kept up with such regularity that the wicks did not require any alteration during the whole night, after having been once adjusted to the proper level for producing a brilliant flame.

There was ample room for getting out the lamp through the space left by either omitting the bottom panel of prisms on one side of the optical apparatus, or hanging it on hinges. In the old lamps, in which the oil cylinder was made roughly of sheet brass, and therefore not truly cylindrical, the piston had to be made a very loose fit and the cupped leather large; and the piston being loaded with weights upon it was liable to get unequally weighted when the weights were changed, so that the piston was canted, and the leather turned inside out, rendering the lamp useless, and requiring the piston te be taken out for resetting the leather. This defect caused a prejudice at first against pressure lamps; but in the new lamps with the cylinder cast and bored, no such accident could occur, and they were so strongly constructed in all the parts that there was now no more occasion for providing a duplicate lamp cylinder than for providing a duplicate optical or revolving apparatus; but duplicates were provided of all the working parts of the lamp which were in the least likely to wear. The weight giving the pressure on the piston was suspended below the lamp, and could readily be increased or diminished according to the degree of fluidity of the oil in the cylinder, without disturbing the action of the lamp.

Mr. Masselin said the fountain lamps were not all abandoned yet, but they were being gradually replaced as they became worn out, by more efficient lamps. There was generally one side of the lighthouse towards the land on which the light was less wanted than on the others, and the oil reservoir was then placed on that side just at the level of the burner.

The range of the light depended on the height of the lighthouse and consequent distance of the horizon: at Lundy Island in the Bristol Channel, where the lantern was about 540 feet above the sea, the horizon was about 35 miles distant, and the light was distinctly seen at that distance. The power of the light at such a distance depended of course upon the concentration of the greatest possible amount of the rays within a very small angle, and the angle of 5 degrees was the maximum amount of vertical divergence in most cases. The extreme minuteness therefore of the angles to be dealt with rendered perfect accuracy of workmanship and adjustment in the optical apparatus of the utmost importance. The middle ray or axis of the light did not issue in a true dead level, but was deflected to the horizon, being depressed by the amount of the dip of the horizon, so as to throw the strongest part of the light full upon the horizon; and of the 2½ degrees or 150 minutes forming the lower half of the divergence, the first 10 minutes alone were sufficient to light three quarters of the distance from the horizon towards the lighthouse, in the case of a tower 100 feet high. If more of the light was wanted on the sea and less on the horizon, the axis was further deflected, so that the central rays fell on the sea nearer in than the horizon.

Mr. Masselin believed it was only in England and the English colonies that there were any lights remaining on the old reflecting system, as they had been entirely abandoned in other countries for dioptric lights; and in this country the present reflecting lights would no doubt be replaced by dioptric apparatus as soon as the reflectors required renewal. He did not know what was the greatest distance illuminated by a reflecting light, but with a sufficient number of lamps and large reflectors there was no reason why as good a light should not be obtained by the reflecting system, for revolving lights, as by the dioptric; but the cost of maintenance and consumption of oil was much greater in the reflecting system, and the whole of the reflectors required entirely renewing after a certain time of wear. The largest reflectors that he knew of were 21 inches in diameter, and the greatest number employed in any one light was from 24 to 30.

The author stated that eighty years ago there were no lighthouses deserving the name, but only a few towers with coal fires to serve as beacons; and even as late as 1820 several of the main lights, at Harwich and elsewhere, were only open coal fires with a brass plate placed behind as a rude kind of reflector. The celebrated Eddystone lighthouse was originally lighted by only a few miserable tallow candles, and in 1780 the first reflectors were used; but these were made only of plaster of Paris, hollowed to a parabolic shape, having the inner face covered over with small pieces of ordinary mirror glass set in the plaster, which were replaced in 1807 by copper reflectors silvered on the face. The old reflecting system continued in general use until 1834, when Fresnel's more perfect dioptric light was introduced into this country, the first being erected on Lundy Island. The optical apparatus then consisted of only the annular lenses forming the central portion through which the light was simply refracted, without any of the catadioptric or totally reflecting prisms by which the light was now rendered luminous throughout the entire height of the apparatus. The number of lights now in use round the coast of England was altogether about 200, of which only about 38 were dioptric lights; but in the United States there were already more than 500 dioptric lights.

The principle of adjustment was that each prism of glass in the apparatus was separately adjusted and fixed at the correct angle for the ray from a distant fixed point, to be directed in each case to a focus where the flame of the lamp was situated, so that all the rays intersected at that focus, and the whole of the light from the lamp was consequently deflected into the required direction towards the horizon. The height that the light had to be fixed above the sea being given, the angle of dip of the horizon was known, and the whole of this adjustment could consequently be made in the works by having a staff erected at a distance as the object to be viewed in making the adjustment of the prisms, the staff being graduated by calculation to correspond with the true direction of the rays if prolonged to the horizon from each line of prisms. A sight was fixed in the focus of the apparatus at the point where the brightest part of the lamp flame was to be, and each prism was separately adjusted until the image of a white line on the vertical staff was correctly thrown into the focus, a separate line for each prism being marked upon a staff specially graduated for each apparatus, according to the intended elevation of the lighthouse above the horizon. The adjustment was formerly in a few instances made at the sea coast, but by this arrangement it was now done at the works with much greater facility. Owing to the flame of the lamp being not a single point, but extending over a height of as much as 4 inches in the largest size, the central rays only could be actually directed to the intended point, and the rays from the upper and lower portions of the flame gave a total divergence of the light of about 5 degrees vertically. Formerly, and still in France, the prisms were all set to a dead level, and on account of the dip of the horizon the central ray was consequently thrown above the actual horizon, and more than half the light was lost by being thrown into the air, instead of upon the sea; but here each prism was treated separately, and set so that its central ray was depressed to the horizon or to a point somewhat within the horizon, so as to throw the greatest intensity of the light where it was most wanted for vessels approaching from a distance, and to make the greatest proportion of the light available.

During the process of adjustment the prisms were held in their places by small wooden wedges; and as soon as the adjustment was completed, they were secured by a little plaster of Paris at three points of each, which set quickly, and the remaining space was filled in afterwards with white and red lead putty; this set very hard in a few days, and held the prisms secure in their right position, and prevented them from touching the metal frame anywhere, otherwise the glass would soon get chipped.

The required accuracy of work was obtained by doing the grinding and polishing of the prisms entirely by machinery of accurate construction. The prisms were set on horizontal revolving tables, like a horizontal face plate of a large lathe, up to 11 feet diameter, the prisms of the same section and the same curvature being fixed on the same table in a continuous circular ring of the required diameter, and having one face bedded in plaster of Paris; the two other faces were then ground and polished in their position by a set of rubbers with emery powder and rouge, worked transversely by machinery as the table revolved, and moving at the required inclination or in curves of the required radius.

No appearance of prismatic colours was noticed in the light, and if there were any it was so slight as not to be perceptible, probably on account of the resolved coloured rays from the different prisms being so completely intermingled by the vertical divergence of the light as to reproduce the white light free from prismatic colours.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting at Cambridge, 1862.

President—The Rev. Robert Willis, M.A., F.R.S.

Vice-Presidents—The Rev. the Vice-Chancellor of the University of Cambridge; The Very Rev. the Dean of Ely, D.D.; The Rev. W. Whewell, D.D., F.R.S.; The Rev. A. Sedgwick M.A., F.R.S.; The Rev. J. Challis, M.A., F.R.S.; G. B. Airy, Esq., M.A., F.R.S.; G. G. Stokes, Esq., M.A., F.R.S.; J. C. Adams, Esq., M.A., F.R.S.

Secretaries for the Meeting at Cambridge—C. C. Babington, Esq., M.A., F.R.S.; G. D. Liveing, Esq., M.A.; Rev. N. M. Ferrers, M.A.

Treasurer for the Meeting at Cambridge—Rev. W. M. Campion, B.D.

General Secretary—William Hopkins, Esq., M.A., F.R.S.; *Assistant General Secretary*—John Phillips, Esq., M.A., LL.D., F.R.S.; *General Treasurer*—William Spottiswoode, Esq., M.A., F.R.S.

The thirty-second session of the British Association commenced its meetings at Cambridge on the 12th ult.

The University and the municipal authorities did all in their power to contribute to the success of the meeting, and to the convenience of the members and visitors. The Senate-house and the halls of the various colleges were thrown open for the meetings of the sections, and the corporation placed the Guildhall at the disposal of the Association for their general and evening meetings. The Fitzwilliam Museum, the Geological and Mineralogical Museums, the Observatory, the Museum of Comparative Anatomy, and the Botanic Garden were thrown open daily during the meeting of the Association.

The first general meeting was held on the 12th ult., at 8 o'clock p.m., in the Guildhall; among those present were—the Earl of Enniskillen, Lord Wrottesley, the Vice-Chancellor of the University, Sir P. Egerton, Mr. Walpole, M.P., the Dean of Ely, Mr. Fairbairn, F.R.S., Mr. Tite, M.P., Mr. V. Harcourt, Mr. E. Chadwick, Rev. Dr. Whewell, Dr. Leapingwell, Professors Owen, Huxley, Phillips, Sedgwick, &c.

Mr. Fairbairn, F.R.S., the retiring President of the Association, said—"Ladies and gentlemen. it is my pleasing duty to introduce to you Professor Willis, the next Chairman of the British Association, I need not refer to the services which Professor Willis has rendered to science; they are well known in Cambridge, and in the country, and appreciated by all the learned societies of Europe. I congratulate you on his appointment to the chair, and I am quite sure it will do honour to the British Association. Last year, at the meeting in Manchester, there were brought forward many subjects of great interest to science, which were most ably discussed, and I have no doubt the result of the meeting now taking place under the auspices of the learned Professors of Cambridge will be equally successful. It therefore gives me great pleasure to introduce to you my learned friend, Professor Willis, and to resign the chair to that gentleman, who will now address you for the first time as President of the British Association.

Professor Willis then took the chair, and delivered the inaugural address. The Professor first referred briefly to the early history of the Association, and then presented a comprehensive review of the various investigations carried out by committees or individual members, by the help of the funds of the Association. He then proceeded to point out some of the most striking advances made in science during the past year, and said:—

"In Astronomy, M. Delaunay has communicated to the Academy of Sciences of Paris the results of his long series of calculations in the Lunar Theory, destined to fill two volumes of the Memoirs of the Academy. The first volume was published in 1861; the printing of the other is not yet begun. This theory gives the expressions for the three co-ordinates of the moon under an analytic form, and carries those for longitude and latitude to terms of the seventh order inclusive, that of Plana extending generally only to terms of the fifth order. The addition of two orders has required the calculation of 1259 new terms for the longitude, and 1086 new terms for the latitude. It was by having recourse to a new process of calculation, by which the work was broken up into parts, that M. Delaunay has been able to advance the calculation of the lunar inequalities far beyond the limits previously reached.

The Earl of Rosse has given to the Royal Society (in a paper read June 20, 1861) some further account of researches in sidereal astronomy, carried on with a Newtonian telescope of six feet clear aperture. These researches are prefaced by an account of the process by which the six-feet specula were made, a description of the mounting of the instrument, and some considerations relative to the optical power it is capable of. A selection from the observations of nebulæ is given in detail, illustrated by drawings, which convey an exact idea of the bizarrerie and astonishing variety of form exhibited by this class of cosmical bodies.

Argelander, the eminent director of the Observatory at Bonn, is carrying on with great vigour the publication of his Atlas of the Stars of the Northern Heavens within 92° of Polar Distance. A large portion of this enormous work is completed, and two volumes containing the data from observation for the construction of the charts were recently published. These volumes contain the approximate places of 216,000 stars situated between the parallels of 2° south declination and 41° north declination.

Simultaneously with the construction of star-charts, among which those of M. Charcornac of the Paris Observatory deserve particular mention, additions have been made to the number of the remarkable group of small planets between the orbits of Mars and Jupiter, their discovery being facilitated by the use of charts. The last announced, which is No. 74 of the series, was discovered on the morning of Sept. 1 of this year, by M. Luther, of Bilk, near Düsseldorf, whose diligence has been rewarded by the discovery of a large number of others of the same group.

"The present year has been signalised by the unexpected appearance of a comet of unusual brightness, which, although its tail was far from being as conspicuous as those of the comets of 1858 and 1861, exhibited about its nucleus phenomena of a distinct and remarkable character, the records of which may possibly at some future time aid in the discovery of the nature of that mysterious action by which the gaseous portions of these erratic bodies are so strangely affected.

"On an application made by the Council of the Royal Astronomical Society, Government has granted £1000 for the establishment, during a limited period, under the superintendence of Captain Jacob, of an Observatory at a considerable altitude above the level of the sea, in the neighbourhood of Bombay. The interesting results of the ascent by Prof. Piazzi Smyth a few years since of the Peak of Teneriffe, for the purpose of making astronomical and physical observations, suggested to the President and Council of the Society the desirableness of taking this step.

In Chemistry the greatest advance which has been made during the past year is probably the formation of compounds of carbon and hydrogen by the direct union of those elements. M. Berthelot has succeeded in producing some of the simpler compounds of carbon and hydrogen by the action of carbon intensely heated by electricity or hydrogen gas; and from the simpler compounds thus formed he is able to produce, by a succession of steps, compounds more and more complex, until he bids fair to produce from inorganic sources all the compounds of carbon and hydrogen which have hitherto been only known as products of organic origin. Mr. Maxwell Simpson has also added to his former researches a step in the same direction, producing some organic products by a synthetical process. But these important researches will be fully laid before you in the lecture on Organic Chemistry, which Dr. Odling has kindly promised to this meeting.

Dr. Hoffmann has continued his indefatigable researches on Poly-ammonias, as well as on the colouring matters produced from coal-tar. Mr. Schlæsing proposes a mode of preparing chlorine by a continuous process, which may perhaps become important in a manufacturing point of view. In this process nitric acid is made to play the same kind of part that it does in the manufacture of sulphuric acid, the oxides of nitrogen acting together with oxides of manganese as carriers of oxygen from the atmosphere to the hydrochloric acid.

The methods of dialysis announced last year by the Master of the Mint, and of spectrum analysis, are now in everybody's hands, and have already produced many interesting results.

In Civil or Mechanical Engineering there is nothing very new.

The remarkable series of experiments carried on at Shoeburyness and elsewhere, have developed many most interesting facts and laws in relation to the properties of iron, and its resistance to projectiles at high velocities, which will doubtless be fully laid before you at some future period; but in the present imperfect state of the investigation, and in consideration of the purpose of that investigation, prudential reasons forbid the complete publication of the facts. My able predecessor in this chair, who has taken so prominent a part in these experiments, has given an account of some of the results in a communication to the Royal Institution, in May last, and also in the new volume for 1861; andis, as he informs me, engaged with a long series of experiments on this subject, which, with his experience and ability, cannot fail to develope new facts, and will in all probability ultimately determine the law of penetration."

Section G.—Mechanical Science.

President:—W. Fairbairn.
Vice-Presidents:—James Nasmyth; Professor J. M. Rankine; Dr. Robinson; John Scott Russell; Professor James Thomson; Charles Vignoles.
Secretaries:—P. Le Neve Foster; Wm. M. Fawcett.
Committee:—Robert Abernethy; J. G. Appold; Theo. Aston; Admiral Sir Edward Belcher; Geo. Bidder; Sir John Dalrymple Hay, Bart.; Professor Downing; Edw. Easton; J. M. Gilbert; James Heywood; Dr. Joule; W. Lindley; J. R. Maclean; J. McConnell; Robert Mallet; Robert W. Myine; J. R. Napier; James Oldham; William Pole; William Smith: C. W. Siemens; Thomas Webster.

Mr. Fairbairn, in opening the proceedings, said

"Every succeeding year presents to our notice some new feature of construction or some new application of science to the useful arts. Last year we had to record several new discoveries in chemical as well as mechanical science, and this year is fruitful of machinery and the industrial developments as exhibited in the courts of the International Exhibition. It is not my intention to occupy your time with a history of these exhibitions, but I may be permitted to notice some of the most interesting objects and some of the ingenious contrivances which we are called upon to witness, and which do honour to the age in which we live. Before I venture on a description of these objects I must however crave your indulgence while I endeavour to notice some of the more important improvements which have taken place in mechanical science during some of the past years.

It may be stated that there is no period of the past history of science so fruitful in discoveries as the present century. Within the last fifty years we are enabled to enumerate the application of steam as a motive power to every description of manufacture, as also to navigation, locomotion, and agriculture. At the close of the eighteenth century the power of steam and its now almost universal application was, with the exception of a few engines by Boulton and Watt, comparatively unknown. Now it is the handmaid of every description of work. This we may consider as the present state of steam and the steam-engine, and we have only to compare the small but beautiful construction of engines for private and domestic use, as seen in the Exhibition of this year, with those which propel our fleets, drain our mines, and move with clockwork precision the innumerable machines of our manufactories. To these we may add the use of steam to locomotion, and we realise the law of heat reciprocally convertible into mechanical force, or the dynamic theory of work done, in the energy of nearly 1000 horses power at fifty miles an hour.

The introduction of steam and its application to such a variety of purposes was shortly followed by that of gas, and this brilliant discovery we owe to the untutored mind of one of our first working mechanics, William Murdoch, of Soho, the assistant and contemporary of Watt. Mr. Murdoch lighted up his own house and Soho about the year 1802 or 1803, and in 1804 gas was first applied to light Messrs. Philip and Lee's cotton mills at Manchester. For some years it made little or no progress, but it was in 1814 employed for lighting the streets of towns; and we are therefore indebted to William Murdoch and carburetted hydrogen for the enjoyment of a pure and brilliant light in our streets and public buildings, and in almost every house and town in the empire. Next to gas came steam navigation, railways and locomotion, and subsequently the electric telegraph.

I shall now only advert to those departments of science in which the members of this section are more immediately interested. In taking even a cursory view of the machinery of the two annexes of the International Exhibition, we cannot be otherwise than struck with the multiplicity of the objects, the perfection of the execution, and the accuracy of the tools, together with the numerous devices by which these are attained. A very casual glance at this Exhibition, when compared with that of 1851, and that of Paris in 1855, shows with what intensity and alacrity the public mind has been at work since the people of all nations were first called upon to compete with each other in the peaceful rivalry of mechanical art. As one of the jury, I examined with care and attention the whole of the mechanical inventions and machines in the International Exhibition. There is no new discovery of importance, except that the machines are more compact and better executed than at any previous Exhibition. Taking the Exhibition as a whole, there is no very great nor very important discovery in mechanical science, but there is a great deal to be seen of a character both interesting and instructive. In land steam-engines there is nothing particularly attractive, if we except the growing importance of the horizontal, which is rapidly supplanting the beam, or vertical, engine. To the horizontal system may be applied economy in the first cost, and nearly equal efficiency in its application to mills and for manufacturing purposes. Another important feature in these engines is their smooth and noiseless motion, their compact form, and the facility with which they can be applied as helps, or assistants, to those of larger dimensions. They are, moreover, executed with a degree of finish and accuracy of workmanship which cannot easily be surpassed. In the agricultural department the same observations apply to this description of engine, where it is extensively used on a smaller scale. They are equally well made, and the country at large are chiefly indebted to our agricultural engineers for many ingenious contrivances, and for their successful application, not exclusively to the farm, but to many other useful purposes in the economy of rural life.

From the motive power employed in our manufactories and its adaptation to agriculture, let us glance at the beautiful execution, compact form, and colossal dimensions of our marine engines; and we shall find in combination simplicity of form, concentration of power, and precision of action never before equalled in this or any other country. Those who have examined the specimens of Mr. Penn and Messrs. Maudslay and Field in the International Exhibition must have been struck by the beauty and exactitude with which these engines are manufactured. In this department of construction we are without rivals, and it is a source of pride that this country, as the first maritime nation in the world, should stand pre-eminently first as the leader of naval propulsion. In locomotive as in marine constructions we are not behind, if we are not in advance of, other nations, although it must be admitted that several splendid specimens of engines from France and Germany are exhibited by some of the best makers of those countries. There is however this distinction between the continental locomotives and those of home manufacture, and that is, in this country there is greater simplicity of design, greater compactness of form, and clearer conceptions in working out the details of the parts. These operations, when carefully executed to standard gauges, render each part of an engine a facsimile of its fellow, and hence follows the perfection of a system where every part is a repetition of a whole series of parts, and in so far as accuracy is concerned it is a great improvement on the old system of construction.

The other parts of the Exhibition are well entitled to a careful inspection. In minerals and raw materials the collections are numerous and valuable to an extent never before witnessed in any Exhibition; and the articles, fuel and ores, will be found highly instructive. The machinery for pumping, winding, and crushing, is upon a scale sufficiently large and comprehensive to engage the attention of the mechanic and miner, and it is only to be regretted that in every case competent persons are not in attendance fully prepared to explain and initiate the inexperienced student in the principles of the workings, and the cases of instruments so neatly classified and spread before him for instruction.

In the machinery department, although there is nothing that strikes the observer at first sight as new, yet there are many useful improvements calculated to economise labour, and facilitate the operations of spinning and weaving; and in tool-making there never were, at any former period, so many hands and heads at work as on the occasion pending the opening of the Exhibition. I do not believe that at any former period there has been such an exhibition of machines, and of tools which are the creators and makers of the machines themselves. Some of the tools, such as the turning, boring, planing, and slotting machines, are of a very high order; and the tool machinery for the manufacture of fire-arms, shells, rockets, &c., is of such a character as to render the whole operations, however minute, perfectly automaton, or self-acting, with an accuracy of repetition that leaves the article when finished identical with every other article from the same machine. Such, in fact, is the perfection of the tool system as it now exists, that in almost every case we may calculate on a degree of exactitude that admits of no deviation beyond a thousandth part of an inch.

Among the many interesting mechanical objects exhibited in the two annexes, may be noticed as original the spool machine for the winding of sewing-thread on bobbins; the machine for making paper bags, invented by a pupil of my own; the saw riband machine, and others of great merit as regards ingenuity of contrivance and adaptation of design. In manufactures, in design, and in constructive art, there is everything that could be desired in the shape of competitive skill; and, without viewing the success of the Great Exhibition of this year in a pecuniary point of view, we may safely attribute its great success to the interesting and instructive character of the objects submitted to public inspection.

Irrespective of the Exhibition, with its invaluable and highly finished specimens, we have briefly to notice some of the improvements and changes that have taken place in the construction of ordnance, and the art of defence, and to chronicle some of the most important results which have placed the whole of our naval and military armaments in a state of transition. It is now well understood that his Majesty the Emperor of the French was the first to apply iron plates as a defence to the sides of ships, and that ships of war protected with a given thickness of plate, 4½ inches, were invulnerable to shot or shell. For a considerable length of time this opinion was prevalent, and was acted upon both in this country, France, and America. The experiments instituted by the Admiralty and War Office have to a great extent dispelled these notions, and it has been proved that a smooth-bored Armstrong gun with a 150 lb. spherical shot can pierce a 4½-inch thick plate and 18 inches of teak. In fact, it has been proved by experiment that no vessel yet constructed is able to carry armour-plates of sufficient thickness to resist such powerful ordnance as has been brought against them. Every effort has been made on the part of the Government to determine experimentally the properties of iron best calculated to resist shot, and the greatest possible care has been observed, both in a chemical and mechanical point of view, to secure the very best description of iron for that purpose. I have myself been engaged, with my friend Mr. Scott Russell, in this investigation, and I think we have attained to a knowledge of the description of iron best adapted to offer the most powerful resistance to shot fired at high velocities. All these facts have been ascertained, as also the penetrating powers of different descriptions of ordnance as compared with the thickness of the plates to be pierced. In this position the balance of force to the resistance of the plate was in favour of the gun, but with this qualification, that the gun had to sustain an explosive force of powder equivalent to one-third the weight of the shot, a charge which the gun was unable to bear. Under ordinary circumstances, with the usual charge of one-eighth weight of the shot, it might reasonably be inferred that the balance was on the side of the plate, and that guns of such heavy calibre were insufficient in strength to sustain these tremendous charges of powder. Again, it must be borne in mind that these results were only produced at certain distances, and under certain conditions of heavy charges of powder and a short range of 200 yards. The inquiry was thus hanging on the balance, when it was determined to ascertain the effect of the large Horsfall gun of 22 tons weight, with a charge of 75 lb. of powder and a 300 lb. shot, against a target representing the Warrior, with her 18 inches of teak and 4½ inches of iron. The result of this experiment was the penetration of the mass with a huge opening in the side of the target upwards of 2 feet in diameter. This experiment is probably not calculated to apply to ships of war carrying ordnance of such immense weight, but it is greatly in favour of forts where an enemy's vessel may be struck at a distance of 1000 yards. Passing from the Horsfall gun, we now come to the last and most important experiments with the Whitworth gun. The first was a 12-pounder field gun, and the second a 70-pounder naval gun; both of the guns were rifled. These experiments are very instructive, and I probably could not do better than quote from the *Times* of September 18, a statement of the effect produced by those guns. Having been present at the experiments, I can state that the account given by the correspondent of the *Times* was strictly correct in regard to the result of the experiments:—

'It will perhaps be remembered that a decided difference was established very early in the controversy between the penetrating powers of solid shot and those of shell. Solid shot at one time failed, and at another time succeeded against armour plates, according to the modified conditions of the experiment; but shells failed, absolutely and invariably. No shell could ever be driven through even a moderately thick plate of iron, and it was concluded therefore that this, the most dangerous and dreaded species of missile, could undoubtedly be kept out of a ship by a thin casing of armour. Accordingly, as a reduction of a ship's armour to the least possible weight was of great consequence, especially in small vessels, gunboats and other craft of the like description have been built in some countries with 2½-inch or 2-inch armour plates and considered effectually shell-proof. On Tuesday however Mr. Whitworth entered the field with two of his pieces, for the service of which he had specially prepared some flat-fronted hardened shells. The 12-pounders at 200 yards presently sent these shells through a 2-inch plate, backed by a foot of timber, from which simple piece of evidence the conclusion is inevitable that vessels protected to that extent only are shell-proof no longer. But in the trial of the 70-pounder an additional result was obtained. It has bren suggested that if, instead of employing a given thickness of iron in one solid piece, the armour of a ship were divided into two plates, each of half that thickness, and these plates were separated by a certain space from each other, the resisting power of the structure might be much increased. The theory was that the first plate, though it would doubtless be pierced, would so deaden the force of the shot that the second plate would repel it; and indeed, as regards solid shot, the question remains still undecided. With respect to shell, however—or rather, Mr. Whitworth's shells—we are not left in doubt, even on this point. The 70-pounder was trained against a target constructed on this principle of a double side. A strong oak frame armed with 4-inch plates was attached to a second plated to the depth of 2 inches, a space of 2 or 3 feet being left between them. The shell from this gun, fired with 12 lb. of powder only, pierced the outer side of the target completely, oak and iron together, after which it burst inside the frame and shattered it to pieces.'

From this statement we learn that 4 inches of solid iron and 9 inches of wood is no protection against shells discharged from a moderately sized gun, and that no gunboat such as those on the American waters could prevent the entrance of these dreaded and destructive missiles. In point of fact, Mr. Whitworth, with a rifled gun lighter than the 68-pounder, could destroy them by his steel hardened shells at a distance of 1500 to 2000 yards. Since the above was written another experiment has been tried with a still larger gun, rifled on Mr. Whitworth's hexagonal principle. This gun was of large calibre, 120-pounder. At a distance of 600 yards, the results seem to prove that the sides of a vessel like the Warrior are no longer shell-proof. In those experiments 130 lb. solid shot, with a charge of 23 lb. of powder, went right through the 4½-inch armour plate, and lodged in the teak backing behind. A shell of the same weight, and a charge of 25 lb. of powder, also penetrated the armour plate and exploded, tearing the wood backing, and lodged in the opposite side. From these more recent experiments we may infer that the victory is on the side of the gun, and that it may be difficult under such fearful odds to construct ships of sufficient power to prevent their destruction by the entrance of shells. Other experiments are however in progress, and means may yet be adopted to solve the question of armour ships *versus* shot or shell.

On Unsinkable Ships. By CHARLES ATHERTON,
Late Chief Engineer in Woolwich Dockyard.

COMPETITIVE rivalry in the arts of naval construction and ordnance destruction, as applied to maritime warfare, having now, as appears by recent demonstrations at Shoeburyness, reached a condition of experimental speculation prospectively of an unlimited character; and as the consideration of this subject essentially embraces the question of the capability of an invulnerably armoured ship to carry armament with reference to the size of the ship itself, it is presumed that a paper thus involving the details of naval architectural construction may be appropriately brought forward and discussed in the Mechanical Section of the British Association for the Advancement of Science.

The object of this communication is not to discuss the question —Whether, by an unlimited expenditure, ships can be made invulnerable to the assaults of all present and future ordnance, nor is it intended to damp the ardour with which peace must be upheld by the moral effect of preparation for any adverse eventuality by our practically adopting for the time being, in common with other nations, the recognised principle of "invulnerability." My object on the present occasion is simply to bring forward the question, whether the principle of "Unsinkability," as based on the average specific gravity of the materials of which a ship may be constructed and loaded being less than the specific gravity of water, and as distinguished from "Invulnerability" as dependent on armour plating, may not be advantageously introduced as supplementary to our present system of naval construction.

This subject has for some years engaged my attention, and in anticipation not only of the now-realised efficacy of direct fire, but also in anticipation of a totally new era of mortar practice not yet entered upon, whereby the decks of vessels may undoubtedly be assailed by the descent upon them of a huge weight (say 10 tons) projected to a great height (say 300 feet) at short range (say 100 yards), thereby attaining precision of descent, and falling almost vertically on the deck and passing out through the bottom of an adjacent ship. Anticipating such results, I have already by various publications, and officially in my late capacity as Chief Engineer of Woolwich Dockyard, directed attention to the principle of "Unsinkable Ships," as a means of obviating the fatal effects at sea of such devices, and I now beg reference to the following letter which appeared in *The Times*, of 12th January, 1859, explaining generally, though incompletely, the views which I entertain:—

TO THE EDITOR OF THE "TIMES."

SIR,—Many suggestions have of late been brought before the public on the construction of gun-boats, mortar-boats, and floating-batteries, with a view to make them invulnerable; and I now beg to add my views on that subject. Why not make the floating body for such special services, up to the line of its load displacement, a solid mass of material of such specific gravity lighter than water that it shall not sink, however much it may be perforated by shot? It appears to me that a solid combination might be made of cork shavings, light wood sawdust, rush stems, cotton waste, flock, hemp, and other light material, which by the aid of a solution of gutta-percha, or other chemical process, would form a solidifying mass, so tough that it could not be knocked to pieces by shot, and so light that it would be only one-half the specific gravity of water, and therefore unsinkable, however perforated by shot, and capable of carrying armament and naval equipment to the extent of nearly one-half the weight of its own displacement in tons. Such vessels of light draught accompanying fleets of war as tenders to line-of-battle ships, whence they might be manned and stored as occasion might require, would, I submit, form a useful auxiliary available for shore service, or for attacking land batteries, which deep draught ships of the line cannot approach, and would be sunk if they could.

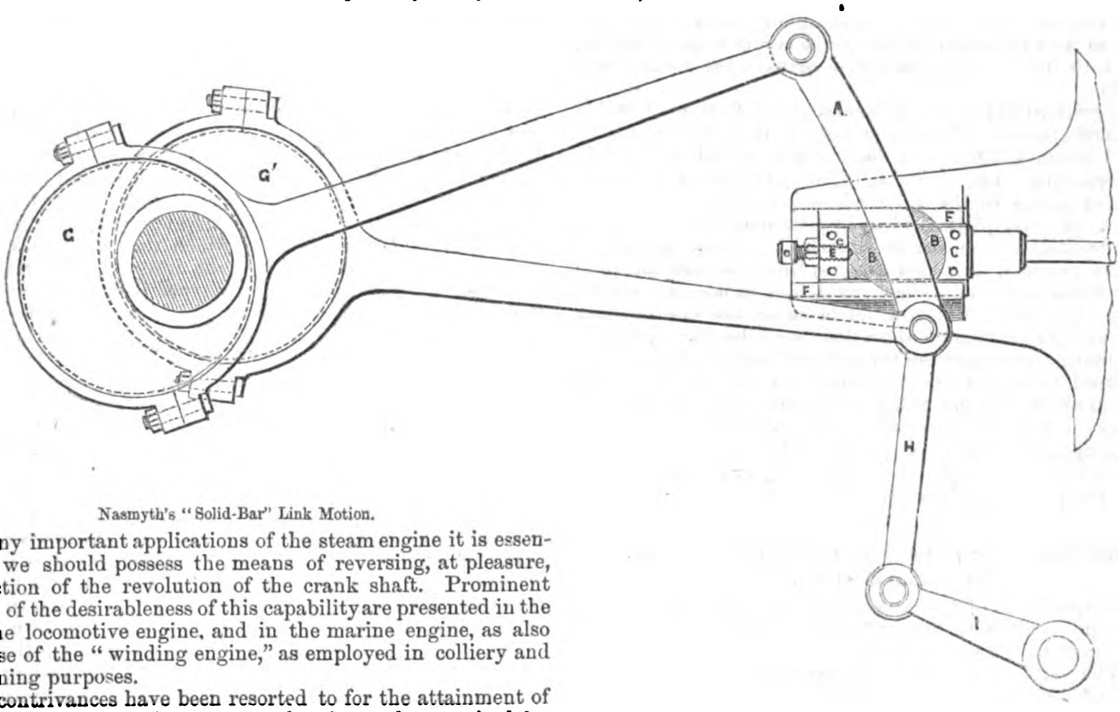
I may observe that this idea was first broached by me two years since as being applicable to the construction of vessels for carrying treasure. They might be wrecked ashore, but the treasure would be recoverable.

I am, &c.
CHARLES ATHERTON.

In respect to the practical carrying out of the general principle of "unsinkability," announced in the foregoing letter, I beg further to explain that I do not anticipate depriving war of the glory and honour which can only be purchased by blood. Without the sacrifice of blood in war the naval and military calling would be ignominious, and the national spirit would become degenerate. No, let ordnance do its best. I would however seek, in the construction of "unsinkable ships," that the life of a man may not be sacrificed by an ounce of lead, and that the whole crew of a ship may not be simultaneously drowned through the effective application of a single shot, or the descent of a single thunderbolt down through the deck and bottom of the ship, or by the lateral concussion of a hostile ram. With these views I always anticipated that the principle of "unsinkability" would, if adopted, be carried out, not exclusively by making the ship solid up to her load-line, but on various plans of arranging and disposing of the buoyant material according to the special requirements of the service contemplated, for example, a treasure ship or ship built for being laden with specially valuable goods may, if so preferred, be a mass of buoyant material up to its load-line. But a steam-ship may be constructed with its engine-room below the level of the load line, into this the water may possibly get access, but the ship when thus water-logged would be saved from going to the bottom by a sufficiency of buoyant material being constructively disposed of in various parts of the ship; such for instance as the hull and decks above the load water-line being composed of as great a mass of material as is equivalent to the entire capacity of hold in space left vacant below the load water-line.

Of course the efficacy of this system would be entirely dependent on the degree in which the specific gravity of the buoyant material may be less than the specific gravity of water. Various communications have already been made to me announcing the discovery of natural substances and artificial compounds not exceeding half the specific gravity of water, and apparently suitable for being used as a buoyant material in the construction of unsinkable ships on the principles thus set forth. The practical prosecution of the subject is so obvious, and the details of arrangements manifestly so adequate to the special objects for which a ship may be intended, that I need not, on the present occasion, encumber this promulgation of my views by entering into details. I would merely further observe that the mass of buoyant material may be so selected and disposed of that it may contribute greatly to the strength of the ship. Of course in the practical adoption of this principle, as compared with the ordinary construction of ships, there must be a sacrifice of capability, but when it is considered that the great mass of buoyant material may be distributed below the water-line, and thus conduce to the stability of the ship, instead of being above the water-line and thus impairing the stability of the ship, as is necessarily the case with the armour plating of invulnerable ships; and moreover when it is considered that the principle of unsinkability is applicable to vessels of small size, whilst invulnerability by iron armour plating can only be carried out with vessels of enormous magnitude, it may be confidently anticipated that the principle of unsinkability by the agency of buoyant materials, as distinguished from the principle of invulnerability by the agency of armour plating, is worthy of attention for mercantile purposes, especially in time of war, and as a supplementary adjunct for co-operating with ships of war in shoal waters, where armoured ships, by reason of their necessarily great draft, cannot operate. In prosecuting the operations of war, ordinary ships, defended by unsinkable ships or otherwise kept out of harm's way, would be available as barracks, hospitals, and store ships for their accompanying fleet of unsinkable ships, of which the stowage for stores may be deficient.

On an Improved form of "Link Motion," By James Nasmyth.



Nasmyth's "Solid-Bar" Link Motion.

In many important applications of the steam engine it is essential that we should possess the means of reversing, at pleasure, the direction of the revolution of the crank shaft. Prominent instances of the desirableness of this capability are presented in the case of the locomotive engine, and in the marine engine, as also in the case of the "winding engine," as employed in colliery and other mining purposes.

Many contrivances have been resorted to for the attainment of this object; all of which, however, has been characterised by considerable complexity, and consequent liability to derangement, unfaithfulness of action, and rapid wear and tear.

It was not until the invention of the justly celebrated "Link Motion," that the problem of "how to reverse the motion of a steam engine" received its perfect solution, at the hands of a mechanic in the service of Messrs. Robert Stephenson, of Newcastle-upon-Tyne, who, by the invention of the link motion, added one of the most beautiful and perfect details to the steam engine, and has thereby conferred a vast benefit on mankind. Not only does the link motion solve the problem of "how to reverse the action of a steam engine," but also we obtain by its means a very perfect and simple, variable, expansive valve motion, combined with the means of arresting in the most gentle and effective manner, the motion of the engine. In all these respects the link motion combines, in one beautifully simple whole, the properties of reversing gear, expansive valve motion, and throttle valve. So perfect in all these respects is the action of the link motion, that the form first given to it by its inventor has been almost universally adopted, and become traditionary, in so far, at all events, as regards the loop or link form of its main and distinguishing feature is concerned.

In the application of this beautiful invention to marine engines, of the larger class especially, some disadvantages, latent in the loop or link form, begin to manifest themselves; the chief of which is the constructive difficulty of taking up the slack, naturally due to the wear and tear of the swivel block working inside the loop of the link, and the consequent unpleasant knocking action and wear which naturally accompanies any such undue slackness in the moving parts; besides which, in order to give the requisite amount of rigidity to the large size of links employed in marine engines of the larger class, an amount of material has to be introduced into them that is, in every respect, desirable to avoid.

It was with the view to remove these objections, as well as to simplify and economise the cost of construction of such link motions, that the writer contrived, in 1852, what he terms his "Solid Bar" form of the link motion, and which he, in the same year, introduced into actual practice in a colliery winding engine, which he made for a firm in South Yorkshire. The perfect action in practice which was found to attend this simple solid bar form of the link motion, led his friend, Mr. Edward Humphrys, to introduce this solid bar link motion into his marine engines; in doing which, Mr. Humphrys has displayed his usual high skill and judgment in the admirable manner in which he has adapted the writer's invention; as may be seen in those magnificent marine engines of 400 horse power which Messrs. Humphrys and Tennant have sent to the International Exhibition.

As it is presumed that this subject can only interest those who are practically conversant with the details of steam engines, it will not be requisite to enter into any minute or detailed description of the "Link Motion" as such, but simply to point out the nature of the modification of form which specially characterises the inventor's arrangement of it. The main feature of which consists in the substitution of a solid bar (marked A in the accompanying figure) in place of the usual link or loop form of the part in question.

This solid bar A is coupled with the sliding block C, C, to which the valve rod is attached, by means of two cylindrical segmental rocking blocks B, B, between which the bar A slides when one or other of the eccentrics is caused to convey its chief action to the valve. The substitution of the solid bar A for the open link or loop hitherto employed, gives us a more rigid and exact agent for conveying the action of the eccentrics to the valve than is the case with the link; while it enables us, by means of the setting-up rod D, and the set-screw E, to take up all "slack" that may from time to time arise from wear, and so secure a most perfect, yet easy fit, to the bar A, in its action between the rocking segments B, B.

The two cylindrical rocking segmental pieces B, B, work inside a corresponding recess in the projecting front part of the slide block C, C, which sliding block having a dove-tail slide back, and corresponding slide recess F, F, secures the most perfect steadiness of action to the valve whose rod is attached to the block C, C. A cover plate, held on by four small bolts, the holes for which are indicated on the slide block C, C, keeps all in perfect relative position, and, at the same time, renders all quite accessible when need be. The lever I, and connecting bar H, are part of the apparatus or gear for bringing the one or other eccentric into chief action on the valve, the solid bar A sliding freely for that purpose between the rocking blocks B, B.

The general simplicity and comparative ease of construction, and "get-at-ability" of this Solid Bar arrangement of the Link Motion, has yielded the highest satisfaction in every case in which it has been applied; and as it appears to be likely to come into general use, it is so far right that the history of its invention be known by the preceding remarks.

On Machinery for Composing and Distributing Type.

By Charles Hart.

The "composition" of type consists in arranging the different characters in words with proper "spaces," between them, and again in arranging the words so formed in lines of any required length. The latter part of the process is technically called "justifying." After the type has been used in the press, it becomes necessary that each character, or "sort," should be restored to its proper position in the "case," and when undergoing this process the types are said to be "distributed."

This branch of industry is one of the very few in which the ingenuity of man has hitherto failed to effect any economy, unless attempts which have been very recently made to accomplish that desirable end shall prove successful. At this day, as in the days of Guttenberg and Caxton, the composition is effected by picking the types with the fingers out of the case, and the distribution is accomplished by reversing that primitive operation. But human ingenuity, if hitherto unsuccessful, has not been entirely idle in this matter. The International Exhibition contains no less than three machines, or rather sets of machines, for composing and distributing. They are known as the machines of Young, of Delcambre, and of Mitchel. The last-named machines have not only been rewarded with a medal at the In ernational Exhibition, but have been adopted by several printers in England, Scotland, and America. They may, therefore, be considered to have established some claim to the notice of those who are specially interested in the diffusion of knowledge.

The composing machine is in shape a right-angled triangle, placed horizontally. There is a key-board at one of the sides, and parallel with and close to this key-board there is a small iron shaft, set in motion by steam power, causing a number of parallel bands of tape to move uniformly away from the key-board, and in a direction perpendicular to it. The several characters or sorts are placed in brass slides, which are ranged in a line commencing at the right of the operator (who faces the key-board), and running across the triangle until it almost bisects the other side. In addition to the parallel bands above-mentioned, which all move with uniform velocity, there is another band, called the "main band," running along the hypothenuse of the triangle, which is greater in length than any of the others, and also moves with greater velocity. Under each of these slides one of the parallel bands is constantly kept moving, ready to convey its proper type to the main band; and, on its arrival there, the type falls into its proper place in the word. The duty of the main band is to carry the words thus formed on to a wheel, which places the type standing upright, and pushes forward the line as fast as it is formed.

One of the principal difficulties which inventors have to contend against in dealing with this subject, was to find some means by which the types could be made to arrive at their destination in the exact order in which they are struck out by the keys. Mr. Mitchel has achieved this result by causing the several types to move with a speed proportioned to the distance over which they have to travel. To understand this, it would be necessary to confine our attention to the triangle formed by the line of the slides in which the types rest, the lowest and longest of the parallel bands, and the main band. The side of this triangle formed by the main band, is about 2½ times as long as the side formed by the parallel bands. The main band moves at a speed 2½ times as great as the parallel bands. It follows necessarily that if two types are struck out at the same moment from the opposite ends of the line of slides, both must arrive together at the point of junction of the two bands, one being carried over a space 2½ times as great as the other, and at a speed 2½ times as great. By this very simple contrivance the types are made to arrive infallibly in the order in which they are struck out, however rapid may be the touch of the operator. The machine has accomplished its duty when the types have been received from the main band by the "setting wheel," which turns each letter into a vertical position, and at the same time pushes forward the line. The long line thus formed is transferred to a justifying stand, and when this is filled, the operator proceeds to justify, leaving another workman to take his turn at the keys. One composing machine, thus worked by two operators, is capable of setting up 50,000 "ens" of corrected matter per day, being about the ordinary work of four men.

The distributing machine exhibits even greater ingenuity than its companion. When one considers the great variety of sorts to be dealt with, amounting to about one hundred and twenty in all, and, further, their great diversity in thickness, it is difficult to conceive that, by a merely mechanical process, each type can be separated from the line in which it is placed, and carried to a receptacle in which it finds no type save one of its own kind.

I have indicated two difficulties, one arising from the diversity of thickness in the types, the other from the variety of sorts. The first is encountered in the separation of each type from the line, the second in conveying each type to its appropriate receptacle. As an example of the first, let us suppose the word "*mill*" presents itself to the vibrating piece of steel which separates the letters. The first letter, *m*, equals in thickness the three following letters, *ill*, taken together. It becomes necessary in this case to prevent the machine from mistaking those three letters for one, and so cutting them off all at one stroke. This is effected by means of a nick inserted in the side or edge of the thick type, into which a small bevelled stopper fits, allowing the type to advance further than it could without such nick. The following letter, *i*, having no such nick, is not permitted to advance so far, and so is cut off singly, the letter *l*, which comes next, not being allowed to come within the range of the vibrating cutter, and so on. In this way, at the first stage of the process, the machine is able to discriminate between the thick and the thin sorts, taking from the line one type at a time and no more.

The nick above mentioned is confined to the thicker sorts of type, and may be called the "separating nick," to distinguish it from those other nicks which are made in the types for the purpose of determining the receptacles to which they are to be severally conveyed. For this latter purpose each type is furnished with one or two nicks, according to the class to which it belongs. There are four classes; the first having only one nick, the other three classes two nicks. When the type has been separated from the line in the manner above described, it falls upon a brass grooved wheel, whose periphery slopes like the side of a cone. The type, dropping into one of the grooves, becomes suspended by means of its nick on a pin placed at the bottom of the groove, the ends of the type projecting below the under surface of the wheel at distances varying according to the position of the nick. At corresponding distances under the wheel there are small stationary pieces of steel which meet the projecting end of the type as it is carried down, raise it off the pin, and allow it to drop into its proper receptacle. A number of small pushers, worked by an eccentric within the wheel, push forward the type as they fall, and the several characters are thus placed in lines, each "sort" or character by itself, ready to be transferred to the slides of the composing machine.

The keys of the composing machine deal only with about forty "sorts," and so far it would seem to be imperfect. But in answer to this objection it is alleged that the sorts not worked by the keys are comparatively so rarely used that in an average page of printed matter they will not amount to five per cent. of the entire. Those sorts, namely, capital letters, italics, and numbers, are picked up by the operator from a case lying before him on the machine, and dropped into a slide, by which they are conveyed on to one of the belts, and are so carried on and set up by the machine in their proper place and order.

In addition to the saving of labour effected by these machines, it is alleged that the wear of type is diminished by their use, that a complete mastery of the machine can be acquired by a smart boy or girl in the course of a few months; and finally, that it substitutes an occupation, light, diversified, and easily acquired, for one which is peculiarly laborious and unhealthy, and to the acquisition of which a period of five or seven years is usually devoted.

Abstract of an Investigation on the Exact Form and Motion of Waves at and near the Surface of Deep Water. By William John Macquorn Rankine, C.E., LL.D., F.R.SS.L. & E., &c.

The following is a summary of the nature and results of a mathematical investigation, the details of which have been communicated to the Royal Society.

The investigations of the Astronomer Royal and of Mr. Stokes on the question of straight-crested parallel waves in a liquid, are based on the supposition that the displacements of the particles are small compared with the length of a wave. Hence it has been very generally inferred that the results of those investigations, when applied to waves in which the displacements are considerable as compared with the length of wave, are only approximate. In the present paper, the author proves that one of those results—viz., that in very deep water the particles move with an uniform angular velocity in vertical circles, whose radii diminish in geometrical progression with increased depth, and consequently that surfaces of equal pressure, including the upper surface, are trochoidal,—is exact for all possible displacements, how great soever.

The trochoidal form of waves was first explicitly described by Mr. Scott Russell, but no demonstration of its exactly fulfilling the cinematical and dynamical conditions of the question has yet been published, so far as the author knows.

In 'A Manual of Applied Mechanics' (first published in 1858), the author stated, that the theory of rolling waves might be deduced from that of the positions assumed by the surface of a mass of water revolving in a vertical plane about a horizontal axis; but as the theory of such waves was foreign to the subject of the book, he deferred until now the publication of the investigation on which that statement was founded. Having communicated some of the leading principles of that investigation to Mr. William Froude, in April 1862, the author was informed by that gentleman that he had arrived independently at similar results by a similar process, although he had not published them. The introduction of Prop. II. between Props. I. and III. is due to a suggestion by Mr. Froude.

The following is a summary of the leading results demonstrated in the paper:—

Proposition I.—In a mass of gravitating liquid, whose particles revolve uniformly in vertical circles, a wavy surface of trochoidal profile fulfils the conditions of uniformity of pressure; such trochoidal profile being generated by rolling on the under side of a horizontal straight line a circle whose radius is equal to the height of a conical pendulum that revolves in the same period with the particle of liquid.

Proposition II.—Let another surface of uniform pressure be conceived to exist indefinitely near to the first surface; then if the first surface is a surface of continuity (that is, a surface always traversing identical particles) so also is the second surface. (Those surfaces contain between them a continuous layer of liquid.)

Corollary.—The surfaces of uniform pressure are identical with surfaces of continuity throughout the whole mass of liquid.

Proposition III.—The profile of the lower surface of the layer referred to in Prop. II. is a trochoid generated by a rolling circle of the same radius with that which generates the upper surface, and the tracing-arm of the second trochoid is shorter than that of the first trochoid by a quantity bearing the same proportion to the depth of the centre of the second rolling circle below the centre of the first rolling circle, which the tracing-arm of the first rolling circle bears to the radius of that circle.

Corollaries.—The profiles of the surfaces of uniform pressure and of continuity form an indefinite series of trochoids, described by equal rolling circles, rolling with equal speed below an indefinite series of horizontal straight lines. The tracing-arms of those circles (each of which arms is the radius of the circular orbits of the particles contained in the trochoidal surface which it traces) diminish in geometrical progression with an uniform increase of the vertical depth at which the centre of the rolling circle is situated.

The preceding propositions agree with the existing theory, except that they are more comprehensive, being applicable to large as well as to small displacements.

The following proposition is new:—

Proposition IV.—The centres of the orbits of the particles in a given surface of equal pressure stand at a higher level than the same particles do when the liquid is still, by a height which is a third proportional to the diameter of the rolling circle and the length of the tracing-arm (or radius of the orbits of the particles), and which is equal to the height due to the velocity of revolution of the particles.

Corollaries.—The mechanical energy of a wave is half actual and half potential: half being due to motion, and half to elevation. The crests of the waves rise higher above the level of still water than their hollows fall below it; and the difference between the elevation of the crest and the depression of the hollow is double of the quantity mentioned in Prop. IV. The hydrostatic pressure at each individual particle during the wave-motion is the same as if the liquid were still.

Friction between a Wave and a Wave-shaped Solid.—In an appexdix to the paper is given the investigation of the problem, to find approximately the amount of the pressure required to overcome the friction between a trochoidal wave-surface and a wave-shaped solid in contact with it. The application of the result of this investigation to the resistance of ships was explained in a paper read to the British Association in 1861, and published in various engineering journals in October of that year. The following is the most convenient of the formulæ arrived at. Let w be the heaviness of the liquid; f, the coefficient of friction; g, gravity; v, the velocity of advance of the solid; L its length, being that of a wave; z, the breadth of the surface of contact of the solid and liquid; β, the greatest angle of obliquity of that surface to the direction of advance of the solid; P, the force required to overcome the friction: then

$$P = \frac{fwv^2}{2g} Lz(1+4\sin^2\beta+\sin^4\beta)$$

In ordinary cases, the value of f for water sliding over painted iron is ·0036. The quantity $Lz(1+4\sin^2\beta+\sin^4\beta)$ is what has been called the "augmented surface." In practice $\sin^4\beta$ may in general be neglected, as being so small as to be unimportant.

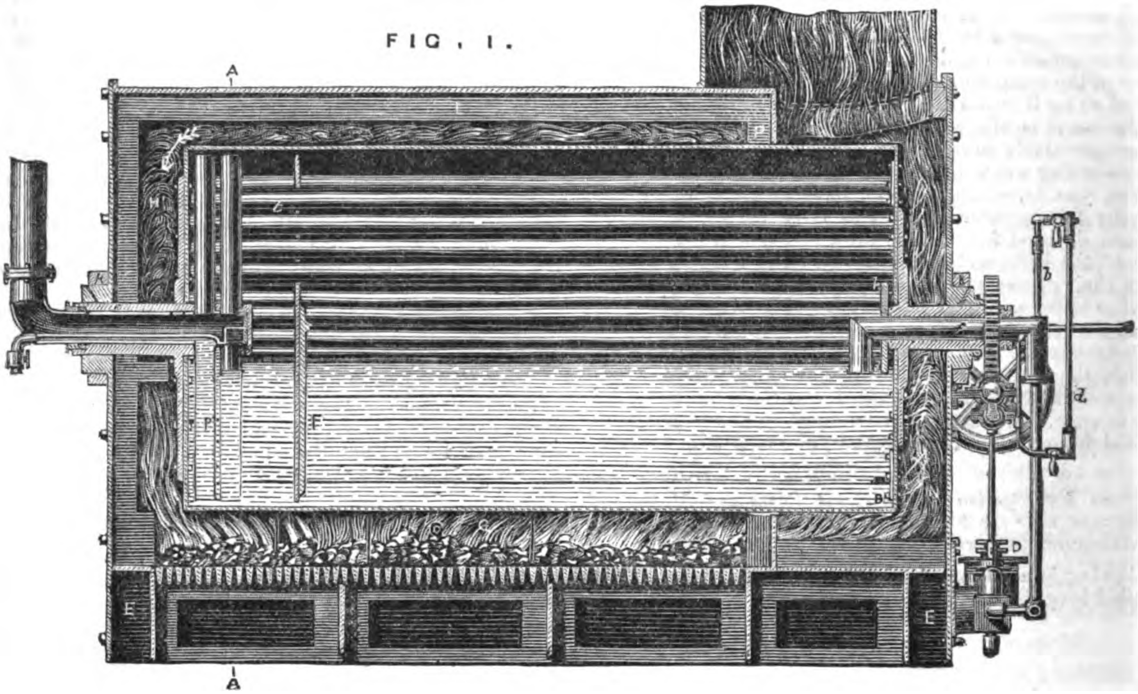
On a New Marine Boiler. By Dr. Filippo Grimaldi.

The object of the present paper is to draw the attention of the Section to a new kind of steam boiler, invented and patented by the author, adapted both for stationary and marine purposes, but more particularly to point out its advantages in the latter case, and especially when employed for generating high pressure steam, or in iron-plated ships of war, where saving of weight and space are of the utmost importance.

The peculiarity of the arrangement referred to is that of making the boiler continually rotate on its axis over the furnace while at work. This involves necessarily a complete change in the shape of the boiler, as also in the mode of feeding it, and in the arrangements for the exit of the steam.

The advantages of the arrangement as regards rapid generation of steam result from the fact that water, being an indifferent conductor of heat, this is disseminated almost entirely by a mechanical mixture of its particles, this mixture being very materially increased by the constant dipping and rising of the tubes, which are dispersed throughout the boiler. Again, it is well known that where steam is generated in contact with a heating surface, if that surface be stationary, there is considerable difficulty in the steam freeing itself from such surface, this difficulty being apparently entirely removed by slowly moving the surface so as to

FIG. 1.



Dr. Grimaldi's Steam Boiler.—Longitudinal section.

bring it successively under new portions of water; the surface being as it were swept of the globules of steam which have accumulated upon it. In the rotating boiler this continual succession of the surfaces applies both to the shell of the boiler and to the tubes, their rotation being very slow, while the water is practically stationary.

The rotating boiler necessarily assumes the cylindrical shape, no other form being so suitable. It is thus specially adapted for the generation of high-pressure steam, and is consequently well worthy the attention of those who have for some years past been aiming at the construction of high-pressure marine boilers, their efforts however appearing to have failed chiefly from such boilers being made to assume a rectangular shape; the ordinary amount of heating surface, if attempted to be obtained in a common cylindrical tubular boiler, involving considerable space, which can be ill afforded in steam-vessels.

Without attempting to fix what precise extent of revolving heating surface will in practice be found equivalent to that ordinarily allowed in marine boilers, it may here be stated that from the experience already had, about one-fifth the surface appears sufficient; 9 square feet of horizontal surface, or 15 square feet of total surface, being usually calculated as sufficient for evaporating a cubic foot of water per hour, and 3 square feet having done this with the boiler revolving. Of course this amount of surface in both cases supposes the surfaces clean; from 20 to 30 feet being frequently given to each horse-power in marine boilers as generally made. The rotating boiler (shown in the diagrams) is cylindrical with flat ends, and nearly filled with 3 inch tubes; trunnions are constructed at each end, through one of which the feed pipe passes and through the other the steam pipe, which radiates from the centre to the circumference between the tubes, the steam entering at the highest point of the boiler or nearly so, and thus taking no water with it; the upper tubes or those passing through the steam space most effectually superheating the steam and preventing priming. The safety valves of these boilers are fitted to the stationary steam pipe, and the steam and water gauges are conveniently arranged in the manner shown. The boiler is kept rotating at the rate of $1\frac{1}{4}$ to $1\frac{1}{2}$ revolution per minute, by means of a suitable connection with the screw shaft or by a separate engine, which may also serve as a donkey for feeding the boilers and other purposes.

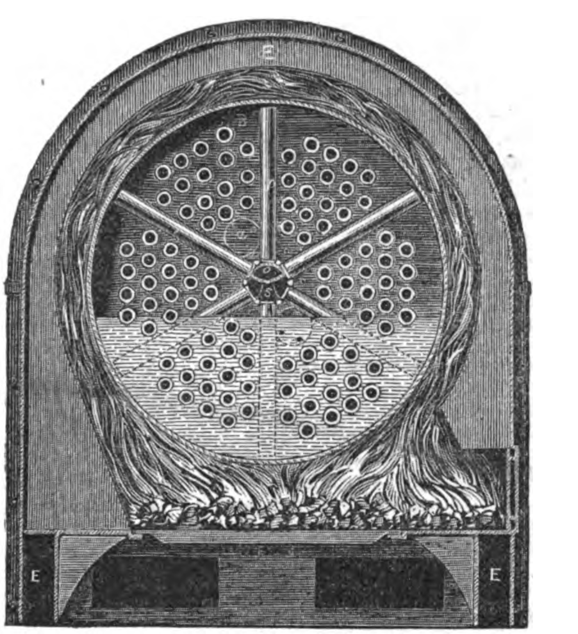
The whole boiler is inclosed in a brick-lined casing, or in a double iron casing filled with water, a few inches larger than the boiler, so as to give a flue space all round it. Every part of the shell of the boiler in its turn passes over the furnace, which is placed beneath it, the entire boiler being thus rendered available as heating surface. This, it should be explained, is one of the reasons why so small a boiler as the one experimented upon was found capable of generating so large a quantity of steam; for, taking the efficiency of moving surface as only equal to double that of stationary surface, the entire shell of the boiler—top, bottom, sides and ends, becomes heating surface, and that of the best kind, being horizontal, and brought immediately over the furnace, which is usually made to extend under the entire bottom of the boiler.

In this arrangement the plates of the boiler can never become overheated, as however small the quantity of water in the boiler, the bottom is certain to be first covered, thus rendering explosion from this cause almost impossible.

It appears that the rotation of the shell and tubes of a boiler, greatly retards, if it does not entirely prevent, ordinary incrustation. The small experimental boiler now in the Exhibition, after being at work with very indifferent water for fourteen months, was examined at about six months' intervals, and found to be covered with a light dust on the inside, but to have no appearance of incrustation; although slight traces of this were found at those parts of the boiler which did not move, such as at the feed pipe, which is stationary inside the boiler. The singular manner in which many marine boilers have been affected apparently by the action of acid formed in the greasy patches found on the sides of the boilers and on the tubes, where surface condensers are employed, has not yet been satisfactorily accounted for, but may partly be due to the scum floating on the water always being in contact with the same part of the boiler. It is more than probable that in the rotating boiler this evil will be entirely remedied, the whole surface of the shell being brought in contact with the scum, but for a very short time only as regards any one part of it. Experience is however wanting on this point.

As regards the employment of this class of boiler for ships of war, and especially for iron-plated ones, it possesses two important advantages; first its being a very low boiler, the largest size not exceeding 10 feet in height; and secondly, its weight with water and casing complete not amounting to one-half of ordinary marine boilers, even allowing the same heating surface, which, as has been stated, will probably be found to be three or even four times more than necessary. Its size is also very greatly diminished, as will be seen from the following particulars:—An ordinary marine boiler having about 1400 feet of effective heating surface occupies a space 10 ft. 6 in. by 11 ft. 6 in., and is 16 ft. 6 in. high, weighing with water $31\frac{1}{2}$ tons. This gives about 51 lb. per square foot of heating surface, and the floor space ocupied nearly equal to $\frac{1}{10}$ of a square foot also per square foot of heating surface. On the other hand a revolving boiler having upwards of 1600 feet of heating surface occupies a space of 9 ft. 6 in. by 7 ft. 4 in., and is 9 ft. 7 in. high, occupying thus only $\frac{1}{25}$ of a square foot per square foot of heating surface, weighing with water 13 tons, equal to 18 lb. per square foot of heating surface.

FIG. 2.



Vertical section of Boiler through line A A.

Thus, assuming for the moment that a square foot of heating surface is equally efficient both in the ordinary marine and the retating boiler, it will be seen that the rotating one is less in every way, viz.—

In weight, about one-third,
In bulk, about one-fourth,
In height, about one-half,
In floor-space, about one-half.

With the revolving surface only doubly as effective as stationary surface, these advantages would be just doubled; and if experience in future justifies the conclusions already arrived at, one-third of the whole amount would be the relative weight and spaces occupied respectively by a rotating boiler of equal power to a common marine one.

One word in conclusion as to consumption of fuel. On this point results of experience cannot be given, inasmuch as the boiler now in the Exhibition is too small to enable conclusions to be formed. It is 18 inches in diameter only and 18 inches long, but it has converted into superheated steam $7\frac{1}{2}$ lb. of water by the consumption of 1 lb. of coal. In larger boilers there can be no doubt that a good result will be obtained, owing first to the small quantity of water contained in the boiler, and consequently to the rapidity with which the steam is raised; and secondly, owing to the steam being in contact with one-half of the whole heating surface, thus leaving the boiler highly superheated.

The decrease in weight and size and consequently diminished cost; freedom from excessive wear in any one or more of its parts, the wear being quite uniform; the strongest possible form and freedom from liability of explosion from this cause, as also from uniformity of wear and tear; simplicity in manufacture and repaire ing—everything seems to recommend this boiler as a most suitabl- high-pressure one for steam-vessels.

In order thoroughly to ascertain what advantages can actually be realised in practice, a boiler of 30 nominal horse-power is now being constructed by Messrs. John Stewart and Son, of the Blackwall Iron Works, and which, after being fully proved upon land, will be placed on board a vessel to be subjected to the ordinary usage of marine boilers.

References to the Illustrations.

Figs. 1 and 2 represent an arrangement of rotary marine boiler. Fig. 1 is a longitudinal section through the axis of the boiler. Fig. 2 a vertical section through the line AA. B is the boiler fitted with three inch tubes *t*; *e* is the fore trunnion of the boiler projecting inside it, and fitted with six pairs of tubes *p* (Fig. 2), which radiate from the centre and are open at each end; S is the outlet steam pipe, which is stationary, and tightly fitting into the trunnion which revolves round it; the same is provided with a longitudinal opening *o*, communicating with the top tubes *p*; so that steam can only pass out through the pair of tubes which are for the time being uppermost, these being the only ones in communication with the outlet pipe. By the position of the tubes in relation to this pipe, any water which might be lifted in a rising tube would flow back to the water-space through the lower open end, and leave the tube perfectly dry, to receive the steam from the highest point of the boiler and convey it to the outlet pipe. One of the bottom tubes *p* communicates with the flow-off pipe *n*. The other trunnion of the boiler is fitted, outside the casing, with the toothed wheel C, by means of which the donkey engine D gives the boiler the rotary motion. The feeding pipe *f* enters the boiler through this trunnion; *g* and *h* are the water and steam pipes of the syphon water-guage *d*. E is the iron casing, forming the furnace G, the boiler chamber H, and the smoke chamber N. The base of the casing to within a few inches of the grate bars, is open at front and back, in order to admit air under the bars. The main frame of the casing, containing the boiler and furnace, is lined with hollow fire-bricks, formed to lock in each other, and anchored to the casing. P is the diaphragm separating the furnace from the smoke chamber. The ends of the casing are provided with doorways for cleaning and repairing the tubes of the boiler.

Suggestions on Balloou Navigation.

By Dr. Isaac Ashe.

A short time since, reading the account of the late balloon ascent at Wolverhampton, I was painfully impressed with the danger incurred by the scientific gentlemen who made it, in consequence of the vast height to which they ascended. I trust Messrs. Glaisher and Coxwell will have no objection to my referring thus to their exertions on behalf of science. The account stated that a temporary paralysis completely overpowered the former, and the latter so far that he was unable to open the valve with his hands, and was obliged to have recourse to his mouth for that purpose: had the voluntary motion of his jaws been also paralysed, it is evident that two valuable lives would have been sacrificed. I beg to suggest a little apparatus, by which, in the event of any such accident occurring again, the valve would be opened in consequence, and the balloon accordingly descend to denser strata of air, where probably the aeronauts would spontaneously recover their faculties. What I propose is, that a sufficient weight be attached to the rope opening the valve, which weight is to be supported on one extremity of a small lever having a ball-and-socket joint as its fulcrum; the other end of the lever to have a small wheel playing freely on it, and kept pressed down by a fixed and slightly inclined plane above it, and capable of being retained in that position by a catch while the balloon is at safe altitudes. When dangerous altitudes are to be reached, the wheel is to be released from the catch and to be kept under the plane merely by the aeronaut's hand; should the aeronaut unfortunately become insensible, as voluntary exertion on his part will instantly be at an end, the wheel will be left free to move, the weight will swing round, removing the wheel from under the fixed plane, and the weight will consequently drop, and in so doing will open the valve, causing an escape of gas and consequent descent of the balloon to denser strata. As a medical man I would suggest, also, that the cold had probably quite as much to do with the loss of sensibility of these gentlemen as the rarefaction of the air, which will account for Mr. Coxwell bearing it better owing to his exertions in managing the balloon. Had it been the rarefaction of the air merely he would probably have suffered more than Mr. Glaisher.

It is well known that intense cold has a strong tendency to produce a state of comatose insensibility, and that the only chance for the patient's life under such circumstances is to force him to keep awake by exercise. Hence, I think, a suggestion as to precautions for retaining the heat of the body in future ascents.

Let me now suggest the application of a principle to balloon navigation which would, I think, furnish that great desideratum, the power of steering; I allude to the principle of the screw. Steam power can of course never be used in balloon navigation on account of the weight of machinery it involves; but considering the small amount of force requisite to propel a floating body through a medium so unresisting as the air, I conceive that a man's exertions, applied by means of a screw, would be quite sufficient to give a considerable impulse to a balloon, and with such impulse a considerable power of steering. Such a screw would of course require to be very light. It might be made of oiled silk, stretched on a slight framework composed of hollow steel arms, with cross-pieces of whalebone or wickerwork, pretty much like the sails of a windmill, which as we all know are an application of the screw principle. It will be objected that at a great height exertion becomes impossible; true, but a great elevation is unnecessary for practical purposes, and a height of 1500 feet would be quite sufficient for all ordinary purposes; such a height indeed as would clear ordinary low mountain ranges, and at this height the rarefaction would be inappreciable to the sensations. Such steerage power would also prevent the unpleasant rotation which is so constantly present in balloons. By a suitable arrangement such a screw might be made capable of being hoisted while the balloon was on the ground, so as to be out of the way. If, for instance, it were made to work in what I might call a meridional band of brass passing vertically round a portion of the car, and made capable of locking the axle of the screw in either the horizontal position or one nearly verticle; if this band were also extended under the balloon, we could obtain a vertical position for the axle, with the screw working horizontally under the car when in the air; and this, I conceive, would be an object of considerable importance, for by means of it a descent could be effected without letting off gas, which necessarily diminishes the buoyancy of the balloon when it becomes necessary to re-ascend. To attain such an elevation as I refer to, the excess of ascensive power over what would be necessary to keep the balloon just in equilibrio at the surface of the earth would of course be very small, and I should suppose easily capable of being overcome by such working of the screw. By reversing the action of the screw in this position considerable ascensive power would also be obtained, which would enable the balloon to clear, say, higher mountain ranges on an occasion without necessitating the remaining at the higher elevation in consequence of loss of ballast.

Steerage might, I think, best be effected on the screw principle also, and the method proposed would, I think, be found available for checking the disagreeable rotation to which balloons are so liable, even should it not be adapted for steering purposes in connection with a propelling screw. It would consist of two small screws similarly constructed to the large one, and placed in front so as not to interfere with the elevation of the propeller, and working vertically but in a plane at right angles with that of the larger one, both the screws turning the same way. Rotation of the balloon on its own axis might evidently be effected by using these screws, and by reversing their revolutions the rotation might also be reversed, and thus the tendency to spontaneous rotation counteracted, and a definite direction impressed on the balloon.

The main direction of the balloon must of course be governed by that of the wind, but I think that with the knowledge at present possessed of the direction and persistency of aerial currents, that a near approximation might be made, by their aid alone, to any given direction; and with the additional capabilities which would be conferred by steerage power I think the balloon might become a very useful apparatus in the investigation of these very currents, a matter of so much importance to commerce and navigation. With a little additional information so gained—nay, even, perhaps with our present information—the balloon might also become invaluable in the exploration of unknown and at present almost inaccessible regions, such as the interior of Australia or South Africa. Rivers easily accessible, such as the Zambesi, might thus be discovered without the labour of a life-time being expended on the search, and whole districts be opened up.

The great difficulty of explorations on foot consists in the uncertainty of finding water, of which there may be an ample supply within a few miles, and yet the traveller pass it by undiscovered; this difficulty would be to a great degree obviated by using the balloon in preliminary explorations, since from an elevation of 1500 or 2000 feet a small pond would be discovered at many miles distance, or in a sterile country the vegetation at its sides would be an equally certain indication. A descent might then be effected, and its position obtained by observations and marked for the guidance of travellers. A little attention to the subject would enable an aeronaut readily to estimate the distance from one landmark to another, and also its bearing from it by the compass, and thus an unknown territory might be laid open with comparatively little trouble.

I dare say there may be practical difficulties in my proposals, but I think it probable that they may be overcome by a little mechanical ingenuity.

REVIEWS.

A Treatise on the Principles of Electrical Accumulation and Conduction. By F. C. Webb, Associate of the Institution of Civil Engineers. Part I. London: J. Piper.

In this small volume, the substance of which has appeared in separate articles in 'The Electrician,' Mr. Webb propounds some theories respecting the accumulation of electricity, and the conditions under which it may be excited, that are opposed to those generally received. Though opinions differ respecting the nature of electrical excitement, yet nearly all electricians have been hitherto agreed that the earth is the source whence electricity is derived. Those who assume, with the earliest experimenters, that there are two kinds of electricity—one of which is excited by the friction of rosin, and the other by the friction of glass—and those who agree with Dr. Franklin in considering electricity to be a single fluid, which becomes manifest only when in excess of the natural quantity, are equally in accord that the earth is the great storehouse of the electric fluid—as it is called, for want of a better term. It is generally agreed, also, that whether electricity be of two kinds—resinous and vitreous—or whether it consist of one kind only, in a positive or a negative state, electricity of one kind cannot be excited without bringing into action an exactly equal quantity of the opposite kind or state of electricity. Thus, for example, on rubbing a rod of glass with a silk rubber, vitreous or positive electricity is excited on the glass, and an equal quantity of resinous, or negative electricity, is excited on the rubber; but, according to the received theory, the latter is not apparent because it is distributed through the mass of the earth with which the rubber is connected. If we understand Mr. Webb correctly, it is this theory which it is his principal object to oppose. He contends that electricity is generated independently of the earth, and that the greater quantity which is excited when the rubber is connected with the ground than when it is insulated from it, depends on different conditions of what he terms the "inductive circuit." We confess to not clearly understanding his idea of the conditions necessary for electrical accumulation, we therefore quote his own words:—

"Whenever electricity is generated at a source and accumulated on the conducting surfaces connected to the two sides of that source, there exists, of necessity, as it were, a chain extending from one of these primary conducting surfaces round to the other, which chain consists, in some cases, simply of a dielectric, and in others is composed of a dielectric separating one of the primary conducting surfaces, in conductive connection with another conducting surface, which, again, is separated by another dielectric from another conducting surface, and so on until the other prime conducting surface forms one of these surfaces, thus completing the chain."

We hope our readers may have a more clear conception of the meaning of the preceding conditions for the excitement of electricity than we possess; for when electricity is excited by merely drawing a stick of sealing-wax through the hand, we fail to discover any links of the complicated chain of conditions which is stated to exist as a necessity. Mr. Webb denies that the negative electricity is absorbed by the earth when a glass rod is excited by friction, but he does not account for its disappearance in any other way. He seems to be of opinion that it is present and active even when the rubber is connected with the ground, but he does not explain why it gives no manifestation of its presence.

When considering the induction of electricity Mr. Webb also contends, with greater accuracy, as we think, that when an electric excited positively induces negative electricity on the surrounding surfaces, an equal amount of positive electricity must also be induced, but he will not accept the explanation that it is absorbed by the earth. He very ingeniously suggests a great variety of experiments by which his hypothesis might be supported; but while thus speculating on the probable and questionable results of proposed experiments, he overlooks those which the electrophorus would readily afford in illustration of the action of induced electricity. When the resinous cake is excited, and the metal plate rests upon it, the instrument presents exactly the condition for which he contends. Positive electricity is induced on the side of the plate that rests upon the electric, and an equal quantity of negative electricity is induced on the upper surface; but after touching the plate with a conductor connected with the earth, the negative electricity disappears, and on lifting the plate from the resinous cake it is found to be charged only with positive electricity. What has become of the negative quantity? According to the received hypothesis it has been absorbed into the mass of the earth and if Mr. Webb can give any more satisfactory explanation, it appears to us that he would support his theory much better than by devising, and assuming the results of, fanciful experiment.

The volume now published contains only the first part of the treatise; the contents of the second part, as announced, will relate to more practical matters, connected with the causes of the retardation of signals by submarine wires. That is a subject of great practical importance, and we hope that Mr. Webb may be able, by means of his original and ingenious mode of inquiry, to discover the means of removing that serious drawback to submarine telegraphy.

The Correlation of Physical Forces: By W. R. Grove, Q.C., V.P.R.S. Fourth Edition. Longmans and Co.

It is upwards of twenty years since Mr. Grove promulgated his ideas of the relation of the physical sciences to each other, in a lecture at the London Institution, and further investigations by himself and other scientific enquirers have tended to give coherence to, and to sanction, the idea that all the known physical forces may be produced by and reproduce each other. The researches of Mr. Joule on the mechanical equivalent of heat, which were announced in 1843, attracted attention more generally to the subject; and the essay by Mr. Grove, based on his original lecture, has now arrived at a fourth edition. The opinion expressed in his lectures, and which he repeats, to vindicate his title to be the originator of the theory of the reciprocal actions of the physical forces now generally entertained, may be quoted as a brief exposition of the assumed relations existing between them:—

"Light, heat, electricity, magnetism, motion, and chemical-affinity, are all convertible material affections; assuming either as the cause, one of the others will be the effect: thus heat may be said to produce electricity, electricity to produce heat; magnetism to produce electricity, electricity magnetism; and so of the rest. Cause and effect, therefore, in their abstract relation to these forces, are words solely of convenience."

This theory, expounded in 1842, has been extended by further consideration and by additional investigations, until it at present includes within its scope, the conservation of force and the resolution of the action of all forces into motions. According to the view now taken by Mr. Grove, all the various physical forces may be resolved into a single force, modified in some unknown manner, which operates by motions of the molecules, and whenever those forces are called into action, that action, or its equivalent, is continued for ever. It seems to follow as a necessary consequence, that as forces cannot be destroyed, neither can they be created. In this respect they are supposed to resemble matter, which it is generally admitted cannot be annihilated, nor can any new matter be created by the operation of any known causes. This consideration leads Mr. Grove into metaphysical speculations, in which he appears to delight. He leads us to infer, and even distinctly states, that there can be no new creation of force; but ingeniously as he supports his arguments by various illustrations, many instances occur to us of the apparent creations of force which the illustrations adduced fail to disprove. When, for example, certain proportions of charcoal, of sulphur, and of saltpetre are mixed together, and a light is applied to the mixture, a violent explosion ensues, which has sufficient force to rend rocks asunder. We are unable to perceive in the composition of the elements of gunpowder evidence of the pre-existence of the force which is excited by its explosion; and the effects of which, in some form or another, must, according to the doctrine of the conservation of force, be continued till the end of time. Again, in considering the mechanical equivalent of heat, Mr. Grove mentions the different effects resulting from the collision of elastic and of non-elastic balls. In the former case, he observes, there is no loss of motion, for it is transferred from one ball to the other, and there is consequently no development of heat; but when two lead balls strike together there is resistance to motion, which evidences itself by heating the metal. This illustration will scarcely apply when two lead balls are suspended by strings, and one of them is allowed to fall against the other. In that case there is no loss of motion, for if the point of impact be in line of their centres of gravity, the ball that strikes against the other will communicate to it a full proportion of its own motion, and the momentum of the two balls after impact will be equal to that of the single ball when moving with the greater velocity. There is therefore no more loss of motion than with impinging ivory balls, but there will neverthelees be a development of heat. We are obliged to attribute the heat thus developed to some other cause than the loss of motion, and the doctrine of latent heat, against which Mr. Grove protests, seems to offer the required explanation. The force of the blow compresses the metal, and it renders sensible a portion of the latent heat natural to it in its previous state. The illustration which Mr. Grove adduces of the magnetising and decomposing actions of a voltaic current in passing through a conducting wire is a perplexing problem of the apparent attainment of double effects by one operating cause, which the explanation given does not satisfactorily solve.

It would require much more space than we can now give to the subject, to notice as they deserve the arguments advanced by Mr. Grove in support of the forward position he has taken in scientific investigations, and to resist, as we feel inclined to do, being led to the consequences towards which his theory points. It would indeed draw us into the depths of metaphysical speculation; in which we should have to combat not only for the possibility of the creation of force, but for the originality of thought. In defence of the latter, we might indeed adduce Mr. Grove's own essay, which contains a vast fund of new matter deserving the earnest consideration of all philosophical inquirers We quote from his concluding remarks the following passage, in which his views respecting the non-creation of force are strongly exhibited:—

"Thus, to take an example previously noticed, and recede backwards; the spark of light is produced by electricity, electricity by motion, and motion is produced by something else, say a steam-engine—that is, by heat. This heat is produced by chemical affinity, *i.e.* the affinity of the carbon of the coal for the oxygen of the air: this carbon and this oxygen have been previously eliminated by actions difficult to trace, but of the pre-existence of which we cannot doubt, and in which actions we should find the conjoint and alternating effects of heat, light, chemical affinity, &c. Thus, tracing any force backwards to its antecedents, we are merged in an infinity of changing forms of force; at some point we lose it, not because it has been in fact created at any definite point, but because it resolves itself into so many contributing forces that the evidence of it is lost to our senses or powers of detection; just as in following it forward into the effect it produces, it becomes, as I have before stated, so subdivided and dissipated as to be equally lost to our means of detection.

Can we, indeed, suggest a proposition, definitely conceivable by the mind, of force without antecedent force? I cannot, without calling for the interposition of creative power, any more than I can conceive the sudden appearance of a mass of matter come from nowhere, and formed from nothing. The impossibility, humanly speaking, of creating or annihilating matter, has long been admitted, though perhaps its distinct reception in philosophy may be set down to the overthrow of the doctrine of Phlogiston, and the reformation of chemistry at the time of Lavoisier. The reasons for the admission of a similar doctrine as to force appear to be equally strong. With regard to matter, there are many cases in which we never practically prove its cessation of existence, yet we do not the less believe in it: who for instance, can trace, so as to re-weigh the particles of iron worn off the tire of a carriage wheel? who can recombine the particles of wax dissipated and chemically changed in the burning of a candle? By placing matter undergoing physical or chemical changes under special limiting circumstances, we may, indeed, acquire evidence of its continued existence, weight for weight—and so we may, in some instances of force, as in definite electrolysis: indeed, the evidence we acquire of the continued existence of matter is by the continued exertion of the force it exercises, as, when we weigh it, our evidence is the force of attraction; so, again, our evidence of force is the matter it acts upon. Thus, matter and force are correlates, in the strictest sense of the word; the conception of the existence of the one involves the conception of the existence of the other: the quantity of matter again, and the degree of force, involve conceptions of space and time."

THE MIDIÆVAL COURT AT THE INTERNATIONAL EXHIBITION.

LIKE the Exhibition of 1851, that of 1862 has also its Mediæval Court. Those however who recollect the glories of the former (and who does not?) will observe with regret the comparatively poor display which the present one offers. There is less space, with more inconvenience; the articles exhibited are all more or less ill-assorted, and the presiding genius of a Pugin, which lent such invaluable aid to the organisation of its predecessor, is here sadly missed. True the Ecclesiological Society have probably done their best, and but for their exertions there would probably have been no Mediæval Court at all; still the comparative shortcoming is at once discernible. We are not going to quarrel with the committee for admitting certain articles which here find a *locale*, while others, which certainly would appear to have a better claim, are banished into the "Object" court, or are scattered about in divers parts of the building: perhaps there are reasons for this with which the public are not acquainted. Whether more space could or could not have been acquired it is not our province to consider, but the present insufficient room furnishes at least some colour of a pretext for what must otherwise appear unaccountable, except on the understanding that the outside exhibitors were the unyielding parties, and voluntarily stood aloof. In either case the fact is to be regretted, since it leaves on the mind of the observer a really inadequate impression of what the state of revived Mediæval art really is.

Probably no department of ancient art had been studied till lately with less success than the secret of its principles of colouring—so severe and yet so refined; so crude and yet so well-blended; so individually coarse or gaudy, yet, in juxtaposition so well toned down. But in the elucidation of this mystery the improvements which have been made in modern stained glass have had considerable share. An entire change has come over the spirit of this work during the last twenty years, and we have now artists who bid fair to realise in their productions some of the most highly-prized efforts of the Middle Ages. So also in tapestry; Pre-raphaelite (as they are called) results of the most gorgeous kind are being produced, which are rich in the extreme, without being necessarily in the least degree vulgar. Men of unquestioned skill are giving their energies to the task of investigation, and it is no slur upon such artists as Rossetti and others that they should be lending their talents to designing hangings and furniture. Thus, on entering the Mediæval court the eye is arrested by a host of these things,—altar frontals, drapery, sideboards, cabinets, sofas, chairs, tables, book-cases, and—to stretch the point a little—organs. In the first-mentioned of these, Mr. Bodley's designs are conspicuous for their beauty, both in conception and working out. Those, too, executed by the Ladies' Embroidery Society evince the successful application of patient labour. For their designs they are mostly indebted to Mr. F. Preedy, late of Worcester, but now of London, who has thoroughly entered into the spirit of ancient examples. Messrs. Morris, Faulkner and Co. are important contributors, by far the best of their works being the different hangings; and, nextly, their stained glass, but in both form has apparently been treated quite subserviently to colour. Messrs. Harland and Fisher show some good things in the way of decoration; and Messrs. Jones and Willis a variety of beautiful specimens, of church tapestry in particular. Messrs. Cox and Son, of Southampton-street, excel more in their curtain materials than in articles of more pretension: but though everything from their establishment bears evidence of care and good workmanship, the designs themselves are not in all cases worthy of the pains bestowed upon them.

Referring to woodwork, plain and coloured, there is ample field for remark, but we must content ourselves with a brief notice of the principal objects. In point of number we believe those of Mr. Burges will claim priority of notice. They consist chiefly of cabinets, inlaid and painted in the proper Mediæval grotesque style, which, for its mere antiquity only, will always enlist admirers of a certain class. Into the discussion of how far it is desirable to cherish such conceits we are not going here to enter, but certain it is that the mania has spread far and wide; while, if anything can assist the movement among those who are disposed to view these things with a favouring eye, it must be the perfection of imitation to which Messrs. Burges, Seddon, and others have attained; whereas to the uninitiated, or those whose predilections follow a different bias, this very perfection will serve proportionately as an antidote. With a humorous fancy Mr. Burges has associated with one of his works, pictorially, the story of the "Wines and the Beers," in genuine Mediæval guise, rich in colours, and quaint in outline. The subject-decorations illustrative of Pagan as contrasted with Christian art, as depicted on one of his bookcases, are of the ultra-mediæval type; and, judged by that test, perhaps more clever than those just alluded to. The subject of the "Metals" has been happily treated on another piece of furniture, the framework of which is not however so good in design. Mr. Seddon has also a large show of furniture, in style much akin to that of Mr. Burges, and, being less recondite in treatment, is consequently more intelligible and likely to be better appreciated. If we might venture on a suggestion, it would be that some of the enrichments might have been spared with advantage to the general effect, and that perhaps a more natural flow of conventional forms (though the phrase may seem a contradictory one) would be more pleasing. On the visitor's right and left on entering this court are two small organs, built by Gray and Davison, from the designs of Messrs. Prichard and Seddon. These will bear comparison with any in the Exhibition building, so far as constructive features are concerned, but the colours, and especially the inlaying, are overdone. The pipes in the front are visible, as they should be; but the diapered ornament on them might be improved, as well as the colours in which they are painted. We may note, parenthetically, that Messrs. Prichard and Seddon exhibit several paving tiles, which are eminently successful as professed imitations of old specimens. They are partly heraldic and partly ornamental, the surface being antiquely rough, and the patterns impressed with artistic freedom. These tiles have been executed with praiseworthy ability by Mr. W. Godwin (of Lugwardine, near Hereford), whose manufactures in this material are deservedly gaining in public estimation, and who is now engaged on a large surface of pavement for Hereford Cathedral, similar in kind to that recently laid down by him at the Priory Church, Brecon. The furniture of Messrs. Morris, Marshall and Co. carries quaintness to the verge of extravagance, and with one or two exceptions must be regarded as a thorough failure. They have not the least pretension as articles of beauty, so that unless the alternative recommendations of perfect adaptation to comfort and utility are manifest, such attempts are better avoided. Gothic they certainly are, but in the objectionable sense of the word, crude and unattractive in form, and for the most part slightly framed together in black wood. The stuffed cushions, &c. are more sensible, as they are evidently intended to wear, and their sombre hues will not show the dirt as do the ordinary delicate colours. Mr. Norman Shaw's elaborate bookcase, executed in various woods by Mr. Forsyth, was described by us when noticing the gallery of the Architectural Exhibition. It is here seen to advantage as viewed along with other things of a similar kind. The specimen of wood-carving by Mr. Wilkie, of Lambeth, is deserving of mention on account of its beauty and the care with which every part has been expressed. It is small, and consists of an arrangement of foliage. The stall ends for Chichester Cathedral have been noticed elsewhere.

In stone-carving there are some clever works. In the higher order of art there is the model of the fine tomb and recumbent effigy in Canterbury Cathedral, to Dr. Mill, executed by J. B. Philip, whose enormous chimney-piece for a mansion in Cornwall, designed by Mr. Burges, is the prominent object on the left-hand side of the court. Around its front and sides is illustrated, in bas-relief sculpture, a local story, with an excellent effect. A particularly fine effigy of the late Earl Cawdor, by Mr. J. Forsyth, is quite equal—perhaps superior—to that of Dr. Mill, to which it bears some points of resemblance. We are glad to observe the new reredos which Mr. Burges has designed for Waltham Abbey Church, and which has been carved in the best style by Mr. Nicholls. In this, sculpture is judiciously distributed, and all maintained in good keeping throughout. One of the intended figures is shown by itself, decorated as proposed: this is done in positive colour, on the Mediæval (?) principle, as distinguished from the more delicate tonings of Classic art. A reredos by Mr. Earp, designed by Mr. S. S. Teulon, is not equal to the beautiful font in the "Object" court from the same hands; while another font, by Farmer, from Mr. Norton's designs, is too puny, and frittered to an absurd degree. The other font, one by Messrs. Kirk and Parry, is nothing less than positively ugly: showing a total disregard of real Gothic feeling. Two eagle lecterns, both by amateurs, may on that account claim indulgence in passing an opinion, otherwise much could not be said in their favour. The large cast for the sculpture of the Resurrection, which is to fill in the tympanum of the Digby Mortuary Chapel, at Sherborne, is here shown, and is a very impressive and noble work, from the hands of a young artist, Mr. Redfern.

We have thus adverted to the most important contributions to the Mediæval court, and can only repeat our regret that the occasion has not called for a more special and extended notice at our hands. It should not be omitted however to call attention to the fine drawing of the new ceiling under the western tower of Ely Cathedral, as proposed by the late Mr. H. Styleman L'Estrange, who had already so zealously and admirably painted the frescoes on the nave roof, and whose recent and sudden death is a loss to art which will not readily be supplied.

FOREIGN PUBLICATIONS.

'Palais, Chateaux, Hotels, et Maisons,' par Claude Sauvageot.—The issue of this work is proceeding regularly, the sixth part having recently come out. The best recent illustrations relate to the Hotel de Bogüe at Dijon. This building must be most remarkable for its richness and variety, and, though far from large, furnishes subjects for a very considerable number of fine plates. It was built at the commencement of the seventeenth century (about 1614) by Estienne Boubier, a man of note in the province, and a lover and student of the arts, and is believed to have been from his designs. Except the portico, which is Italian in its conception, the house is in style quite French—may be even called Burgundian. It belongs to that fertile local school which at the close of the sixteenth and commencement of the seventeenth centuries covered this province with edifices, and furnished them with those innumerable coffers, cabinets, and chairs of carved work which are so much sought after by collectors at the present day. A certain coarseness in execution, more abundance than elegance in details, a certain disregard of rule in the arrangement of features, but a richness and variety which are unequalled; extreme boldness in the selection of leading features and in the system of decoration, and something of a picturesque recollection of Mediæval art shining through the formality of the Renaissance;—all these characteristics are proper to the works of this school, and they all are to be found in this work of Estienne Bubier. Besides this charming house, the Chateaux of Pailly, Taulay, and Aucy le Franc, and other examples, furnish subjects for illustration. The execution of the plates continues admirable.

'Ausgefuhrte Bauwerke,' von Fr. Hitzig ('Executed buildings,' by F. Hitzig), Berlin: folio, 2 vols. *'Architektonische Ausführungen,' von E. Titz,* ('Architectural Executed Examples'). Berlin: folio, 1 vol.—are two works of much the same nature: they consist of lithograph engravings from working drawings, showing the whole or portions of executed works, with a few perspectives appended; which last, by the bye, are by no means the best executed or most creditable parts of either book. The works of Titz show talent and originality. They are in a somewhat peculiar style, a version of the modern classical manner which prevails so largely in Paris, but treated with very much greater freedom, the details bearing some resemblance to Swiss decorative work—especially in the use of pierced spandrils, and the treatment generally of the woodwork. The mouldings throughout are original and good, and the decoration often very successful. In Hitzig we have an artist of a wider range, of whose works more numerous illustrations are given, and whose designs evince a deeper feeling for the classic in architecture. This is especially shown in the house of Count Pourtales at Berlin; the dwelling-houses in the Schiffes Strasse; and the mansion on the exercising ground, also at Berlin; and several designs for houses in the suburbs. Three large castellated mansions are illustrated, all of them possessing something grandiose and happy in grouping, but eminently unsatisfactory in detail and in decorative treatment to an English eye, the art being on a par with that of the worst parts of Windsor Castle. As specimens of planning however these mansions deserve the most careful study, and display ability of the highest order, as indeed do all the plans in the book; and on this account alone these volumes would be well deserving attention. Many excellent hints are to be got from them; and the two or three specimens of internal decoration which they contain (excellently printed in colours) will be found especially suggestive to the artist.

'Die Kunst des Mittelalters in Schwaben,' ('Mediæval Art in Suabia'). *By C. Heideloff, Stuttgart*: 4to. with folio atlas. This work is one which will probably have more a local than a general interest. The district which it illustrates is hardly one of the richest in objects of architectural or archæological value. A very large number of Mediæval fragments or works still remain however scattered about through the district, and a very respectable volume, prepared with all the care of the German archæologists, is the result of the determination to illustrate them. The plates are treated with the peculiarities which beset all German engravings, and of which, certain want of skill to render foliage correctly is one. This defect is markedly present here; but in other particulars the book is well illustrated, and throughout it is very carefully prepared.

EAST INDIAN RAILWAY, NORTH WEST DIVISION.

The Consulting Engineer gives the following general progress report of the operations of the East Indian Railway in the North-Western Provinces, for the half-year ending December 31st, 1861. Up to that date 243¾ miles of railway, extending from Allahabad to Sekoabad, was open for public traffic. Since then it has been extended to Agra, making a total of 279¾ miles opened up to date:—"Thirty-four and a half miles of new line were finished during the half-year, and opened for public traffic. Progress in the next 36 miles to Agra has been delayed by the want of sleepers. This length has since been opened on April 1. The line from Toondla Junction to Allygurh is ready for permanent way, but waiting for sleepers. From Allygurh to Ghazeeooddeenugger, within 12 miles of Delhi, will be ready for the permanent way long before the latter has been laid to Allygurh. Plate-laying on the length between the Kurrumnassa and Benares will commence as soon as enough sleepers have been delivered to insure the work being carried on without interruption. Messrs. Dear and Co. have begun to deliver sleepers at the mouth of the Gunduck, and the transport department will convey them up the Ganges, and deposit them at convenient ghauts near to the line. The Chief Engineer lays stress on the growing difficulty of procuring sleepers, and advocates the use of a wrought-iron road on a section of this railway. An indent for 150,000 creosoted sleepers, to be sent out from England, has lately been referred to the Board of Directors for compliance. The Commissioners of Kumaon, Meerut, and the Superintendent of Forests in Oudh, have been addressed on the subject of supplying sleepers to this line, and inquiries are being pursued in the jungle tract south of Mirzapoor. The electric telegraph is now in working order from the Kurrumnassa to Ferozabad, near Agra, a length of 397 miles. There are 26 stations, and the working is satisfactory."

The gross receipts on the opened line amount, for the half-year, to rs. 8,67,644, and the working expenses to rs. 3,63,925. The expenses and profits are therefore respectively 41·95 to 58·05 per cent. earnings. The Consulting Engineer thinks that this shows economical working. The profit is about 2½ per cent. per annum on the expended capital—a result which seems far from satisfactory. But even from this a considerable subtraction should be made, as it includes the cost of transporting railway materials, which is estimated at rs. 2,50,242, or almost one-half of the total profits.

The Traffic Manager reports on the passenger and goods traffic, that the former is becoming more and more developed every day; that the Coaching Traffic in the half-year under review is rs. 1;30,230-2-1 in excess of that for the corresponding half-year in 1860. The increase in the goods traffic is very large, being rs. 2,05,053-8-2 in excess of the corresponding half-year, and when it is taken into account that a vast quantity of grain was sent over the line, consequent upon the famine during the half-year ending December 1860, and none this half-year, the increase must be regarded as highly satisfactory.

CLASSIFIED LIST OF PATENTS SEALED IN OCT. 1862.

1819 Merolla, S.—Fire arms—May 8
1061 Lemat, F. A., and Girard, C. F.—Fire arms—April 13
2007 Hill, T.—Rifle butts—July 12
1146 Rose, W.—Barrels of fire arms—April 19
1158 Monckton, E. H. C.—Metal for ordnance—April 21
2067 Tranter, W.—Fire arms—July 19
1281 Napier, J. M.—Machinery for manufacturing projectiles—April 30
1230 Hale, W.—Rocket—April 25
1194 Bond, J.—Projectiles—April 24

974 Colling, J.—Reefing ships' sails—April 5
982 Simons, W.—Constructing ships—April 7
991 Brown, J.—Coating ships—April 8
1004 Wright, J.—Joining armour plates—April 8
1018 Jones, J.—Constructing and arming ships—April 9
1027 Coles, C. P.—Ships' masts—April 10
1033 Bruge, G.—Protection for ships, forts, &c.—April 10
1071 Harratt, C.—Masts, yards, &c.—April 14
1085 Bedson, G.—Wire ropes—April 15
1646 Betteley, J.—Ship building and armour—May 31
1023 Nunn, W.—Ships' lanthorns and signals—April 10
1188 Phillips, J. S.—Method for propulsion of vessels—April 19
1160 Lumley, H.—Rudder—April 19
1171 Warner, A.—Vessels of war and batteries—April 29
1506 Sickels, F. E.—Steering apparatus—May 17
1243 Vaile, R.—Propellers—April 28
1362 Hopwood, T. H.—Raising sunken vessels—May 7
2006 Mennons, M. A. F.—Floating batteries (a com.)—July 12
977 Kobitzsch, R. A.—Diving apparatus—April 5
1088 Peacock, R. A.—Lock gates—April 15
1216 Aspinall, J.—Safe for ships' papers, &c.—April 25

956 Silver, T.—Governors—April 4
963 Fielding, S. R., and T.—Valves and lubricators—April 4
1016 Knoweldon, J.—Steam and other fluid engines—April 9
1063 Spencer J. F.—Steam engines—April 14
1179 Birkbeck, G. H.—Lubricators (a com.)—April 23
1159 Brooman, R. A.—Jackets to prevent loss of heat (a com.)—April 21
1191 Endean, J.—Valves—April 24
1257 Childs, D. M.—Steam engines (a com.)—April 29
1100 Stott, D.—Steam joints in paper, &c.—April 16
1128 Brooman, R. A.—Valves (a com.)—April 17
1215 Shaw, J.—Indicators (a com.)—April 25
1214 Elder, J.—Steam engines and boilers—April 25
1091 Phillipson, F. C.—Steam hammers—April 15

1129 Brooman, R. A.—Buffers and springs—April 17
1132 Rideal, S.—Railway breaks—April 17
1133 Clark, W.—Railway rail (a com.)—April 17
1210 Mansell R. C.—Railway wheels—April 25
1519 Mennons, M. A. F.—Locomotion on steep inclines—May 20
1192 Haggett W.—Locomotives—April 24

1125 Perin, J. L.—Morticing machinery—April 17
1529 Barlow, H. B.—Cotton presses (a com.)—May 21
1275 Oxley, J.—Apparatus for bread cutting—April 30
1259 Childs, D. M.—Changing the movements of machinery (a com.)—April 29
1376 Riddle, W.—Hydraulic presses—May 8

972 Begg, W.—Smoke-consuming apparatus, furnace-bars, bridges—April 5

1034 Bartholomew, C.—Circular blooms—April 10
1202 Mushet, R.—Puddling furnaces—April 24
1062 Payton, E.—Angle iron—April 14
1338 Marrel, F.—Iron bar and armour plates—May 5
1161 Attwood, T.—Kitchener April 21
1228 Alleyne, J. G. N.—Manufacture of iron and steel—April 26
1329 Wilson, T.—Manufacture of armour plates—May 5
1260 Wilson, E. B.—Manufacture of malleable iron and steel—April 29
1339 Wilson, E. B.—Malleable iron and steel—May 8

1075 Brooman, R. A.—Pumps—April 14
2267 Cooper, J.—Pumps—August 13

1900 Callebraut, C.—Sewing machines—June 28

1110 Johnson, J. H.—Wheel cutting machinery—April 16

1000 Sharpe, B.—Harrows—April 8
1188 Newton, W. E.—Manure—April 23
1262 Newton, W. E.—Mowing and reaping machines (a com.)—April 29
1731 Allison, J.—Harrows—June 10
1052 Howard, J.—Steam cultivator—April 11
1174 Boby, R.—Clod crushers—April 22
1136 Dennison, R.—Mowing machines April 19
2097 Clark, W. Manure (a com.)—July 21
1211 Drummond, P. R.—Revolving rake—April 25
1221 Fisken, W.—Steam cultivator—April 25
1253 Ross, J.—Grindstones (a com.)—April 29
1258 Childs. D. M.—Mowing machines (a com.)—April 29
1277 Carter, J. M.—Harness, &c.—April 30
1318 Fowler, J.—Hauling engines—May 3
1322 Schlickeysen, C.—Machinery for moulding bricks, turf, &c.—May 3
1894 Mennons, M. A. F.—Apparatus for reducing tumors in the limbs of horses (a com.) June 28

985 Haseltine, G.—Lamps for hydrocarbon oil—April 7
1005 Cobley, T.—Treatment of ores—April 8
1030 Deacon, H.—Caustic soda—April 10
1857 Nicholson, E. C.—Preparation of colouring matters—June 24
1058 Drewett, E.—Chemical bottles—April 12
1090 Gray, T. W.—Explosive compounds (a com.)—April 15
1235 Bischof, G.—Obtaining metallic copper and silver—April 26
1874 Peterson, G.—Hydrometer—June 26
1177 Moir, W.—Hydrometer—April 23
1184 Hodgkinson, A.—Bleaching vegetable substances—April 23
1252 Clark, W.—Preserving meats &c. (a com.)—April 29
[illegible]5 Walker, R.—Malting—May 2

1007 Andrew, J. E. H.—Looms—April 9
1010 Bullough, J.—Looms—April 9
1011 Taylor, W.—Cotton spinning—April 9
2162 Wauklyn, W.—Preparing East Indian cotton—July 30
2189 Briggs, J.—Webbs, tapes, laces, &c.—August 2
1048 Butterworth, E.—preserving the forms of cops—April 11
1056 Whitesmith, I.—Power looms—April 11
1055 Nussey, N.—Preparing fibrous materials—April 12
1086 Platt J.—Looms—April 15
1087 Platt, J.—Apparatus for cleaning wool—April 15
1120 Harling, W., and Todd, M.—Looms—April 17
1122 Murphy, J.—Loom—April 17
1134 Rivett, J. C.—Preparing fibrous materials for spinning—April 17
1193 Wheatley, H. Steam drying apparatus—April 24
1141 Stewart, R., and G.—Flyers and spindles—April 19
1171 Bates, G. W.—Dressing lace—April 26
1877 Coquatrix, J. B.—Weaving carpets—June 20
2104 Rawson, H.—Woolcombing machinery—July 24
1226 Brocklehurst, T. U.—Reeling—April 26
1833 Anderton, J.—Sizing yarn—June 21
1265 Travis, A. and B.—Carding cotton and other fibres—April 30
1280 Norton, J. L.—Drying apparatus—April 30
1286 Loy, W. T.—Carding machine (a com.)—April 30
1293 Bodden, W., and Mercer, W.—Roving machines—May 2

1043 Gedge, W. E.—Lamp for mines—April 11

980 Duncan, C. S.—Ventilating apparatus—April 7
1204 Zimard, B.—Stove for heating and ventilation—April 24
1266 Tizard, W. L.—Heating and condensing apparatus—April 29

1234 Hart, H. W.—Reflector for gas lights—April 26
1196 Winsborow, John.—Gas meters—April 24

1364 Wood, N.—Polishing plate glass—May 7
1912 Easton, W.—Annealing glass—June 30

976 Faconnet, L.—Tiles—April 5
1044 Langston, J.—Portland cement—April 9
1251 Clark, E.—Arches—April 29
1278 Prince, A.—Imitation of marble (com.)—April 30.

1165 Creeke, C. C.—Drain and other pipes—April 21
1151 Trouchon, A. P.—Constructing houses, walls, &c.—April 21

1971 Gille, J. M.—Inkstand—July 9
1328 Allman, H.—Locks—May 5
1269 Dairs, G.—Nails, screws, &c.—April 30
1250 Newington, S. W.—Tap—April 29
1246 Wells, H. F.—Screw clamps—April 29
1168 Putnam, S. S.—Forging horse shoe nails—April 22
1145 Loysell, E.—Locks, &c.—April 19

959 Moulton, G.—Rollers for calico printing—April 4
1201 Dangerfield, F.—Printing presses—April 24
1354 Clark, W.—Printing machines (a com.)—May 6
1170 Carpenter, W.—Printing in colours—April 23

1065 Tolhausen, F.—Telegraphic printing apparatus—April 14
1268 Davies, G.—Electric apparatus (a com.)—April 30
1223 Negretti and Zambra.—Thermometers—April 25

987 Jackson, T.—Pianofortes—April 7
1148 Wornum, A. N.—Pianofortes—April 19
1284 Willis, H.—Organ valves—April 30

998 Moncton, E. H. C.—Timekeepers—April 8
1481 Buckney, T.—Timekeepers—May 12

977 Brearey, W. F.—Medicated vessels—April 8
1263 Michael, H.—Aerating liquids (a com.)—April 29

1222 MacLachlan, L.—Photography—April 25

964 Brooman, R.—Cases for reels of cotton, silk, &c.—April 4
975 Clark, A.—Revolving shutters—April 5
1064 Bunnett, J.—Revolving shutters—April 12
999 Jaques, J.—Instrument for the game of croquet—April 8
1009 Hollinshed, G.—Sandwich cases—April 9
1024 Houghton, John.—Havresack—April 10
1037 Fox, W.—Brooms and brushes—April 10
1045 Rigollot, F.—Boots and shoes—April 10
1049 Clarke, W.—Leathern accoutrements—April 11
1069 Hampshire, J. K.—Safety cage for miners—April 14
1224 Newton, W. E.—Lamp chimneys (a com.)—April 25
1285 Newton, W. E.—Lamps (a com.)—April 30
1320 Newton, W. E.—Method of joining boxes—May 3
1076 Brooman, R. A.—Hobby horse—April 14
1080 Bennett, T. H.—Hats and caps—April 15
1096 Edwards, T.—Letter boxes—April 16
1097 Barbour, J.—Upholsterers' hammer—April 16
1135 Wedgewood, R.—Fire escape—April 17
1230 Clark, W.—Collars and cuffs (a com.)—April 26
2230 Haseltine, G.—Carriage wheels (a com.)—August 9
1142 Rhodes, B.—Paper and other pipes—April 19
1166 Lea, T.—Alarms—April 21
1167 Monckton, E. H. C.—Umbrellas and waterproof fabrics—April 22
1186 Bousfield, G. T.—Carriage springs—April 23
1197 Davis, G.—Malting—April 24
1233 Boyle, A.—Hair pins—April 26
1324 Lefebvre, P. V.—Fountain pens—May 3
1361 Markland, T.—Wearing apparel—May 7
1990 Townsend, E.—Boots and shoes—July 10
2052 Morrill, O. F.—Cooking stove—July 18
2075 Clark, W.—Pomade (a com.) July 21
2256 Wheeler, C. A.—Perforating paper—August 12
1237 Lester, A.—Berlin wool work—April 26
1264 Moore, E.—Shirts and dresses—April 30
1271 Miden, J.—Safety lamps—April 30
1279 Staufen, W.—A new material for the manufacture of brushes—April 30

THE SPECIAL EXHIBITION OF WORKS OF ART AT THE SOUTH KENSINGTON MUSEUM.

To the stimulus of the International Exhibition is due the suggestion and organisation of the marvellous collection of Mediæval, Renaissance, and other works of art displayed in the new buildings at South Kensington. This is familiarly known as the "Loan" Museum, inasmuch as the objects now deposited there have been lent for the purpose by their respective owners, subject to the understanding that, while no limit shall be assigned to the term of their exhibition, they may at any time be reclaimed by their several proprietors. The felicitous idea which gave rise to this collection has resulted in a success as extraordinary as it was certainly unexpected; and the interest which it awakens in the sympathies of all classes of the community is evidenced by the crowds which throng the museum both on the private and public days. Though originally intended as a kind of adjunct only to the International Exhibition, to be inaugurated about the same time, and closed simultaneously with it, this latter proposal has not been adhered to; consequently, though the products of the world's great fair are by this time dispersed, the priceless treasures in the adjacent building are, for the most part, still on view; and, now that their counter-attraction has ceased, the opportunities for careful study are enhanced, and the anxiety to make the most of them appears to be increasing rather than on the wane.

In endeavouring to present to our readers a brief record of the chief objects connected with Fine Art, as being most strictly within our province, it may be thought that this specific notice has been deferred too long; but it must be remembered that, in an exhibition of this kind, no description, however clearly and completely given, can compensate for the lack of an actual inspection; while it may be presumed, there are few who make the least pretension to an interest or acquaintance with such subjects but have long ere this found some occasion for thus personally examining them. So that what we have now to detail may rather be viewed as a deliberate *resumé* of the whole collection for useful permanent reference, than as a mere introductory key or catalogue to its contents.

It should be premised, however, that the formation of this Loan Museum formally originated with the Committee of Council on Education, who, in a minute addressed to Her Majesty's Privy Council, stated the intention of the department to assemble this special collection of works of art, "with the view, more particularly, of bringing together for temporary exhibition the finest known specimens of their several kinds in this country." The subjects thus more especially contemplated for illustration were —Decorative works in metal of the Mediæval and more recent periods; gold and silver plate, bronzes, decorative arms and armour, jewellery, enamels, earthenware and porcelain, carvings in ivory and other materials, decorative furniture, miniatures, &c.; and an efficient managing committee was speedily organised to give practical effect to this resolution. The main classification of objects, as above enumerated, was rigidly adhered to; but the general scheme admitting of subdivision, many kindred features were introduced, of more or less importance and subserviency to the whole; while a very proper regulation was enunciated from the first, which was that, as the aim was less the formation of a very extensive collection than that of an extremely select and systematic one, the reception of unnecessary or duplicate specimens must be avoided; and also, on the other hand, that the most careful consideration should be exercised in the selection of the real and acknowledged treasures of art alone desired on this occasion. These additional classes furnished a by no means unimportant supplement, embracing, among others, works in marble and terra-cotta (within the period assigned), cameos and engraved gems, niello and impressions from ancient nielli, engravings, implements and utensils of ornamented cutlery, mosaics, glass, textile fabrics in general, including articles of costume and lace, bookbindings, and illuminated manuscripts.

This noble attempt has succeeded, as we have stated, far beyond the expectation of its projectors. Thus, here are concentrated the splendour, wealth, and curiosity of the central gallery of the Manchester Exhibition, of the temporary museums formed by the Society of Antiquaries and by the Archæological Institute, the exclusive gatherings of the Fine Arts Club, and the wonders exhibited at Ironmongers' Hall last year. The thorough arrangement of so overwhelming a mass of articles, amounting to many thousands, has of necessity proved an insuperable difficulty, and even with the help of the excellent catalogue which has now—unfortunately too tardily—made its appearance, it is next to impossible to follow their order as enumerated, owing to so many of the most important objects having been removed to more conspicuous positions. But these disadvantages are more than counterbalanced by the opportunities thus furnished for thoroughly minute investigation, and the observer is amply repaid for the additional trouble caused by the displacements.

In dealing with the subject at large, it will be evident that, from the limited space which can be devoted to its consideration, our remarks must be chiefly confined to such portions as bear a legitimate and practical value in relation to the several branches of architectural art, and our aim will be to dwell particularly upon such instances of applied skill as, either from their variety or their instructive elements of design or workmanship, claim this distinction. A very few words must suffice on the subject of the sculptures in marble, terra-cotta, &c. and carvings in ivory. In the former of these the most interesting are some of the productions of Michael Angelo and Torregiano; and there is a very fine circular relievo in "gesso duro" (No. 21), ascribed to Lorenzo Ghiberti, It is, unquestionably, a Florentine sculpture, the subject being the Virgin and Child with Angels. There is also (6) a good specimen of "Della Robbia ware," circa 1460; being a statue or group in the round, in terra-cotta, the drapery and accessories enamelled. The very numerous and extraordinary collection of sculptures in ivory, lent by Mr. Webb, will be viewed with interest by all who can appreciate the extreme care and delicacy required in such works. Some of its various specimens date anterior to the 13th century, and the series is continued, through various stages, to the Renaissance. These subjects are 122 in number, and consist, for the most part, of small diptychs, triptychs, and devotional tablets, carved with scriptural and allegorical groups in the most exquisite manner. Besides these, there are some crosiers and other objects of religious use; also some remarkable coffers and caskets. A beautiful example is of the third century, and is a small bas-relief, in height six inches, and representing a part of a sacrificial procession. The roughness of this specimen points to perhaps the very start of the art. No. 39 in the catalogue is the first example of Christian art in ivory, and belongs to the sixth or seventh century. It is a book cover in five panels, bound by metal bands, and represents the Virgin and Child, with figures on each side, probably of Isaiah and Melchisedec. A medallion of a head of our Lord, supported by angels, is above, and three scenes from the Nativity below, the middle figures. A Byzantine bas-relief of the ninth century represents SS. Peter and Paul, with an angel between, and above the Greek words ΠΟΛΙΟ ΡΩΜΗ, which, on a Byzantine carving, seem to require some explanation. A tryptych, or hinged altar-piece, of the fourteenth century, is a good work and interesting. No. 105 is curious from the fact that the group of the Virgin and Child bears traces of painting and of metal work added to the ivory.

In the collection of ivories belonging to Mr. Brett will be noticed several beautiful pierced tablets, such for instance as (197), which is in four pieces, and contains sixteen subjects from the life of Christ, surmounted by Gothic canopies and elaborate tracery; in the spandrels are angels playing on musical instruments. The date is about 1400. (202) is a triptych carved from narrow pieces of bone, set in marquetery borders: it is of North Italian work, fifteenth century, and belongs to the Bodleian Library, Oxford. A devotional tablet, representing the Crucifixion and the Adoration of the Magi, is also particularly meritorious. Mr. H. G. Bohn has a tablet with a filigree metal border, which is curious, and seems to us later than the date assigned in the catalogue, which is the ninth century. Mr. G. H. Morland has a beautiful tryptych of nearly eight inches in height, and bearing numerous delicately-wrought figures in groups, under Gothic canopies; it is of the period of the fourteenth century. Mr. Edward Waterton has a similar, but smaller, tryptych; and from Stonyhurst College there are several beautiful specimens of tryptychs and tablets. Mr. Hope Scott has a very pretty group of the Virgin and Child, which belonged to Syon Nunnery, and is of English workmanship, between 1200 and 1300 A.D. An exquisite crosier head belonging to Mr. P. H. Howard (206), is in every sense a most remarkable production; on one side is a representation of the Virgin and Child, seated, and attended with angels; below are diminutive figures of the three kings; on the other side is our Lord, seated in judgment between two angels, bearing emblems of the passion; at his feet are human figures issuing from their tombs. The upper part of the crook is pierced and composed of very elegant running scrolls of foliage; on the knop are the twelve apostles arranged under six canopies, with two niches in each. It is of English work, date fourteenth century. Mr. Beresford Hope has also a good, but a plainer, crosier, entire, the crook representing the coronation of the Virgin Mary, as Queen of Heaven. This is also of the fourteenth century. A crosier head from the Ashmolean Museum at Oxford belongs to a similar period, but has been supplemented by silver work of a later date. Some ivory horns, by which the owners hold tenure of manors and forests, are remarkable, the most interesting being the Bruce horn, belonging to the Marquis of Ailesbury. It is a plain polygonal horn of ivory, mounted in silver gilt, and enamelled; the two upper bands are decorated with quadrangular panels incloaing figures of animals, with a ground in translucent enamel representing landscapes; round the mouth is an arcade with birds; the other two bands are more recent. The belt is studded with enamel plates, with the arms of the Earl of Moray, probably those of Thomas FitzRandolf, nephew of Robert Bruce, and Regent of Scotland, who died in 1331. This belongs, it is supposed, to the fourteenth century. Some chessmen of the twelfth and thirteenth centuries bear witness to the great antiquity of the intellectual game. The most complete set belonging to the former period is the property of Lord Londesborough, who is a large contributor to the Loan Museum. A statuette of Jonah, from a marble statue attributed to Raffaele, is an exquisite work of art, which will repay examination. The Tutbury horn, or tenure horn of the honor of Tutbury, in Staffordshire, is a plain horn, with a belt of black silk and silver mountings; at a junction in the belt is a silver shield with the arms of France and England quarterly, differenced by a label ermine, and impaling Ferrers Earl of Derby. The length of this horn is one foot, and it is in date early in the fifteenth century. Both these horns have been described in the Archæologia. An oval dish in ivory, belonging to Mr. Beresford Hope, is most elaborately and minutely carved in many compartments with hunting subjects; also the ewer to stand upon it, in stag's horn, mounted and inlaid with ivory, is minutely carved in the same style as the dish; being apparently the work of an eminent artist of the school of Augsburg. We may mention, also, as a curiosity in this class, a tankard in ivory, richly mounted in silver, the property of the Earl of Derby. The subject of the carving is a Bacchanalian procession; the silver base and cover are of old English work of the last century, and at the top is the crest of Horace Walpole. There are in all 277 separate objects in carved ivory, which form this section of the exhibition.

Of "Art Bronzes" (as they are termed) there are no fewer than 399 specimens, mostly of statues and busts, and of Roman workmanship. There are however, interspersed among these, some very elegant domestic and other articles, viz., a bronze saltcellar, belonging to Mr. C. D. E. Fortnum; also a triangular sweatmeat-stand, or saltcellar, belonging to the same gentleman. It is in gilt bronze and silver; the lower part or stand formed by three sea-horses; the bowl formed by pecten shells in silver, and surmounted by a gilt statuette of Neptune. A bronze candlestick, the stem of which consists of a statuette of Venus, holding up a vase or basket which forms the nozzle, and whose wide base is richly ornamented in relief with amorini, arabesques, &c., is an exquisite Italian work of the first half of the sixteenth century; the height is only 8½ in. So also we would direct attention to a bronze knocker (460 in the catalogue), which forms a decorative composition of cornucopias and terminal figures, the latter jointly upholding a pedestal, on which (in the centre of the composition) stands an elegantly draped female figure; in the lower portion is an eagle perched on a severed human head. It is of Florentine (?) workmanship, the period being about 1520. There is a historic curiosity in the life-sized bust of Henry VII., ascribed to Pietro Torregiano. This bronze is apparently a contemporary reproduction by Torregiano of the bust of the effigy from the tomb in Henry VII.'s Chapel at Westminster: its height is 2 ft. 4½ in. The Rev. Montague Taylor sends, among other things, a mask (463) of a marine deity (Scylla ?), surrounded or composed, in a decorative sense, with dolphins, &c. Portions are plated or damascened with silver, and the eye-balls are formed by rubies. This rare specimen of Græco-Roman work was found at Pompeii. It appears to have been originally an appliqué ornament to a bronze vase.

Furniture, considering the wide range it embraces, appears to be rather feebly represented, both as regards numbers and the circumscribed nature of the designs; these being either for the most part Renaissance, or depending for effect upon surface and inlayings, usually of a highly florid description. Moreover, since no particular arrangement has been followed in their classification, the different articles are deposited in various parts of the rooms, whence it is not easy to obtain a just appreciation of their comparative merits; nor is the catalogue, in this particular, of any signal service. Numerous large ebony cabinets will perhaps most attract the eye, and not undeservedly. Thus (802), the property of Mr. R. S. Holford, may be taken as a fair type of the majority: its dimensions are 7 ft. 3 in. in height, by 6 ft. 3 in. in width, and it dates about the first half of the seventeenth century. The panels are elaborately carved with scriptural subjects in bas-relief, and, by way of contrast, other portions are in full relief, such as scroll ornaments, statuettes, &c. There is another kind of decoration observable in some of the cabinets, namely, by oil paintings in the panels. Of this kind the most notable specimen is (803), from the Penshurst collection. The front is inlaid with twenty-one small paintings in oil, by eminent Dutch masters (Berghem, Paul Brill, Polemberg, and Bonaventura Peters). Two small highly-finished landscapes, with cattle and pastoral figures, by Berghem, are conspicuous in the lower part. These paintings are highly finished, and as fresh as when first produced. The date of this cabinet is the seventeenth century, and it has long been an heir-loom in the Sidney family. Two knee-hole tables (811, 812) are quaintly constructed. These are similar in age and design (circa 1700), and are made of old red boule, with drawers on the top, and mounted with ormolu and silver. (825 and 826) are the property of the Duke of Hamilton: the former is a cabinet or secretaire in marquetery, mounted in ormolu, the panel in the upper part contains an oval medallion in ormolu; subject, a trophy or group of doves, a quiver of arrows, garland of flowers, &c.; the lower panels, in marquetery, are ornamented with elegant arabesques, wreaths of natural flowers, &c.; the signature of the artist, "Riesener fe., 1790," is visible in the right-hand lower corner. The latter is a small square étagère or writing table, "en suite" with the previous piece; the top inlaid with a trophy of books, natural flowers, a bow and arrows, quiver, &c., elaborately mounted in ormolu, with hanging festoons of flowers, &c. These specimens, with a third "en suite," now at Hamilton Palace, were executed for Queen Marie Antoinette; the marquetery, as indicated by the signature on the cabinet, is the work of the celebrated "ébéniste" Riesener; whilst the ormolu mounts are believed to be by the equally famous "ciseleur" Goutière.

Her Majesty the Queen exhibits (827) a circular-fronted secretaire in marquetery, richly mounted in ormolu; at each end is a beautiful branched candelabrum in gilt metal, and at the summit a pierced gallery. The marquetery decoration consists of elaborate trophies of natural flowers, books, and various emblems; both marquetery and chasing are of the utmost possible excellence. This chef-d'œuvre of French cabinet work is doubtless the work of Riesener, but of an earlier date than the preceding specimens. Its height is 3 ft. 10 in., and its width 4 ft. 3 in. Her Majesty also sends a pair of encoignures in marquetery and ormolu, surmounted by Griotte marble slabs, very beautiful specimens of the work of Riesener (?), executed probably towards the end of Louis XV. or beginning of Louis XVI.'s reign. A third contribution, from the same source, is one of the well known attractions at Windsor Castle. This, too, is a cabinet, in mahogany, richly mounted in ormolu, supported on eight legs formed as quivers of arrows; at the summit an elaborate composition in ormolu, of scroll work, amorini, &c., flanking a shield of arms. This magnificent cabinet, a masterpiece of the celebrated French "ébéniste" and "cisileur" Goutière, was executed either for the Comte de Provence—afterwards Louis XVIII., or the Comte d'Artois—Charles X.—circa 1770-80. Probably one of the most perfect and brilliant specimens of old Sèvres inlaid furniture ever executed is the cabinet belonging to Mr. Mills, (835). It is mounted in ormolu, and inlaid with four large oval plaques of Sèvres porcelain, which have green margins. Its dimensions are, height 3 ft. 11 in., width 2 ft. 8 in. The two large panels in front are exquisitely painted with "corbeilles" of flowers. We must not omit reference however to the nuptial casket of old Japan lac, inlaid with mother-of-pearl, circular topped, which belonged to Margaret, Duchess of Norfolk, daughter and heir of Thomas, Lord Audley of Waldew, and who was the second wife of Thomas Howard, 4th Duke of Norfolk, beheaded by order of Henry VIII., 1572. The date of her marriage has not been ascertained. This beautiful coffer doubtless contained some of the most precious portions of her *trousseau*. The present fortunate possessor is Mr. Philip H. Howard, of Corby.

The "objects of ancient Irish and Anglo-Saxon art," which compose Section 5, are very numerous; articles of dress, such as brooches, fibulæ, and armlets, being especially frequent. Thus, in Irish work (855) a circular torque, or breast ornament of gold, is the largest known. It is formed of four flanges of metal united along their inner edges and then twisted; the ends solid, recurved so as to form hooks; one of these prolonged for 10½ inches in length into a projecting bar. It was found (1810) at Tara, co. Westmeath, and now belongs to the Royal Irish Academy, (869) is a very curious relic, in the possession of the College of Columba; a portion of a bronze ornament, heart-shaped, and formed of a double volute, enamelled, and inlaid with vitreous mosaics; with three sockets for bosses, one retaining a portion of blue glass. The back is rudely lined with interlaced ornament, in which occurs the emblem of the fish. It is of ancient Celtic work, tenth or eleventh century in date, perhaps a portion of ornament from a shrine, and is figured in the article on "Vitreous Art," by A. W. Franks, M.A., in the "Art Treasures of the United Kingdom." The "Tara" brooch (874) will also be examined with interest. It is of white bronze, annular, the expanded portion occupying nearly half the diameter; the depressed parts overlaid with plaques of gold, to which is soldered gold interlaced filigree of great delicacy and elegance. Bosses and lines of brown amber and small portions of glass and lapis lazuli (?) are set in the projecting parts. To one side is attached a piece of silver chain similar in design to that made at Trichinopoli; the wedge-shaped head of the pin is similarly ornamented with filigree, &c. It is Irish work of the twelfth century; its diameter, 4 in., and the length of pin, 9 in. (892) is a bronze fibula, formed of a central arched band of metal, with expanded ends, overlaid with thin bronze of a somewhat different alloy; the plaques covering the expanded ends are rivetted on and hammered up into a very peculiar scroll ornament; the covering metal of the central arch is soldered on and repoussé in an interlaced braided pattern. The back is minutely punctured round the edges, and shows traces of silvering. The pin and its fastening loop are complete. This remarkable fibula may probably be of very early date; it certainly seems of Irish work. It belongs, as do many of the most valuable in this department, to the Royal Irish Academy, Three pastoral staves (895, 896, 897) display some peculiarities in their design as compared with those of English or more foreign work. The former of these is of yew, overlaid with bronze rivetted on, and having the surface covered with interlaced ornament in repousse. There are also indications of enrichments of bands, and rows of studs which appear to have been of coral and of glass respectively. In the next, "the Clonmacnoise crosier," the staff is also overlaid with bronze; the curved head inlaid with silver, and nielloed in an interlaced pattern; surmonnted by a row of grotesque animals, carved in bronze, joined together; a portion of these only remains; the end of the crook has the figure of a bishop treading on a dragon; a projecting band of ornament below the head is formed of grotesque monsters with feet and tails interlaced, as is frequent in ancient Irish work, and set with studs of blue glass; a projecting band of ornament, inlaid with silver and nielloed, surrounds the centre, and another band, with inserted plaques of interlaced ornaments, and with sockets for studs of glass (?) surrounds the staff above the spike at its base. In the third staff the head is partly gilt, and set with bosses of glass or vitreous mosaic, and surmounted by a lacertine openwork ornament, terminating in a monster's head, with blue glass eyes. A projection of ornament surrounds the centre; the lower portion of the staff nielloed and inlaid with silver, as is also the ornament finishing. It appears from inscriptions on it, to have been made for Nial Mac Mic Deducain, Bishop of Lismore, who died 1112-1113. Besides the ornaments in niello, there is a lavish use of damascening and enamels. It has been supposed that these latter were fabricated by putting sundry small sticks of glass together in a pattern, then heating them and drawing them out until they became much more slender. In this state the roll of glass was cut into slices, which was afterwards fluxed into the metal settings made to receive them.

The Shrine of St. Manchan, or St. Monaghan, is a coffer of yew, the sides sloping together from the base upwards to a steep roof-like ridge; mounted in gilt brass or bronze; standing on four legs, from three of these project strong brass rings, 3 in. diameter, through which staves to carry the shrine might have been passed; the fourth ring is wanting. On each of the sloping wooden sides is rivetted a bronze ornament in form of a Greek cross, 19½ in. by 18½ in., with hollow hemispherical bosses at the ends of the limbs, 3¾ in. diameter, engraved with interlaced patterns; a similar large boss in the centre of each cross seems to have been ornamented with silver-gilt repousse plaques, one of which, showing a leaf ornament, remains. Beneath the limbs of one of the sides of the crosses are rivetted ten bronze figures of saints, gradually diminishing in size from 6½ in. to 5 in. The angles are bound with brass, supported by grotesque animal heads, with eyes formed of dark enamel or glass, four of which, and fragments of others, remain. Along the base of the shrine the interspaces are filled with oblong pieces of enamel, 1½ in. long by ⅜ in.; deep yellow and red in angular patterns; four pieces of similar enamel ornament the limbs of each of the crosses. The wood of the coffer is now uncovered over all the remaining surface of each side. The triangular ends are filled with brass plaques, chiseled with interlaced lacertine patterns in relief; framed in an edging 1 in. wide of engraved brass. This very remarkable monument of ancient Irish art appears to belong to the same period, and perhaps to the same workshop, as the "Cross of Cong," now in the Museum of the Royal Irish Academy, and of which full-sized coloured drawings are exhibited near the shrine; it was in all probability made in the beginning of the twelfth century. The remaining specimens of Irish work consist of a reliquary, in the form of a hand and fore-arm (898); two "shrines," of the Gospels and Psalter respectively; "the Dunvegan cup," a cup or "mether" of yew, quaintly devised as to its pattern, and having an inscription in black letter round its rim; and within, on each side, the sacred monogram I H S; and a "drinking horn," called the horn of Rory More, which is apparently old Irish work of the ninth or tenth century, and is mounted with a rim of silver 2 in. deep, engraved with interlaced patterns, and with circles filled up by grotesque monsters.

The metal-work of the Anglo-Saxon period, as here illustrated, is very similar to the Irish, just described, the majority of the specimens being contributed by the Ashmolean Museum. Of these, (907) is a circular brooch of bronze, overlaid with silver at the back; the front has been elaborately ornamented with gold filigree and garnets (?); the pattern is formed by a circle of ornament round a central boss, united by the limbs of a Greek cross to another circle of ornament at the circumference. The interstices occupied by plates of gold enriched with entwined filigree, and with bosses that appear to have been set with freshwater pearls or pearl matrix, the surface of which has decayed, the body remaining, but considerably altered in texture; the remainder of the brooch is covered with a diaper forming sockets for small pieces of garnet (?), the edge is grooved and gilt. It was found at Abington: the diameter is 3 in. Another brooch of Anglo-Saxon work, from the same collection, is of bronze silvered; the face nielloed and gilt, and ornamented with interlaced pattern in repousse, set with four pieces of garnet (?) over foil, and with four sockets for white enamel, portions of which remain; the centre ornament is wanting. (915) is an extraordinary relic, lent by the Warwick Museum, and may be described as a crystal of quartz, flattened, somewhat pentagonal, and perforated in the centre, the girdle or circumference shaped into ten triangular facets, the angles now much worn. This crystal, which resembles a smaller one in the Museum of the Society of Antiquaries, might have been conjectured to have formed a portion of the decoration of a cross, shrine, or other object of ecclesiastical use; but it was found in association with an Anglo-Saxon fibula; it may therefore have been worn as an amulet suspended from the acus of the fibula, as appears occasionally to have been the case with similar objects. The last in this class to be especially noticed, is a circular bowl of thin reddish yellow bronze, hammered up, with a circular elevation or boss in the base, and a flat fold of metal with a deep groove round the edge, probably to hold a metal band or other means of suspension; the surface overlaid with applique ornaments made of thin plates of bronze, tinned or silvered, arranged in four divisions, each separated by a narrow band, and finished by a circular ornament, to which are attached on each side an axe-shaped piece. The intervals are occupied by rude representations of deer, of cocks fighting, of other birds, and of fishes (?). The surfaces of all these applied ornaments have been grooved in narrow lines with various patterns, some interlaced, apparently to receive enamel, a few traces of which, of an orange-red colour, seem to remain. The four circular plates of ornament exhibit the triple character of pattern frequent on early Celtic work. Beneath the bowl, in a circular hollow produced by the hammering up of the boss before alluded to, have been pieces of similar applied and engraved ornament, two of which remain. It is probably of early Saxon work, and was found near Lullingstone Castle, Kent.

(To be continued.)

THE RECENT GUNNERY EXPERIMENTS AT SHOEBURYNESS.

We give elsewhere* a paper read by Mr. Aston at the meeting of the British Association, at Cambridge, on the Whitworth guns and projectiles, and their capabilities for attacking armour-plated defences. The experiments at Shoeburyness, on the 13th and 14th of last month, have fully borne out Mr. Aston's statements regarding the powers of the penetration shells, and thus fairly established the superiority of attack over defence.

The target prepared for the occasion was a box-target, the front of which resembled in some respects the original "Warrior" target, but exceeded it in strength, two out of the three iron plates which covered it being 5 inches thick, while the remaining one (one of the old "Warrior" plates) was 4½ inches. The backing was 18 inches of teak as before, and the inner skin of ⅝ inch iron. The whole of the iron was of excellent quality. Against this target the Whitworth 120-pounder was laid at a range of 800 yards. Two shells, each weighing 150 lb. including a bursting charge of 5 lb. of powder, were fired in succession, with 25 lb. gun charges. The first struck the centre plate of the target (5 inches thick), and penetrated it, exploding in the backing. The teak was torn into shreds, and the inner skin burst open. Some fragments of the shell went through into the box representing the ship's deck. The second shell struck the top plate (4½ inches thick), and penetrated and exploded as the first, but the explosion occurred when deeper in the backing, and with more destructive results. Splinters from the shell and plate were scattered with violence inside the box, and the teak backing was ignited. The velocity of impact was 1220 feet per second.

A 130 lb. shell, with a bursting charge of 3¾ lb. and a gun charge of 27 lb., struck the target with a velocity of 1280 feet per second. It penetrated a 5-inch plate, and burst either deep in the backing, or else when right through; the hole in the inner skin being twice the diameter of the shell, of which the base as well as splinters, with fragments of the outer plate, the wood, and the inner skin, were found within the box.

The material of the shell was in each case homogeneous iron, such as is employed for all the Whitworth penetration projectiles. To show the inferiority of cast-iron when employed against armour plates, a solid 130 lb. projectile of this material was fired with a charge of 27 lb., striking the target with a velocity of 1260 feet per second. Although a lower velocity had sufficed for penetration in the previous cases, the cast-iron projectile failed to pierce the plate, and broke to pieces.

A solid 130 lb. projectile of homogeneous metal, fired with a charge of 25 lb., struck the target on one of the 5-inch plates with a velocity of 1240 feet per second. The penetration through the plate, backing, and inner skin, was complete. The head and fore part of the shot was found inside the box, the rear part having been torn away in the passage through.

The Whitworth 70 pounder (so successful in its last practice against the plated target at 200 yards) was now laid against this more formidable target, at a range of 600 yards, with a gun charge of 13 lb.: the 70 lb. shell struck the 4½ in. plate at 1160 ft. per second, and penetrated, but does not appear to have reached any depth in the backing when it burst. The shells which struck the 5-inch plated portion of the target failed to penetrate. For the 70 lb. shell, a considerably higher velocity of impact is apparently necessary to secure equal penetration with the 130 lb. projectiles.

During the second day's experiments a result was obtained conclusively showing that the flat-fronted projectile will not glance off the side of a plated vessel, even when the impact is very oblique. The Whitworth 12-pounder sent two shells of homogeneous metal through a target of 2½-inch iron plate, inclining backwards at an angle of *forty-five* degrees. The range was *one hundred* yards, and the gun charge 1½ lb.

It will be observed that the shell, being made to the full as heavy as the solid projectiles of the same calibre, strike with the same velocity of impact, and possess, as blind projectiles, a power of penetration little, if at all, inferior. The depth of penetration before explosion takes place depends partly on the velocity of impact (regulated by the gun charge) and partly by the thickness of the flannel case in which the bursting charge is enveloped. The breach seems usually to be clean cut on the outer face of the armour plate, torn on the inner face, shattered in the teak, and smashed or jagged in the inner skin. It may be added that the flat-fronted projectile is capable of piercing a ship's hull, or damaging the rudder or screw at some depth below the water line.

* See page 395.

ON THE VOLUNTARY ARCHITECTURAL EXAMINATIONS.*

By Arthur Ashpitel.

Among those institutions which have gradually developed themselves during a few past years, and which seem likely to exercise a great and lasting effect on the future, the establishment of professional examinations is certainly not the least. In all countries the pursuit of the liberal arts and sciences has had the most beneficial influence on civilised life; and anything that may tend to elevate the character of professional men in the eyes of the world, and to give them a better status among their fellows, must conduce to promote a higher and more intellectual tone to society at large. Having taken a deep interest in the question, and having been one of those who were intrusted by the Institute to take preliminary steps to endeavour to insure to our own the benefits which we believe other professions have received, I venture to trouble you with a few remarks that have suggested themselves in the course of our inquiries; although, to treat of so important a subject as this in the manner it would deserve, would require a longer time and greater ability than I have to devote to it.

For many years, as you are all aware, an inquiry into the mental training and amount of information any one might possess, was confined to those about to enter the church or the medical profession. The important functions of both seemed obviously to demand that there should be a searching examination as to the competency of any candidates before undertaking their responsibilities; but it was not so with other professions. The lawyers however were the first to establish a change. Formerly, they who had managed to get "articled," as it was called, and had a hundred pounds to pay to the stamp office, were admitted to practice as attorneys or solicitors without inquiry. The consequence was, many men endued with some cunning and very little legal knowledge, crept into the profession; and, what was worse, the pretended practice of the law was frequently a mere cloak for money-lending and all sorts of disreputable employments. Feeling this very strongly, the chief respectable solicitors united together in forming an institution to inquire into the fitness, both in point of a liberal as well as of legal education, of the several candidates before they were permitted to enter on the practice of the law. It is scarce twenty years since this institution came into active use; and since that time, I have been informed by old members of the profession, its character, as a body, has been raised to a degree beyond their most sanguine expectations. The cunning, vulgar, ignorant, pettifogging attorney, so frequent a character in the old novels and comedies, is almost extinct; and in their place we have, with very few exceptions, able and well-educated gentlemen,—men of whom society is proud, instead of ashamed.

The next movement to insure a proper education and competent ability among their members was made by the chemists. Here, as in our own body, any man might assume the title, and enter into practice at his mere will. The lawyers had always the semblance of an education, though it often consisted of the mere farce of "giving articles," but any man might write up "chemist," and compound the most complex medicines, or sell the strongest poisons, without question or challenge. So many evils

* Read at the Architectural Association.

arose out of this system, that the respectable chemists in a body applied to the legislature for powers analagous to those already given to the lawyers. They however were met by a loud opposition, and it was asked what a chemist was, and where his functions began and those of the drug-dealer ended; and it was said it would be sadly interfering with the liberty of the subject if a man might not sell an ounce of salts, or a pennyworth of rhubarb, without an examination. It was also stated that, in country places in particular, the mere practice of scientific chemistry was but a very small part of a man's business; and just as many a little country builder calls himself "architect and surveyor," they demanded the right to assume at their own will the title of chemist. The respectable men replied, this might be true, but they had no right at any rate to pass themselves off on the public as *scientific* chemists, if they were not so; and at last the legislature gave them powers of incorporation, and of examining candidates as to their competency, and the sole right to use the title of "pharmaceutical chemist," as a distinctive mark of a proper scientific education. Something of this kind has been proposed with regard to the architects, and, with certain modifications, might perhaps be made to work well; but as the general wish seems at present to be to leave everything possible to voluntary action, and in no way to fetter the profession, I think it well to pass by all such questions for some future time. It seems to be wise to do nothing further till the results of our proposed experiments shall have full and fair opportunities to develop themselves.

The greatest step however to establish an enlarged system of examination took place in consequence of the Crimean war. The hardships and sufferings arising from the blunders and incompetencies which were charged against the Government officials—although these may have been exaggerated, and although too little allowance may have been made for the change from near forty years' peace to a sudden and tremendous war—still the attention of the public was forcibly called to the necessity of some change. Our public service was stigmatised as a circumlocution office; red tape became a popular bye-word; and it was stated again and again that political influence, and that alone, was the qualification asked for in all our Government offices. It is beside our purpose to inquire as to the correctness of these charges; it is sufficient to say that the comprehensive scheme of an examination into the qualifications of every candidate for Government service, whether civil or otherwise, was immediately established. It has now existed seven years; and I am informed, on the authority of the most competent judges, that the improvements in every branch have been greater than was ever anticipated. Since this the system has been extended in every direction, and almost to every intellectual pursuit.

Of course, there has been a very great opposition to these changes, the chief of which have been summed up in the third Report of the Commissioners of the Civil Service. One was the very old and hackneyed objection to all sort of advancement, that the course intended to be pursued would "make men above their business." Now, this is certainly an argument of some force as to charitable education, where the ultimate business of those taught will be to dig or to plough, and no more; but in Government employ, and especially where the men were stated to be much below the level of their every-day business, it was surely a poor argument to say "do not raise them at all." In our own case however, this notion would plainly be worthless, most of our *best* architects having been the best educated men of their day, and our profession certainly inferior to no art, as it mingles at once the practical, the scientific, and the beautiful.

The arguments then took rather the form of opposition to examination of individuals as a special matter, than to that of education in the abstract; and three principal objections were raised:—First, that examinations in general became too scholastic; that they involved, necessarily, a system of reading, a routine of class books, and, in common phrase, induced a system of "cramming." The second was, that the result of examination proved but little as to the real solid knowledge a candidate might possess, inasmuch as it might so happen the questions before him were such as he might chance to have picked up, while very ignorant of all the other branches of the subject. The third, and, as regarded the civil service, perhaps really the most valid, was that no examination would develope or prove that the candidate possessed the best and chiefest qualifications of all, namely—integrity, industry, activity, foresight, presence of mind, and a number of other qualities of similar character of the highest importance in confidential positions.

The first objection had much weight in the case of the civil service, but I should hope in ours it must fall to the ground. I would ask any one to look at the sketch form of voluntary examination, just circulated, and say whether it is not of such wide and comprehensive character, and so thoroughly practical in its essential details, that no amount of mere book work, no amount of "cram," would satisfy the examiners that the candidate had a right to a place in the class of proficiency as an architect.

To the second objection I hope there is quite as good an answer. Let enough questions be given, more in number than you expect or require any candidate to have time to answer,—but, of course, let this be well understood, else he will feel deterred by the length and weight of the paper; give opportunity for selection, and let it be known the examiners do not wish the greatest possible quantity of work to be hurried through;—a few questions thoroughly well answered will weigh more with the judicious than five times as much of slovenly work. On this point I shall venture to enlarge, with your permission, a little further on.

The third point urged against the civil service,—that examinations will prove nothing as to integrity or other moral qualities of candidates,—does not, of course, apply in this case; but it might very well be put in another form, and men might say no examination will give genius, fancy, invention, or artistic talent. This in the abstract is granted; the *mens divinior* is certainly a gift; but, constituted as we propose our examination to be, if it does not give men elegant faculties, it most clearly will afford a means of developing them and exhibiting them to the world. We do not propose to teach you to draw, to carve, to design, to devise, but we do propose to give you an opportunity of showing what you have done, and can do in all the more elegant branches of our art. It is hoped the various powers of all minds may be developed in all their gradations, whether purely artistic, whether strictly utilitarian, or whether of that happy mixture of both that is really the glory of our profession; and not only so, but that it will elicit the fruits of the wise watchfulness which you may have exercised during your novitiate; and, what is much the same, the care you have taken to store up in your minds all that may be valuable in your future career. We hope, whatever your speciality of talent may be, to offer you a wide, a fair field for its exertion and display.

And here it may be convenient to consider in what way our proposed examination may differ from others. In the first place, it is not like a collegiate examination—the great termination of a long series of studies, the harvest of seed sown some time back, and long and carefully cultivated. It is not an honoured end and rest from labours; neither is it the entrance into life, like that of the lawyer, or medical man,—the opened gate through which he is to pass, and then to encounter his first struggles in the world. In the language of the schoolmen, it is neither a *terminus ad quem*, nor a *terminus a quo*. It is not an individual struggle for victory—the battle for the olive crown; nor such a struggle as those are for scholarships or high appointments, where there can be but one, or very few victors, and where the unsuccessful feel in the position of the vanquished. It may rather be likened to those military displays, where, after long training and active practice, the younger members march out confidently, hoping to prove they are soldiers of such proficiency as to be fit to act with veterans in the field, and trusting in time of need to be equal to do their duty ably to their country.

A very able writer in one of our professional journals has likewise shown the difference between the system of rewards now generally offered to students, such as the Soane medallion, or any other similar mark of distinction, and the present proposed system. These rewards have been of three sorts—for the best essay, the best design, and the best measured drawing from an existing building. I will leave out of the question any chance of improper assistance when work is done at home, nor will I touch on the help obtained from books, or hints from friends; but it must be obvious to all, as the writer says, that the best drawings may not be the production of the best draughtsman, but of him who has the most leisure to bestow on their production; and that the excellence of measured drawings depend also, not only on leisure, but in the money there may be to pay for assistance, scaffolding, travelling expenses, and a host of other things which attach themselves to such undertakings.

It has been said, the reason why the English make such excellent medical men is, they begin practically; they "walk the hospitals," as it is called, on their first entrance into the profession; they act as dressers, in subordinate practical capacities; and receive the instruction of the lower, before they attend the lectures of the higher professors. Abroad, the scholastic education comes first, and many a man who has considerable theoretical medical knowledge would be quite at a loss by the bedside of the sick, while the man accustomed to practice from early life sees the state of things at a glance, and acts promptly and successfully. There is no doubt the active daily duties of the office are indispensable to the young architect, and it is in them, if he keeps his attention properly on his work, that he will find he has unconsciously gathered material to master the most important part of the examination we propose to offer. But it is equally true that these very circumstances operate against his chances of obtaining the distinction of medals, and other similar rewards, and it is very probable, as has been suggested by the writer above quoted, that this is the true reason why such rewards are so little sought, and of course often so little valued.

We all know how often it happens that rising men wish to enter the offices of their seniors, with the hope to work their way up to independent practice. Of how little use is the production of a medal, or a portfolio containing designs for some unlikely or perhaps impossible marine hotel, or gigantic cathedral. Of how little value in the eyes of the man of business is the medal for the essay, which, in general, is simply a well expressed account of something other men have executed. It may be valuable in its way, as every literary *tentamen* is; but it may have taken months to write, and of what value is it in the active practice of the profession? Let us however ask, which would be the better testimonial—the exhibition of any such solitary mark of distinction, however respectable, or the production of a set of full, fair, and comprehensive papers on every branch of the art, such as it is hoped will be laid before you, and the simple assurance that you have been fairly tried and found to be proficient therein, and that wholly unassisted and on the spur of the instant?

And now it may be asked, what should an examination be? It should be *full*, that is to say, such a one as shall be amply sufficient to show the proper status of the candidate. Any examination which may be too easy degenerates into a grave farce. No one would care for such a distinction as any idle or weak-minded creature might attain. No: the examination should be such that in after life the successful candidate should be able to refer back to his paper of questions with pleasure, and exhibit them as such as in his days it was his pride to answer. But here comes the difficulty, the questions must not only be *full*, but *fair;* they must be proper and pertinent. Nothing is easier than to set questions that scarce anyone can answer. Nothing is easier, with a little perverted ingenuity, than to set questions of no great difficulty perhaps in themselves, but worded so as to mislead or puzzle a candidate. In competitive examinations, or those wherein a certain prize is to be conferred on the best man, and on one alone, it is not unusual for examiners, by way of shortening their work, to set what are called "catch questions;" but nothing can be more unfair or improper in an examination like this which is proposed. It is a system of finding out the weak points, instead of developing the strong—of hunting out faults instead of exhibiting excellencies—and, as a matter of course, depressing the general body of the rising men, instead of encouraging it.

These considerations led us to another and very important point—that no examinations should be *vivâ voce*, but every answer should be put on paper. It also led to the adoption of what to some may appear a complex system of numbers and changes by the moderators, which is by no means so difficult as at first sight appears, but which insures the judgment of all answers by their merits alone, as the examiners have no chance of knowing in any way the name of the person on whose papers they are about to pronounce an opinion. It is the matter alone, and not the individual, that is judged, and in this respect at least the utmost fairness is in all human probability insured.

The system of *vivâ voce* examination is abandoned now by almost all learned bodies. Many examiners, however, cling to it, as it shortens their labours so much; they consider they see in so little a time who are the competent men, and who are not; but they do not allow for that modest timidity many men can never divest themselves of, and they often attribute hesitation not to diffidence, but to ignorance; while, on the other hand, men who possess but a smattering of knowledge, and have readiness and assurance, will blunder through when far better men will fail. There is also this complaint on the part of those who not able to satisfy the examiners, and that is always a charge of unfair questions, of bullying, of misleading, of browbeating, of wishing to reject a candidate to the advantage of some favourite; in short, it is impossible to find any one who has been rejected under a *vivâ voce* examination who does not attribute his being "plucked" to the bad feeling and unfair conduct of the examiners, rather than to his own deficiencies; and this not from a desire to pervert the truth, but simply from the pain and confusion which the candidate naturally gets into when on the point of what is called "breaking down." We hope we have reported such a course to the Institute that there can be no question that the proposed examinations shall be fair,—unquestionably fair in all respects.

I would now venture to call your attention to the form of examination itself. The first remark that we have heard is, that it is too difficult—in University language, "too stiff a paper." This has been intentionally done, as the object is to show the standard we hope the rising men of the profession may come to in a few years' time, and not that at which we shall begin. And we think we have a good reason for this. Examinations are all contests for which the mind must be trained. It is much the same as with bodily contests. The fleetest foot that ever ran on the Olympic stadium, if out of practice, would be easily beaten by a slower runner; the strongest wrestler in the palæstra, if out of training, would easily be thrown by a weaker man in full practice. Knowledge, especially such as is of the most value to the architect, is of slow growth, and comes as much from observation as from reading. Now, it is clear the study and experience of three years must be infinitely greater than those of one year only. We thought it would be equal justice therefore to those who come up at even less than a year's notice, to set the standard lower than we think ought to be done three years' hence; and we believe that those who pass now will in future be considered to be on an equality with those who have answered much more difficult questions at that period.

Another objection has been that the questions are too numerous to be answered in the time allotted. This has been purposely done for the reasons above stated, that the chance of failing on those points to which alone the candidate has not happened to have given his attention, is so lessened that it can hardly be taken into account. Of course the examiners will carefully consider how many questions ought fairly to be answered, and if, say one-half is the number, the marks should be so allotted that one-half should enable the candidate to get his full complement of marks.

Questions have also been asked as to the class of reading to be recommended. This must be left very much to the tone of each candidate's own mind. It has been thought better, especially in so short a time, not to limit the range to certain books, a course which so often leads to a system of cramming. But there is one point I would venture to remark on: it is a common error for candidates, when the examination draws near, to confine their attention to the more advanced branches of the various subjects, and thereby probably finding themselves deficient in the groundwork. Now, every examiner naturally looks to see whether a good foundation has been laid, and considers work based on sound elementary principles of much more value than more showy and attractive matter, which may be got up by cramming, and is easily forgotten. I would therefore recommend, that shortly before the examination every candidate should go carefully through the elements of any branch of science, and see that they are properly ranged in his mind. This course will afford a confidence and facility in examination no other method will give.

There is no disguising one fact. The general tone of society has been much raised within less than half a century, and has become more refined and more intellectual. That which is now considered on all hands to be so indispensable to every gentleman, and generally designated "the education of a gentleman," would have been called "pedantic stuff." It was gentlemanly then to drink three bottles of strong wine after dinner, or to call out your best friend for a hasty word, and shoot him dead the next morning. In their softer moods, the gentlemen of George the Fourth's day devised patterns for waistcoats, cut collars for coats, and invented marvellous curls for the hair and whiskers; while every leisure hour of both ladies and gentlemen was devoted to cards or worse forms of gambling. Things have changed very much since that time; and yet gentler manners, and more intellectual pursuits, have not brought with them luxury or effeminacy. Although far more temperate in living, and more simple and natural in dress, nothing of true British spirit has decayed. They who rode at Balaclava, or who crushed out the horrible Indian mutiny, were as heroic men as any age could boast of: and under our own immediate notice is now as noble and patriotic a movement as ever was at Sparta or Athens. In a quiet and unostentatious way, men have joined together heart and hand for the defence of their own hearths and altars, and have spontaneously taken on themselves the fatigue and toils of military life, in such a manner as to convince the world the spirit of the British nation is as great and as manly as ever.

But there is also no disguising the fact that, in spite of the exertions of the various architectural bodies, the professors of that science do not seem to be recognised in society as they ought to be. At any rate, the word architect is not the password here it is abroad. Why this may be we will not stop to inquire; nor will we repine if it be so. One thing we are quite sure of, if the whole body assume and deserve a higher status in society, they certainly will find themselves in an advanced position ere long.

This is one of the great advantages the system of examination offers. It not only must be valuable in a professional point of view, but it must be of the greatest use in showing to other professions and to the world in general, that the architect has received the education of a gentleman. Let every rising man then who has the love for his art, and respect for his profession, assist in our endeavours to elevate both in the eyes of the public. A standard is offered by which you may judge your powers. Without some trial or some means of comparison, who is to judge their own stature? If at present you fall short of such height it is no more blame to you than if you are but five feet ten instead of six feet; but there is this difference, although after a certain time the bodily stature will not increase by proper cultivation, that of the mind always will do so, and it must be very hard if he who falls short of the standard, after having had only a few month's notice, will not reach it after the experience of another full twelve months has been added to it.

And now we should be ungrateful to the members of the Architectural Association if we did not acknowledge their support in this attempt. On them will fall a great share of the labour,—on them will devolve the task of showing, as a body, the rising architects are men who do not shrink from that mental toil, that intellectual training and tuition, that all other professions undergo. They have given (it may, as it ought to, have been) a cautious support, but still it has been most genuine and unselfish. The fruit of all our labours, if fruit there be, must be expected to show itself slowly; but it is my earnest hope that I may be spared to see it, and on some future occasions within these walls to talk over the old tales, to narrate our former labours, and to congratulate the members on the success of the united efforts of the Institute and of the Architectural Association.

INSTITUTION OF CIVIL ENGINEERS.

JOHN R. M'CLEAN, ESQ., Vice-President, in the Chair.

November 11, 1862.—Before commencing the business of the evening, on this the first meeting of the Session, and in the absence of the President, the chairman said it was his duty to notice the loss the institution had sustained by the death, during the recess, of two of its most eminent members, Mr. John Edward Errington, Vice-President, and Mr. James Walker, Past President.

For upwards of thirty years, and indeed ever since the introduction of the railway system, Mr. Errington occupied a prominent position as an engineer, and, in conjunction with Mr. Locke, executed some of the principal railway works in Great Britain. He was, like his partner, Mr. Locke, a strong advocate for economy in the first cost of construction. By his death the profession had lost one of its most distinguished members, the Institution one of its warmest supporters, and many of us a sincere friend, and one ever ready to afford advice, especially to his numerous pupils and assistants, whose interests it was his constant endeavour to advance. As many of his pupils were actively engaged in the practice of the profession, and had, through his influence, been enabled already to take good positions, the chairman expressed the hope that they would feel it a duty, no less than a pleasure, incumbent upon them, to communicate plans and descriptions of the works of their eminent masters, and so keep alive the memory of "Locke and Errington" in the Institution of Civil Engineers. Mr. Errington had proved his attachment to the Institution, and his desire to see it prosper, by bequeathing to it the sum of £1000, free of legacy duty, and without attaching any condition whatever to the gift.

Mr. Walker was one of the oldest members of the profession, having been in active practice as an engineer for upwards of sixty years. He was also one of the earliest members of the Institution, having joined it in the year 1823, and, after the death of Mr. Telford, became its President. For a period of eleven years, during which he so ably conducted its proceedings in that capacity, he was most devoted to its interests, and to his zeal and energy must be greatly attributed the eminent position it held on his retiring from the chair in 1845. Mr. Walker's name was associated with many of the greatest hydraulic works in England and Scotland, including lighthouses, harbours, bridges, embankments, and drainage. His opinion was much valued by the Elder Brethren of the Trinity House, by the Lords of the Admiralty, and by the Corporation of the City of of London, and it must not be forgotten, especially at the present moment, that twenty years ago he laid down lines for embanking each side of the river Thames, which have never been improved. As the chairman had had the privilege of being in Mr. Walker's employment for many years prior to 1844, he had an opportunity of knowing his worth, and must express his gratitude for many acts ot kindness, and state that it was Mr. Walker's constant endeavour to promote the interests of himself and others. Many members of the profession had also been trained in the same schools, including Burges, Bidder, Hawkshaw, Borthwick, and Hartley. During his long and useful career he had secured the admiration and respect of numerous influential friends, as well as the regard of his professional brethren.

The chairman had much gratification in announcing that Mr. Walker having left at Mr. Burges' disposal the twenty-five remaining copies of Telford's 'Life and Works,' as well as the copyright and the copper-plates, Mr. Burges had, in the most handsome and liberal manner, presented them to the Institution.

The Paper read was on "*The Railway System of Germany*," by Mr. ROBERT CRAWFORD, Assoc. Inst. C.E.

It was stated that in Germany, as in England, tramways had formed the germ from which subsequent enterprise developed the vast network of railways now extending throughout the length and breadth of the land. 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. Subsequently, a concession was obtained for a line from Linz to Gmünden, 42½ miles. The cost of the Budweiss, Linz, and Gmünden line was about £4877 per mile. The gauge was 3 feet 7½ inches, and it was worked by horses until 1854, when small locomotive engines were employed, first upon a portion of the line, and in the following year upon the entire length.

A proposal to adopt steam as a motive power, instead of horse-labour, was carried into effect for the first time in Germany in the case of a railway, 4 miles in length, from Nüremberg to Fürth, which was opened for public traffic on the 7th December, 1835. 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. In the five following years, railways were introduced into all parts of the country, so that at the close of 1840 there were twelve railways, either wholly or in part finished, with a total length opened of 377 miles. In the next ten years this had been increased to 4487 miles; by the close of 1860 to 8512 miles, and at the end of 1861, a total of 8866 miles had been constructed at an average cost of £16,400 per mile. Nearly one-fourth of the entire length was provided with double lines of rails. About 38 per cent. of the existing lines was Government property, 10½ per cent. the property of companies, but worked by Governments, and 51½ per cent. the property of, and worked by private or joint stock companies. Further, it appeared that 39½ per cent. of the entire length was constructed by the different states, 24¾ by companies under a guarantee of interest, or a Government subvention, and 35¾ per cent. by companies at their own cost and risk; so that Government aid had been granted, directly or indirectly, to nearly two-thirds of the entire system. These 8866 miles of railway comprised sixty-two different undertakings, as at present constituted, under as many different organisations, and were managed by nineteen Government departments, and forty-three boards of directors.

At the close of the year 1861, Germany had, in addition to the railways, about 143 miles of tramways, constructed at an average cost of £3200 per mile.

With a view of establishing a common plan of action, and of regulating, to a certain extent, the relations of the different railway companies with each other, a society was formed in the year

1847 under the title of "The Association of Government Railway Directions," which now embraced the whole of the lines, with very unimportant exceptions. Each company subscribed a fixed sum towards the general management fund, together with a variable amount depending upon its length, and was represented at the meetings of the association and in the debates, in proportion to importance. A code of laws had been drawn up and agreed to, which was revised from time to time, the rules expressing the decided opinion of the associated body upon all points usually involved in the construction and working of railways. The gauge was now universally throughout the country 4 ft. 8½ in. With regard to curves and gradients, the rules laid down were —First, the radius of curvature should, if possible, not be less than 3600 feet in level land, nor than 2000 feet in hilly districts, except in particular instances, where it might be necessary to reduce it to 1200 feet, or even in very rare cases to 600 feet, but never less. Second, the general scale of maximum gradients admissible on railways was 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountain lines. Several examples of sharp curves upon works already executed were then noticed. The increased power of locomotive engines had led to a severer character of ruling gradients being introduced than was fomerly contemplated, and there were ample proofs in every part of the country that the limits recognised at present as suitable for the working of locomotives had been reached. Many instances were then given of steep gradients and sharp curves, including a particular account of the Semmering railway, and of the mode of working it. As, however, a description of this railway had been brought before the Institution by Mr. C. R. Drysdale, in the year 1856 (Minutes of Proceedings Inst. C.E., vol. xv., p. 349), it would suffice to say that the experience derived from the working of the line went to show, that one of the goods engines was capable of drawing up the incline of 1 in 40, at the rate of 9½ miles per hour, a train whose gross weight varied from 100 to 165 tons, according to the state of the rails and of the weather at the time. The ordinary rate of speed was fixed at—

	Ascending. Miles per hour.	Descending. Miles per hour.
For express trains	14½	16⅛
ordinary passenger	11¾	14½
goods, including military transport .	9¼	9¼

The maximum number of trains which had passed over the line in one day was seventy-two, counting both ways. This was during the Italian war. The ordinary number was twenty-seven, with from seven to eight carriages each. The line was about 25½ miles in length, was laid with a double way throughout, and had cost £98,270 per mile.

It appeared 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 throughout, but not to lay the second line of rails until the success of the undertaking and the requirements of the traffic demanded it. Some of the heaviest earthworks executed up to the present day were then alluded to, including one on the Southern State Railway of Bavaria, the greatest height of which was 172 feet, and which contained nearly 3,000,000 cubic yards of material. A list of the largest tunnels on the principal lines was next given.

Viaducts and bridges were treated under two headings;—first, bridges composed altogether of masonry, and second, iron bridges. The views of the Associated Railway Directions on bridge building were,—1st, For bridges, arches of stone or good bricks were preferable to every other description of structure, except in cases which required very oblique bridges. 2nd. Timber bridges were inadmissible. 3rd. When iron bridges were made use of, the portion of the structure which sustained the roadway should consist either of wrought or rolled iron. Thus cast-iron bridges as well as timber ones were removed from the field of investigation; the former by negation, and the latter by direct condemnation.

Instances were then adduced and details given of several examples of stone viaducts and bridges of imposing dimensions and extent, including those over the Goeltzsch and the Elser Valleys, on the railway from Leipzig to Hof,—and the Neisse Viaduct on the railway from Kohlfurth, to Goerlitz, in Prussia. 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, in the latter case, gave the proportions most suitable for yielding a quick setting, hard concrete, at 22 per cent. of cement; 22 of sand, and 56 of small broken stones, not exceeding 2 inches diameter. In regard to the bridge over the river Neckar, on the railway from Frankfort on Maine to Heidelberg, it was stated that the depth of the keystone was somewhat over the minimum required both by Desjardin's formula and by that of Gauthey; but on the other hand it was 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, the

	Metres.
Neckar Bridge as actually built had a depth of key of	1·200
" according to Gauthey's formula it required	1·125
" " Desjardin's "	1·140
" " Perronet "	3·241

In the case of wrought-iron bridges the arrangement most usually adopted, when the spans were wide, was that of a lattice construction in some one of its various modifications. One of the earliest examples, which was described in detail, was the bridge over the river Kinzig, at Offenburg, on the Baden State railway, in which it was considered that the arrangement of the material was not judicious, as—1st. The dimensions of the ironwork were uniform throughout the length of the span. 2nd. Although a stronger lattice construction was adopted in the case of the central girder, still the top and bottom sections were of similar dimensions to the outside ones; and 3rd. The cross sectional area of the iron had not been properly proportioned to its different powers to resist compression and extension, where those forces acted. The bridge over the river Vistula, at Dirscham, on the Eastern Railway of Prussia, was next referred to. It consisted of six spans, each 397 ft. 6 in. in the clear, the depth of the girders being 38 ft. 9 in., and the whole of the material in the superstructure being carefully proportioned to the nature of the strains to which it would be exposed. The Marienberg bridge over the river Nogat, on the same railway, was likewise minutely described. The next examples selected were those over the Rhine, at Cologne, and at Kehl, close to Strasburg: in the latter case the method adopted in constructing the foundations, by means of compressed air, was also mentioned. It was stated that the operation of sinking the foundations progressed at the rate of about 20 inches per day of twenty-four hours.

In addition there was also another bridge over the Rhine at Mayence, which consisted of thirty-two openings, having together a clear waterway of 3134 ft. 6 in., lineal measure. The iron-work in the superstructure was somewhat similarly arranged to that of the Saltash bridge, modified in some particulars, as to the cross section and the form in which the material was applied, according to what was known in Germany as the system of Professor Pauli of Munich, which gave a rectangular top to the beam instead of an oval one.

Attention was then directed to the Permanent Way. It appeared that about seven-eighths of the rails in use were of the broad base, or contractor's pattern; the remainining one-eighth being composed chiefly of chair rails, with a small proportion of bridge-shaped ones. As to size the rails were not less than 4½ inches in height by 2¼ inches width of head, and the surface was curved to a radius of from 5 to 7 inches. They weighed generally from 66 to 76 lb. per yard. Fish-plates were now almost universally adopted for connecting the ends of the rails, and the joints were always supported by a sleeper; a wrought-iron chair being interposed between the rail and the timber. Recently, a trial had been made of the modern English system of leaving the joint free without any sleeper under it, and the result had been so satisfactory that it was intended to extend it. The almost universal system of supports was that of cross-sleepers. They were of oak, where it could be procured at a reasonable price; but different descriptions of larch and fir were often used, after being prepared by some chemical process to resist the tendency to decay.

The quantity and description of rolling stock in use on different railways in Northern and Southern Germany varied greatly; but as nearly as could be estimated, at the close of 1861, there were

Locomotive engines	0·414	per English mile.
Passenger carriages, average 41·8 seats each	0·807	"
Goods trucks, average load 6·9 tons .	7·040	"

Before any engine was permitted to be used its boiler must be tested with hydraulic pressure to at least one and a half times the maximum steam pressure which it was intended to sustain, and a similar test must be applied after the engine had run its first 46,109 miles, and be subsequently repeated every time an additional 36,887 miles had been made. The rate of speed was usually, for express trains, from 27 to 35 miles an hour, for ordinary passenger trains from 20 to 25 miles, and goods trains from 10 to 15 miles per hour, in each case exclusive of stoppages.

ON THE CONSTRUCTION OF WROUGHT-IRON LATTICE GIRDERS.

By Thomas Cargill, C.E.

(*Continued from page* 305.)

Before proceeding further with the practical part of the subject, I propose to make some remarks on the formulæ in general use, for calculating the horizontal strain in a girder; and to endeavour to investigate them in a manner which, without departing from recogn sed principles, may render them of more easy application in the designing of structures similar to those of which I am treating. The first formula to which our attention is directed is that which gives us the greatest horizontal strain at the center of a girder under a uniformly distributed load, in

$$\text{which } S=\frac{WL}{8D} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

W being the total load uniformly distributed, L the span, and D the depth between the centers of gravity of the top and bottom booms. Putting w for the constant load or weight of girder and portion of superstructure, and w_1 for the maximum variable load, we have $W=(w+w_1)$. We may consider the value of w_1 to be fixed, and always equal to one ton per lineal foot for every line of rails on the bridge; and confining our attention to one girder, we have $w_1=L$. In bridges of moderate spans, that is, within the limits of 150 feet, it has been found by engineers sufficiently accurate and safe, in practice to take the constant weight of a bridge = 1 ton per foot run, which gives us, in the present instance, $w=\frac{w_1}{2}=\frac{L}{2}$. Substituting these values in equation (1), we have

$$S=\frac{\left(\frac{L}{2}+L\right)L}{8D}=\frac{3L^2}{16D} \quad \ldots \quad \ldots \quad (2)$$

The value for w is rather in excess of the actual weight in girders of small spans, but on the supposition that the weight of a bridge acts in direct opposition to the momentum of a moving load, it will be found an advantage rather than otherwise. That this opinion is entertained is shown by the fact that more than the necessary quantity of ballast is often heaped on bridges of small spans, for the express purpose of making them heavier.

Fig. 1.

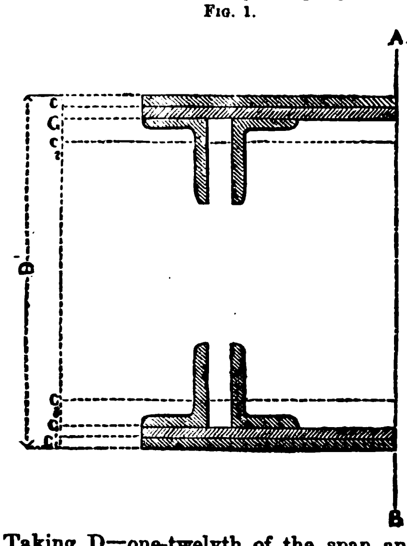
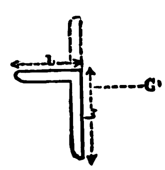


Fig. 1a.



Taking D=one-twelvth of the span and putting this value in equation (2) and reducing, we find for the simplest equation for the maximum horizontal strain at center

$$S = 2{\cdot}25\times L \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

This value for D agrees with that for the center span of the Boyne Viaduct, in which S=264 feet and D=22′ 5″; the exact ratio is as 1 to 11·7, but as 22′ 6″ represents the depth from out to out, it would be reduced to about 6 inches less, by taking it to the center of gravity of the booms, which would thus give $D=\frac{L}{12}$

In all girders having discontinuous webs, the depth is capable of a greater variation with a limited increase of strain, than those of the continuous web form; the effects of the depth will be better seen when treating on the strains on the web.

In making calculations respecting the strength of girders, D is frequently taken as the total depth instead of the depth between the centers of gravity of the flanges; as it is necessary in some cases, and more correct in all, to adopt the latter value, we will proceed to determine it for a double lattice girder of a similar construction to that given in the number for October. Let Fig. 1 represent the half section of the top and bottom flanges of the girder, the remaining half being precisely similar, the centers of gravity of each flange will be somewhere in the line AB. It may be remarked that with their horizontal position, or position along the breadth of the flanges, we have nothing to do; it is their vertical position alone which affects the value of D in our equations. The simplest method of proceeding will be, to ascertain, first, the position of the centers of gravity of the top and bottom plates, and then that of the angle-irons, and to consider their weights as concentrated in those points, from which the position of the centers of gravity of the whole top and bottom flanges may be determined. In Fig. 1, let CC_1 be the vertical position of the centers of gravity of the top and bottom plates respectively, C_2C_3 those of the angle-irons; the distance which is required to be found is GG_1, the available depth for calculation, answering to the value of D in the preceding equations. Make D_1 the total depth of the girder, as shown in the figure, and T_1T_2 the sum of the thicknesses of the top and bottom plates, then as the plates are supposed to be perfectly homogeneous,

$$CC_1=D_1-\left(\frac{T_1+T_2}{2}\right)$$

In order to obtain the centers of gravity of the angle-irons, it will be only necessary to find that of one of them for each flange. Let the angle-iron be imagined to be unrolled, or one of its flanges to be bent back into the position shown by the dotted lines in Fig. 1*a*, so that it shall assume the appearance of a straight piece of bar iron; if l_1 be the length of one of its flanges, l the length of the other, and t its thickness, its total length in the position shown will be $=(l_1+l-t)$, and the position of its center of gravity from either end will be $=\frac{(l_1+l-t)}{2}$; now supposing l to be the vertical flange of the angle, and l the horizontal in Fig. 1, the distance of its center of gravity or of the point C_2 from the under surface of the top plates will be

$$=l_1-\left(\frac{l_1+l-t}{2}\right)=\frac{l_1-l+t}{2};$$

similarly for the distance of C_3 from the interior surface of the bottom plates, for although the sum of the thicknesses of the top and bottom plates may vary, yet the angle-irons both at top and bottom ought to be of the same scantling: we thus have the distance

$$C_2C_3=D_1-[(T_1+T_2)+(l_1-l+t)]$$

The accurate position of all the points C, C_1, C_2, &c., will be in the line AB which divides the section into two similar halves, but for convenience sake I have placed them as shown in the figure. We may consider the force of gravity to act in vertical parallel lines, the resultant of which for the top plates passes through the point C, and for the angle-irons through C_2, and for the bottom flanges through C_1 and C_3, the distance $CC_2=$

$$\frac{T_1}{2}+\left(\frac{l_1-l+t}{2}\right) \text{ and } C_1C_3=\frac{T_2}{2}+\left(\frac{l_1-l+t}{2}\right)$$

Our required distance $GG_1=CC_1-(CG+C_1G_1)$.

Put A_1 for the area of the top plates, A_2 for that of the bottom ones, and a_1 for the area of the top or bottom angle-irons, then as the weight per unit of both plates and angle-irons is equal, in order to find CG we have the following proportion:—

$$CG : (CC_2-CG) :: a_1 : A_1$$

$$\text{and } CG=\frac{CC_2\times a_1}{(A_1+a_1)}$$

$$\text{also for the bottom flange, } C_1G_1=\frac{C_1C_3\times a_1}{(A_2+a_1)}$$

If both the flanges be equal to one another, then $CG=C_1G_1$, and $GG_1=CC_1-2CG$; in this case $CC_2=C_1C_3$, and finally, as $T_1=T_2$, we obtain for GG_1 by substitution in the above equations

$$GG_1 = D_1 - T_1 - \left(T_1 + (l_1 - l + t) \times \frac{a_1}{A_1 + a_1}\right)$$

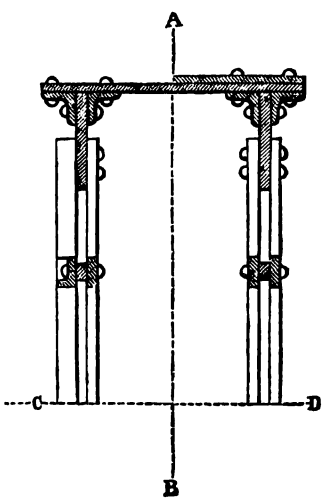
If b be the breadth of the plates $A_1 = bT_1$ and $a_1 = 4(l_1 + l - t)t$; and applying the formula to an example, let $D_1 = 60''$, $T_1 = 1''$, $b = 24''$, and angle-irons $= 4'' \times 3'' \times \frac{1}{2}''$; then $A_1 = 24$ square inches, and $a_1 = 13$ square inches; and the available depth for calculation will be equal to $GG_1 = D = 59'' - \left(2{\cdot}50 \times \frac{13}{37}\right) = 58{\cdot}12''$.

In girders of a less span than 40 feet it would not be necessary to make this allowance, but it would be quite sufficiently accurate to take the total depth and calculate from it.

In treating of the duty of the angle-irons in the number for October, it was remarked that there was no advantage to be gained by employing angle-irons with their vertical flanges of a length very much exceeding the horizontal ones. Apart from the considerations there mentioned, it will be now evident that the result of the vertical portion of the boom is to lower the center of gravity of the whole boom, and so reduce the depth required for calculation. In the above investigation I have taken no notice of the rivet holes; a_1 and A_1 are the gross areas, because, except where the strength is concerned, the holes may be considered to be completely filled by the insertion of the rivets.

That the consideration of the correct value for D materially affects the shape which should be given to the booms of girders will be seen from the inspection of an ordinary form shown in Fig. 2, in which the web, instead of being rivetted directly to the angle-irons, is attached to vertical plates which are rivetted in between the angle-irons; these vertical plates must at least be half an inch thick, in order to effectually take the strains of the struts and ties which are brought upon them, not continuously, but *per saltum*, as is the case in every lattice girder; consequently their area will bear a very large proportion to, and very probably exceed that of, the horizontal plates, and thus produce an injurious effect by considerably diminishing the value of D which, as shown by the above investigation, is, *cæteris paribus*, inversely proportional to the area of the vertical portion of the flanges. It will be seen on examining the section in Fig. 2, that the area of the vertical plates cannot be included in the calculation of the area of the flanges, insomuch as they form no actual portion of them, but are merely a prolongation of the web. Their sectional areas being useless, they can only be regarded in the light of stiffening pieces to the booms; as they are four in number (two only are shown in the half section in Fig. 2), and as they are continued throughout the whole length of the girder, an estimate of their weight would show that this advantage is obtained at too great a sacrifice of material, and addition to the dead weight of the girder; their own weight also acts in a most disadvantageous manner, and adds to the side strain on the horizontal plates, and although they may tend to somewhat stiffen the entire booms, they have a contrary effect on the plates considered independently, for they increase their liability to buckling.

FIG. 2.



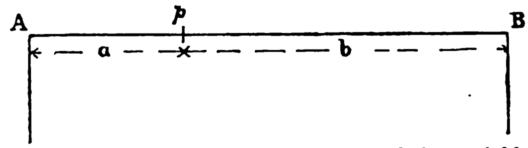
It would be well here to draw a distinction between the meaning of the terms "booms" and "flanges;" the booms always include the flanges, but the flanges may or may not include the booms; the flanges, together with any stiffening or packing pieces applied to them, constitute the booms, but it must be borne in mind that it is the area of the former alone which can be included in computing the strength of the girder. Fig. 1 is an example of the simplest form of flange for a double lattice girder, the whole of the area of which might be used as the gross area for determining its strength.

Where this mode of imparting stiffness to the boom is adopted (see Fig. 2) it would be preferable to increase the length of the vertical flanges of the angle irons; this method is open to the objections already urged against it, but we should on the other hand obtain the value of the sectional area of the stiffening pieces, which we do not where the vertical plates are employed. The use of the vertical plates causes twice as much rivetting in the webs than what is required in the other arrangement, where the web is attached directly to the angle irons.

To return to the horizontal strains. The case of the strain resulting from the effect of a weight at the center offers but little interest, except in the deflecting and testing of girders, so we pass on to a consideration of the general formula for the horizontal strain on any part of the boom of a girder, produced by a uniformly distributed load.

In Fig. 3, let AB represent one of the booms of a girder, it is required to find the strain at a point P, which divides AB into segments a and b. The uniform load in the present instance

FIG. 3.



will consist of two portions—the constant, and the variable load, which equal respectively w and w_1. The total load $w + w_1$ produces an upward reaction at $A = \frac{w + w_1}{2}$, and the moment of this force to cause fracture at $p = \frac{w + w_1}{2} \times a$. Let S = horizontal strain, D = depth of girder, and let m = weight of segment a; then the forces acting in opposition $= S \times D + m \times \frac{a}{2}$, from which

$$S = \frac{w + w_1}{2D} \times a - m \times \frac{a}{2} = \frac{a}{2}\left(\frac{w + w_1 - m}{D}\right)$$

But $m = \frac{w + w_1}{a + b} \times a$, and putting this value in our equation

$$S = \frac{a}{2}\,\frac{\left((w + w_1) - \frac{(w + w_1)}{a + b}\,a\right)}{D}$$

Making $w + w_1 = W$, we have

$$S = \frac{a}{2D}\left(\frac{W(a + b) - Wa}{a + b}\right) = \frac{W \times ab}{2D\,(a + b)} \quad \ldots \quad (4)$$

The limits for the value of a and b are $a = o$, $b = L$, and $a = b = \frac{L}{2}$ in the former case $S = o$, and in the latter $S = \frac{WL}{8D} \quad \ldots \; (1)$

If in equation (4) we substitute the value before given for $W = \frac{3L}{2}$, we have $S = \frac{3ab \times (a + b)}{4D(a + b)} = \frac{3ab}{4D}$, and making $D = \frac{a + b}{12}$ we have for girders of this particular class

$$S = \frac{9ab}{L} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

The two equations (1) and (4) supply sufficient data to calculate with ease and accuracy the strains on any part of the boom of a girder. In adopting $D = \frac{L}{12}$, I have been guided by the best examples existing of lattice girders—which are unfortunately but too few—and also, that in a large number which have come under my personal observation and direction, I have found this ratio is either actually obtained or very closely approximated to. The facilities it offers for calculation have been already shown.

The next point to be considered is the quantity of material required, or what the sectional area of the flanges should be in order to resist a strain acting at any point p. This depends altogether upon the amount of strain we wish to impose upon any square inch of iron. Widely different opinions have been, and are still, entertained upon this point, but without wasting time, and encumbering valuable space with attempts to judge between their relative merits, I shall assume that the safe working strain is equal to one-fifth of the ultimate tensile strain of the material. The tensile strength of plates may be taken at 22 tons per square inch; this is about two tons higher than it is usually considered at, but the demand for iron of a better quality than what was formerly employed in bridges has led to the manufacture of iron of a superior description. Anyone may be convinced of this fact by perusing the specifications respecting the quality and tests of the iron to be used in our large railway bridges for India;* the bar iron is specified to be able to resist a tensile strain of 24 and even 26 tons, and it is evident that such a requisition could only be founded on the fact that a much better class of iron is now turned out of the workshops than when 20 tons per square inch was the highest standard of efficiency. We shall thus have $\frac{22}{5}=4{\cdot}4$, or $4\frac{1}{2}$ tons for our working strain on iron in a state of tension. In apportioning the strength of the flanges it must be kept in mind that the top flange is in compression and the bottom in tension, and that iron is weaker in compression with respect to tension as 11 : 12; and consequently, making A = the section required for the bottom boom, and A_1 for the top, $A_1 = \frac{12\,A}{11}$. The effect of the rivet holes in the top and bottom flanges must be also taken into account. If in the top flange, which is under compression, the rivet holes were completely filled up by the inserted rivets, their effect might be disregarded; that this is the case where steam rivetting is employed will be shown hereafter; therefore, reducing in the above proportion, we shall have the safe strain for iron in compression = 4 tons per square inch.

In order to avoid confusion by having two constants for the booms, and also to provide for the contingencies of hand rivetting, in which the holes are never filled entirely by the rivets, it will be more advantageous and safer to take the net area of the top boom at 4·5 tons, instead of the gross area at 4 tons, and thus make the calculations similar. If A = net area required in the bottom boom at any point, n=the number of rivets in the cross section of the flange at that point (taking care not to make the section across a wrapper or covering plate placed over a joint), d=diameter of rivets, and t=thickness of plates; then the gross area a=A+ndt and if a_1=gross area of top boom,

$$a_1 = \frac{12}{11}\,A + ndt$$

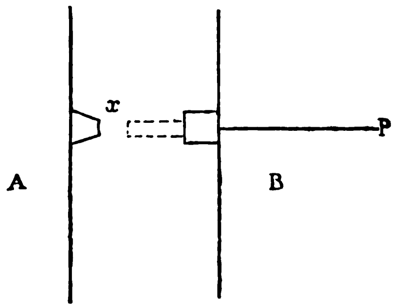
Let A = area required at center of boom, then $A = \frac{S}{p} = \frac{WL}{8D \times p}$ making p=4·5 tons, and substituting the values assumed above, we have for the area at the center $A = \frac{L}{2}$ ... ... (6)

and for the area at any other point where $a \, . \, b$ are the segments into which the span is divided, $A = \frac{2ab}{L}$ ... ... (7)

In small bridges the top and bottom flanges may be made equal to one another in area, but where the proper proportion is observed A must be reduced or increased accordingly.

Before passing on to the strains on the web, which constitutes the essential difference between this and other forms of girders, it may not be out of place to make a few remarks respecting steam and hand rivetting. If the heads of rivets which have been inserted in a plate by hand rivetting be cut off, the rivets themselves may be knocked out of the plate by a hammer; but the rivets which have been put in by the machine cannot be so displaced, the only means of removing them is by either punching or drilling them out, which is equivalent to reboring the solid plate; if a piece of plate be examined which has been sheared across the rivets, it will be observed that, if the rivets were put in by the machine, they appear to have become completely incorporated with the plate itself, and to form a part of it. The flanges are the only portions of a double lattice girder to which steam rivetting can be applied. This will be manifest from an inspection of Fig. 4, which is a diagram representing the main features of a steam rivetting machine: it consists of two principal parts, A and B; A is the portion which forms the resistance, and the projection on its surface takes the place of the sledge which is held by one man in hand rivetting against the head of the rivet, while P is the hammer, worked by a small cylinder and piston-rod, which gives the blow, and in so doing is brought into the position shown by the dotted lines. It is clear that any portions of a girder which are required to be united by rivetting must be able to be brought into the space shown by x in the figure, and which does not admit of any very great variation, although capable of adjustment within certain limits. In constructing the girder in the workshop, the angle-irons and plates are put together by temporary bolts and a few rivets driven by hand, and then the whole boom is slung up on a cross beam traversing the length of the workshop, and passed in succession backwards and forwards through the space x of the machine, until the whole of the rivets are inserted. A single lattice or plate girder may be rivetted together completely by the machine. One of the great difficulties to be overcome in hand rivetting cannot possibly occur where the machine is employed—viz., the difficulty of bringing the

Fig. 4.



two heads of the rivet exactly opposite; in hand rivetting they are frequently not so, that is, the longitudinal axis of the rivet does not pass through the center of both heads, and the consequence is that the head is not concentric round the rivet hole and the bearing surface, or the force which draws the plates together is not equal on both sides of the plates. If the bearing surface were very unequally distributed around the rivet hole, it is evident that if a sudden shock came upon the rivet it would start, and be drawn through the hole. Another advantage of the machine is that it altogether dispenses with the preliminary hammering of the plates in the vicinity of the rivet hole, and which has often in thin plates injuriously affected their strength by producing a distortion or wind in them.

We shall next consider the strains on the compression and tension bars composing the web; and also notice the forms best suited to the different strains brought upon them.

(To be continued.)

INTERNATIONAL EXHIBITION, 1862.—JURY REPORT, CLASS VIII.—MACHINERY IN GENERAL.*

Subdivision III.—Pneumatic Machines.

Section I.—Air-pumps.

These pumps are principally represented by exhausting machines for creating a vacuum for the evaporation of syrups in the manufacture of sugar. They are constructed on a nearly uniform model. Each has a vertical steam cylinder with beam, connecting-rod, and fly-wheel; the pumps, two or four in number, and made of gun-metal, are placed on either side of the beam. The construction of this kind of machine has been scarcely modified for many years.

We place in this class the exhausters constructed by Messrs. Gargan and Co. (France, 1031), for the drawing of coal gas from retorts. These machines are represented by excellent drawings by M. Fouche. It is known that in large gas-works it is usual for the prevention of waste, to pump the gas from the retorts, in order that the pressure therein may not be raised above that of the atmosphere; whilst it is delivered into the gasometer with the necessary pressure. Blowing fans have also been employed with the same object. Messrs. Gargan have constructed exhausting machines with three parallel double-action cylinders, driven by a steam-engine. The employment of these three pumps, which draw from a small regulating gasometer, is sufficient to maintain a very regular current of gas. These machines, which offer a great economy of motive power over blowing fans, have been adopted by the Gas Company of Paris.

An ingenious instrument of Mr. J. J. Silbermann (France, 1162)

* See Mr. Humber's last work, 'A Complete Treatise on Cast and Wrought-Iron Bridge Construction.'

* Concluded from page 334.

was remarked. It is an air pump for physical and chemical researches. It is furnished with a stop-cock, pierced with several openings arranged in such a manner that the pump, which is in communication with three receivers, can pump the gas either in or out of each of the three receivers and into the other two at the will of the operator, by simply turning a stop-cock.

SECTION II.—BLOWING-FANS.

Among the blowing-fans exhibited may be remarked those of Mr. G. Lloyd (United Kingdom, 1913), and Mr. T. Lemielle (France, 1135). The former was in the Exhibition of 1851; both in Paris in 1855. The first is composed of blades, the width of which decreases from the centre to the circumference. These blades are contained within two cheeks, forming one body with them, and assuring the complete carrying away of the inclosed air. The absence of lateral leakage accounts no doubt for the comparative noiselessness of the action of the machine.

The blowing-fan of Lemeille, the action of which produces air-chambers of various capacity, acts rather like a piston machine: it continues to furnish excellent results in the ventilation of mines, and it is employed as an air-blast in many large works.

The North Moor Foundry Company (United Kingdom, 1948) has exhibited a blowing-fan patented by Messrs. Schiele and William, consisting of a fan having its wings curved and of diminishing width, mounted on the same shaft with a steam turbine, which drives it. This fan is particularly applicable to the ventilation of steam and sailing vessels.

The Vienna Imperial and Royal Commission for the Ventilation of Military Hospitals (Austria, 630) exhibits a ventilating fan of Dr. Heger. This instrument consists of a wheel, having the same axis as the tube which incloses it, and having blades inclined to this axis, it will be evident that the rotatory movement of the blades sets in motion the air within the tube. The variable sections of the tube and of the openings for the passage of the air are arranged in a manner to diminish as much as possible the loss of motive power.

From the reports furnished, this machine appears to have attained a useful effect of 25 per cent. of the power employed, which is considerable for a ventilator.

SECTION III.—BLAST ENGINES FOR FURNACES, &C.

The blast engines exhibited are very few. The vertical beam engine continues to be preferred in England. A blast engine of very fine workmanship is exhibited by the Lilleshall Company (United Kingdom, 1910).

A double horizontal engine on the system of W. Fossey, is exhibited by M. L. Pérard (Belgium, 273). The admission and expulsion of the air take place through circular sides placed at the bottom of the blowing cylinders, which are pierced with sixteen openings radiating from the centre; the slides have similar openings. In turning round their centre the slides open and close simultaneously all the openings in the bottom of the cylinders; thus is obtained a large area for the admission of air with a slow movement of the valve, which only makes one turn for sixteen made by the machine. During the period of the delivery of air the pressure on the slides is in a great measure compensated by the pressure of the air circulating in a false bottom, which prevents the separation which would be produced in spite of the guides between the slides and the bottom of the cylinders. At a speed of seventy turns per minute this machine can deliver 150 cubic metres of air, at a pressure of eight or ten inches of mercury. Like the blast engine of Messrs. Laurens and Thomas, this machine is free from the shocks of the valves, notwithstanding the great speed of the pistons, but it presents over its predecessor these advantages—viz., that the speed of the slides is low, and that the pressure on the different parts is balanced, and from this reason they are not so likely to get out of order.

Mr. Holmgren (Sweden, 269) has exhibited a model of a blowing machine of three single-acting vertical blowing cylinders, the driving shaft is placed below, and the connecting rod is composed of four diverging pieces of wood directly attached to the piston. The different positions of the piston are not parallel with each other; if it were replaced by a sphere of the same diameter as the cylinder it would have an action theoretically as perfect as that of a cylindrical piston. To profit by this property there has been provided for the piston a spherical fitting, and the connecting rod lengthened as much as possible to diminish the extent of the oscillations of the piston.

Mons. J. Schaller (Austria, 561) exhibits forge bellows, and a portable forge with double-acting bellows of a cylindrical form, and inclosed in a square case of sheet iron, having on the upper part the fireplace and a small hood.

SECTION IV.—MISCELLANEOUS.

Under this head are arranged a certain number of machines belonging to the Class VIII., but which it is difficult to distribute in the different sections of the class as defined by the Jury Directory. In the first place is the apparatus of Dr. Normandy (United Kingdom, 1946) for the production of fresh water from sea water. The water is distilled by the steam from the boilers of the steam ship, or from a special boiler in sailing ships.

The apparatus is disposed in such a way as to retain along with the steam from the evaporated water all the air previously dissolved in this water and in that which is employed in condensation, which in the upper part of the condenser nearly reaches the boiling point. This total quantity of air exceeds that which fresh water can hold in solution, so that the condensation produces water perfectly aërated. The empyreumatic taste occasioned by the distillation has still to be got rid of, and this it appears is successfully accomplished by filtration through wood charcoal. The whole apparatus is simply and practically disposed: the evaporation is entirely self-acting, requiring only the regulating of some stop-cocks.

The machines for the manufacture of aërated waters are very numerous, and are generally well constructed. It could hardly be otherwise with the manufacturing machinery required by an industry which becomes daily more extended.

M. Heckmann (Prussia, 1303) has exhibited an evaporating pan of large dimensions, for the boiling of sugar in vacuo, 3 metres diameter, and 3·60 metres high, and of very good workmanship.

M. F. Legal (France, 1157) has sent the model of a similar sugar vacuum pan, with some peculiar modifications to avoid the carrying over of sugar with the steam.

Subdivision IV.—Hydraulic Machines, Cranes, &c.

SECTION I.—HYDRAULIC MACHINES, PUMPS AND FIRE-ENGINES.*

The different systems of pumps are represented in great number. Among the chain-pumps may be remarked that of Mr. J. U. Bastier (United Kingdom, 1792), formed by a series of circular pistons in caoutchouc, moving in a tube of iron enamelled on the inside. To avoid friction the pistons have a diameter somewhat smaller than that of the tube, which itself is slightly narrowed at the lower part, sufficient to allow the pistons to pass with slight friction, thus preventing all loss of water. This apparatus is easily fixed; but we think nevertheless, that the other pumps would be preferred for great quantities of water, or for great depths.

Murray's chain-pump, exhibited by Mr. Middleton (United Kingdom, 1930), formed of plates of wood firmly connected together with iron chains, and moving in a rectangular case or trunk, is easily set up for temporary drainage purposes.

The force and lift pumps are in great variety: a large number of constructors have sought to give to the waterways and valves dimensions which render as small as possible the loss of power by friction. They have also sought to give a continuous movement to the ascending column of water, independently of the action of the reservoir of air. This result is obtained in the pump of Messrs. Carrett, Marshall, and Co. (United Kingdom, 1813). The solid piston is worked by a rod of half the section of the piston itself: during the up-stroke the upper surface forces a volume of water into the ascending column, and the lower surface draws in twice that volume. In the down-stroke these two volumes are sent into the receptacle communicating with the upper face of the piston. One of the volumes here fills the space which would otherwise be left empty; by the descent of the piston the other volume is sent into the rising tube. These pumps, which are of small size, are only exhibited as donkey pumps, for the continuous feeding of steam boilers with water.

The uniform movement of the water is obtained in a still more simple manner in the pump of Messrs. Farcot and Sons (France, 1152), in which two equal pistons with valves affording very large waterways, work parallel to each other in two pump cylinders. During the successive strokes the first piston draws in water by its upper surface, and delivers it to the ascending column by

* The report on the fire-engines is drawn up by the Special Jury on that subject.

causing it to traverse the second piston. In its ascending course, the second piston raises in its turn the column of water by its upper face, whilst the lower face sucks the water, causing it to traverse the first piston. This pump has yielded all the good results promised by its ingenious construction, and it is adopted in the water supply of Paris.

M. Letestu (France, 1167) exhibits pumps which are already very well known, as well as a double pump of large dimensions for drainage purposes. It is chiefly in operations where the waters are charged with mud or gravel that the pumps of M. Letestu have been found most useful.

The pump of Messrs. Knowelden and Co. (United Kingdom, 1901) has the general disposition of a fine engine pump, but between the extremity of the piston and the valves is a diaphragm: the free space between the piston and this membrane is filled with water covered with a layer of oil, so that the greasing of the piston is always perfect, and no sort of liquid nor foreign body can interrupt the action of the piston. The four valves, inlet and outlet, are arranged on the same bed plate, and can be easily visited and repaired. Their grouping presents this advantage, that by turning the bed plate this pump acts in the opposite sense, and can thus easily cleanse the ascending tube from any foreign bodies which have happened to get in, as they are very apt to do.

M. Perreaux (France, 1142) exhibits valvular pistons in caoutchouc. The piston is in one piece, and hollow below, and terminated in the upper part by two thin lips, generally closed, and so much the more effectually as the pressure above is greater, but which open to leave a passage for the water from below as soon as the pressure on this side predominates. With this piston, and a similar piece forming a bottom valve, a pump is obtained of a very simple construction. It is necessary to remark, however, that the repairs of the pistons in the generality of cases cannot be easy, and that the resistance of the material at the opening, and the small dimensions of the orifices, require an excess of motive power which would become of importance in pumps of any but of small dimensions.

The centrifugal pumps are chiefly represented by the systems of Appold and Gwynne. The first, constructed by Messrs. Easton, Amos, and Sons, obtained a very remarkable success in the first universal Exhibition of 1851. The second, very inferior at that time as regards the successful employment of motive power, has been so well modified, that in the absense of comparative trials it would be difficult to decide to which of these two machines the preference should be given, for they offer no essential difference except in the position of the axis of the wheel, which is vertical in the first and horizontal in the second. We believe that this system of pumps will receive numerous applications by the ease with which it can be set up, and its working without shock; by the employment of a steam-engine at a high rate of speed, which would be easy of transport and readily fixed. It is well fitted for employment in large temporary drainage works.

We would mention also, for simplicity of arrangement of the different parts, the drainage pump of Mr. Godwin (United Kingdom, 1862), and the double-acting pump of Mr. Hansbrow (United States, 40), and the double-acting pumps of M. Hubert (France, 1200), which furnish the French fountains in the grounds of the Horticultural Society.

Steam Pumps.

Messrs. Harvey and Co. (United Kingdom, 1880), employed in more than the half of the water-works of London, have exhibited a model of one of their large single-acting steam pumps, imitated from the drainage pumps of the Cornish mines. They are now adopted in nearly all large towns. The comparative experiment which will shortly be made at Paris between this system and that of Messrs. Farcot and Son (France, 1152), will therefore be highly interesting. It is useful to remember that in the Cornish engines, even in those used for the drainage of mines, where the mass in movement is more considerable, the action of the steam valve has never been so perfect as desirable. The diameter of the piston has always been too large to allow of the admission of steam at the pressure in the boiler (30 to 45 lbs.) without causing a detrimental velocity: there arises a throttling effect which absorbs a great part of the available work.

A great number of steam feed pumps are to be found at the Exhibition, all with steam and water pistons on the same piston rod, sometimes vertical but more often horizontal.

Two pumps may be seen from the United States: Mr. H. Steel (39), and Mr. Worthington (28). They are without fly-wheels; one of them has only one steam cylinder and one pump; the slide valve is brought into action instantaneously at each stroke of the piston by means of a small supplementary steam piston very ingeniou ly disposed. The other pump is composed of two cylinders of each kind: the steam slide valve is guided in each machine by the piston rod of the other; by this means the movements are simultaneous in opposite directions with perfect regularity.

To mention Giffard's injectors, exhibited by Messrs. Sharp, Stewart, and Co. (United Kingdom, 1299), Flaud (France, 1164), is to record their success. They are found at the Exhibition universally amongst the principal industrial nations, thus showing how this invention has been appreciated.

Professor Colladon (Switzerland, 106) is the inventor of a water-wheel to be set in motion by large streams of water, and constructed on the most scientific principles. It is at present used for the raising of water; between two exterior cylindrical surfaces exists a spiral partition in which the water stands at the level of the axis, and can be raised to a height commensurate with the number of the spirals.

Messrs. Wentworth and Jarvis (United States, 54) exhibit a windmill for the raising of water; self-regulating when the force of the wind increases; the guide sails close in, and increase the obliquity of the angle formed by the motor-sails, with the direction of the wind.

There has also been placed in Class VIII. a well-arranged machine for washing and bleaching of tissues, exhibited by Messrs. Sulzer Brothers (Switzerland, 112), and a machine for washing linen by Mr. Parker (United States, 89).

Water Rams.

The different hydraulic rams exhibit no new arrangement, with the exception of that of Messrs. Bollée and Son (France, 1165). By the adoption of a clack valve analogous to double-seated valves, he diminishes considerably the intensity of the shock; the pump feeding the air reservoir set in movement by the play of the ram, but always situated above the level of the highest waters, works even whilst the ram is under water, which allows it to be placed in such a manner as to profit by all the height of the fall. Finally, the valve is counterpoised at will by a regulator, by means of which the velocity of the machine is governed. There is here a manifest progress which should render the use of this machine more frequent.

Hydraulic Presses.

Among the hydraulic presses exhibited, there are some in which it has been sought to perfect the movement of the pumps: we may mention that of Messrs. Peel, Williams, and Peel (United Kingdom, 1954), in which the two pumps of different diameters work together. Both work in the usual way up to a pressure determined beforehand: when the effect of the large pump ceases the small pump works alone to the point fixed for the maximum pressure to be obtained, and when its play ceases to have any effect. This modification of the working of pumps is obtained by the very ingenious arrangement of two safety valves acting on the same lever; so that when the pressure reaches the first fixed limit, a valve is raised and gives to the lever a slight movement which causes the water to be driven into the cistern instead of the press: at the second limit another supply valve, raising the former fulcrum of the lever, annihilates in its turn in the same way the action of the small pump. As soon as the pressure descends below the second or the first limit, the small pump, and then the large one, recommence their effective work.

Mr. F. O. Ward (United Kingdom, 2015) has sought simplification of another kind. On a hollow bed, serving also as a cistern, he groups a horizontal steam-engine and pumps, thus compressing two machines into the space of one. The pumps are peculiarly constructed to avoid accumulation of air. They are also of thrice the usual length, and coupled in pairs by a novel arrangement, allowing all four to be driven by two connecting rods—a considerable economy. That their threefold length may not involve diminished directness of thrust, the connecting rods are proportionately lengthened. Thus twelve pumps with their twelve sets of valves are replaced by four, and twelve connecting rods, with their costly fittings, by two. This cheapened construction implies less cost of maintenance, fewer working parts and reciprocating motions, fewer valve beats, and less "back slip." The power is transmitted by pinion and spur wheel, geared to afford suitable leverage and suitable relative velocity of the steam and water in motion. These are all points of advantage, but it would seem desirable to isolate the steam cylinder from the cistern, in order to avoid refrigeration.

M. Lecointe (France, 1166) has obtained a simplification still greater: his apparatus of pumps and cisterns can supply twelve presses. It consists of two force pumps, the contents of which are led into a reservoir of variable capacity by the play of a plunger moving vertically, weighted to 1200 or 1400 lbs. to the square inch. It is this reservoir which distributes the water to the presses at this constant pressure. If the pumps furnish more water than is used, the regulating piston, arriving near the extremity of the stroke, raises a balance weight, the action of which immediately cuts off the action of the pumps. The power returns as soon as the piston of the reservoir is lowered; but this return of power is combined in such a way that it takes place only at the commencement of the stroke of the piston, so as to drive the water with slow velocity at first, essential to the preservation of the machine. The mechanical regulator is ingenious; but it is advisable to avoid the noisy shock of the connecting rod against the clutching lever, which continues as long as only one of the pumps is in action. With the exception of this objection to a matter of detail, the machine of M. Lecointe presents a very important progress in the production of hydraulic presses, and the success which this machine has obtained in a great number of works is perfectly well deserved.

Water Meters, &c.

Water-meters are of many different constructions. That of Mr. Siemens (United kingdom, 1987), which was to be seen in the Exhibition of 1851, consists of a small turbine traversed by the water to be measured. It remains to be decided by well authenticated trials whether this instrument registers accurately under the different pressures with which water may have to traverse it.

The other systems of meters consist of filling with water a constant capacity, and registering the number of the operations. That of Mr. Jopling, exhibited by Messrs. T. Lambert and Sons (United Kingdom, 1903), is of very simple construction. It is composed of two equal parallel cylinders, of which the pistons work together in the same direction, the piston rod of each piston regulating at the extremity of the stroke the admission of the water into the neighbouring cistern. All the water must pass through one or the other of these two cylinders; and the number of oscillations registered measures the quantity of water which has passed. The cylinders are inclosed in a case of cast-iron, so that the pressure is the same at the exterior as the interior of the cylinders, and its influence on the play of the machine is nearly annihilated.

The Manchester Water-meter Company (United Kingdom, 1923) exhibit several water-meters. One of them is provided with only one cylinder, in which the introduction of the water is regulated by a system of two pistons, which are alternately driven in different directions by a slide, the position of which is changed by the piston rod of the large piston at each end of its stroke. Among the other water-meters of the Company may be seen one (Frost's patent) without packing, which will work with warm water, for the filling of steam boilers. It is composed of two pumps, formed each of a rectangular box, moving horizontally in the right angle formed by two fixed planes. A partition, fixed perpendicularly in the intersection of the two planes, and filling the section of the box, performs the office of a fixed piston, and separates the two cavities of the box, which fill alternately, as they are extended. The box slides in grooves adjusted on the fixed planes, each governing the slide valve of the other. It would be very desirable that regular experiments should be made with these instruments, which would be very rapidly adopted by the public, could they confide in the register of the machines.

M. Sacré (Belgium, 277) has exhibited an hydrometer for distilleries. The liquid is measured as it leaves the still, at the same time that a small quantity of liquid, variable at pleasure, is preserved at each measuring, and conducted into a special receptacle, which allows of recording readily the mean density of the liquid distilled.

SECTION II.—CRANES.

The principal kinds of machines for lifting exhibited, are either cranes or jacks.

With the cranes are ranged those called Derrick cranes, presenting generally an extended basis, and consequently great stability. Cranes properly so called are either fixed or movable, worked by hand, steam, or water. We remark in the two first classes the system of M. Neustadt, exhibited by J. F. Cail and Co. (France, 1144), and C. Fauconnier (France, 1161), which consists in applying to cranes the Galle chain. This chain, formed of plates of wrought-iron united by pins, has no forged joints, and presents a very great solidity. It adapts itself to the teeth of a pinion, and the free extremity of the chain is received into a box or directed into a sheath. This system presents over the others the advantage of doing away with the drum and one of the cog wheels, seeing that the diameter of the pinion is about one-third of that of the drum; of avoiding the oblique winding of the chain, and consequently of notably simplifying the construction of cranes. An experience of seven years has confirmed the use of cranes with the Galle chain. Nearly 500 of them have been constructed, and are used in large establishments. Amongst the most important are those of the Imperial Marine of France.

A crane moved by hydraulic pressure forms part of the exhibition of Sir William Armstrong and Co. (United Kingdom, 1785), and which also appeared in the Exhibition of 1851. The drum is totally suppressed: the chain of the crane when it reaches the head of the vertical standard is passed over pulleys; one of the pulleys is fixed, and the other is set in movement by a piston of an hydraulic press. The rotation of the crane is also effected by the pressure of water. This crane is suitable for a locality where water is distributed at a high pressure. It can be fed from a high-pressure hydraulic reservoir, the reservoir itself, fed by force pumps driven by steam, furnishing an advantageous means of replacing the continuous work of the machine by the intermittent work of the crane. The Armstrong system comprehends also a capstan moved by water under high-pressure. Three pumps are thus put in motion, and work together on a horizontal shaft carrying a conical pinion which works against a wheel fixed at the base of the capstan.

Messrs. Ransomes and Sims (United Kingdom, 1961) have exhibited a portable steam-engine which can act as a steam capstan. A winding drum is placed beneath the boiler; it is driven by a conical-toothed wheel, put in motion by the steam-engine situated over the boiler. The whole of this arrangement is ingenious; but it may readily be understood that this machine cannot exercise very great power. The machine exhibited could only raise 25 cwt. The most useful application of it would be in the raising of building materials.

The hydraulic lifting jacks already seen at the Exhibition of 1851 have become more numerous. In those of Messrs. Adamson and Co. (United Kingdom, 1780), the oscillations of the lever in raising are lessened by an angle block which butts against the head of the jack. It is only by moving the lever laterally on its axis that the stopping of the operation is prevented, and that the water from the bottom of the press is allowed to pass into the head of the jack, causing at the same time the lowering of the object lifted. With the machine of Messrs. Tangye, Brothers, and Price (United Kingdom, 2002), the lowering is obtained by a special screw. These instruments are simple, and offer great advantages over those with rack wheels.

We must also draw attention to the crab of Mr. Winand (Belgium, 28), set in motion by an endless screw which can guide the gearing but cannot be moved by it. The lowering of the weights can only be obtained by turning a handle in the opposite direction, or by unwinding the screw when a rapid movement is desired.

SECTION III.—PILING ENGINES.

The Jury have granted no awards in this section.

P. LUUYT, Reporter.

Subdivision V.—Weighing, Measuring, and Registering Machines for Commercial Purposes.

SECTION I.—COMMERCIAL WEIGHING INSTRUMENTS.

In these some very excellent instruments are exhibited of simple construction, beauty of design, and of very superior workmanship. Several cranes have weighing apparatus attached to them, so that the weight raised may be weighed at the same lift—a very evident advantage.

C. Schember, Vienna (Austria, 581).—Centimal and decimal weights. Medal awarded. Good workmanship, practical utility.

Z. Deschamps, Geneva (Switzerland, 107).—Assaying balance, good design, good workmanship, accurary, and sensibility. Medal awarded.

B. Grabhorn, Geneva (Switzerland, 108).—Assaying balance, good design, good workmanship, accuracy, and sensibility. Medal awarded.

M. A. Hasemann, (Prussia, 2041).—Scales with column. Honourable mention.

E. Pfitzer, (Saxony, 2326)—Decimal weighing machines, balances, &c. Honourable mention.

Prof. C. A. Klingenfeld, (Bavaria, 175)—Scales invented by him. Honourable mention.

N. Obach (Belgium, 272)—Weighing machine. Honourable mention.

SECTIONS II. & III.—REGISTERING INSTRUMENTS, AS GAUGES, INDICATORS, AND TELL-TALES.

Great improvements have taken place of late years in articles under these heads, and have thereby contributed greatly to reduce accidents in steam-boilers, by accurate notation of pressure, height of water, &c. The steam gauges exhibited are in most cases constructed with discs of thin metal, corrugated and plain, secured and made steam-tight at the outer edge, the pressure acting upon the surface, and the amount of deflection is communicated to a movable pointer, which indicates upon a dial the exact amount of pressure. Others are constructed with diaphragms of india-rubber, the pressure being met with spiral or volute springs, and the motion communicated as above. The bent tube manometer of Mr. Bourdon is a most ingenious and correct indicator of pressure, and under all circumstances the best in the exhibition. Indicators and tell-tales of simple construction and practical utility are well-represented. For the most part these are automatic, being self-acting for the regulation of feed-water, and giving notice by whistle of conditions where it is necessary to call attention.

Allen, Harrison, and Co., Manchester (United Kingdom 1782)—Gun-metal fittings for steam-engines. Medal awarded for good workmanship and general excellence. This firm exhibit a very excellent safety plug for steam-boilers; a valve seat is placed or fitted into the boiler flue over the fire-place, having a lid or valve with perforations filled with metal fusible when not covered with water.

Frieake and Gathercole, Mark Lane (United Kingdom, 1857)—Salinometers, telegraphs, indicators. Medal awarded for good workmanship, &c.

Routledge and Ommaney, Salford (United Kingdom, 1972)—Engine-pumps, boiler-feeders, magnetic machines for separating iron and brass. Medal awarded. Practical utility. A very useful and efficient boiler-feeder is exhibited by this firm, which may thus be briefly described. A small close cistern, through which the feed-water passes, is placed in connection with the boiler; steam is first admitted into the cistern and afterwards condensed with a small quantity of cold water, thus forming a vacuum, which by a self-acting arrangement causes the cistern to fill with water from the hot-well of the engine or any convenient source. Steam is then admitted so as to act with equal pressure to that in the boiler, and the water enters the boiler by its own gravity: this apparatus is very perfect in its action, and will feed with water at any temperature below 200 degrees.

G. Salter and Co., West Bromwich (United Kingdom, 1978)—Spring balances, dynanometers, pressure gauges, &c. Medal awarded. Excellent workmanship, practical success. These owe their efficiency to well-tempered springs, and are not surpassed. The pressure guages act by means of the steam or the water passing against an india-rubber plate, on which lies a metallic plate with rod in connection with the mechanism, and which is kept down by one of Salter's springs.

J. Chandler, Mark Lane (United Kingdom, 1817)—Flat glass water-gauge for boilers. Honourable mention.

Smith Brothers, and Co., Nottingham (United Kingdom, 1991)—Pressure and vacuum gauges. Honourable mention. These gauges are on the principle of Salter's, excepting that a volute spring, instead of a spiral is used, a diaphragm of india-rubber preventing the passage of steam.

F. Wise, Adelphi, (United Kingdom, 2028).—Feed water regulator, indicators, alarm for steam boilers. Honourable mention. The regulator for steam boilers consists of a copper float attached to a lever within the boiler: to this lever is connected a small gun metal slide, which rises and falls with the float, and when the water level is slightly in excess of the proper height, opens a port whereby air or steam is admitted to the suction pipe or working barrel of feed pump, thereby suspending its action until the water is below or at its proper level.

J. White, Borough (United Kingdom, 2021).—Engine oil feeders, &c. Honourable mention.

E. Bourdon. Paris (France 1156).—Manometers, barometers, injectors, centrifugal pumps, &c. Medal awarded. Originality of design; good workmanship of the several articles; practical success of manometers and barometers. Mr. Bourdon has a very interesting exhibition of pressure gauges, vacuum gauges, barometers, &c. These are based on the principle of the distortion of tubes having elliptical sections by an internal pressure, and torsion or twisting by external pressure. In these pressure gauges a curved tube of elliptical section is fixed at one end, both ends being hermetically sealed. Steam is admitted, which has a tendency to straighten or uncoil the tube; the other end is attached by a small link and lever to an indicating finger. Mr. Bourdon also uses a twisted tube, in the form of a quick-threaded screw: steam being admitted has a tendency to untwist the tube, and the motion is communicated to the indicating finger as before.

A gauge for very high pressures is made by having two curved tubes, filled with water, in connection, one being secured in a vessel so as to be acted upon externally. This causes a pressure to act upon the exposed tube internally, and the movement is communicated to dial as before.

Mr. Bourdon also exhibits several modifications of a mode of raising water by jets of steam, which are in all respects on the principle of Giffard's injector for feeding boilers.

L. J. F. Desbordes, Lyons – France, 1160.—Manometers, pyrometers, barometers, &c. Medal awarded. Good workmanship; practical success.

Desbordes and Rodault, Paris—France, 1139.—Manometers &c. Honourable mention. These manometers act by pressure upon a flexible disc, which gives its indication upon a dial by means of a lever and toothed quadrant working into a small pinion on the point of the indicating needle.

A. Achard, Paris—France, 1023—Electro-magnetic safety apparatus. Medal awarded. Ingenious and original design. This machine is very perfect in its action; and in addition to its being a self acting regulator of the supply of feed-water to the boiler, gives notice by ringing a bell of any derangement under the following circumstances:—

When the water is too low or too high; when the steam is too high; when the feed-pump is out of order; and, when the apparatus itself ceases to act.

F. T. Moison, Mouy—France, 1171.—Dynanometers. Medal awarded. Original design; practical utility. The dynanometers of Monsieur Moison are very ingenious and practical; the driving pulley gives motion to the machine to be tested through three bevel wheels in the usual manner, one being placed upon an axis at right angles with the other, its fulcrum being the shaft upon which the other two wheels revolve. The power is registered by dials acted upon by the spindle upon which the intermediate bevel-wheel is placed. Monsieur Moison also exhibits a steam-engine and water wheel governor; the former acts much in the same manner as the dynamometer, a fly-wheel being driven by wheels upon a balance lever, upon one end of which is a weight tending to depress it. When the speed of the engine is such as to overrun the fly-wheel, the weight is raised and the throttle valve closed; the latter is a pendulum or ball governor, running horizontally, having a spring to counteract the tendency of the balls to expand. On one end of the governor spindle is fixed a spur-wheel, which gears into another running loose upon a shaft, parallel with governor spindle: on the opposite end is a conical pulley, giving motion by means of a strap to another pulley which runs loose on the same spindle as that on which the spur-wheel is placed. The strap is moved by means of the ball governor; giving a varying speed to the driven cone pulley. The driven spur-wheel and driven pulley are connected by means of an intermediate bevel-wheel, and when the speed of one exceeds that of the other, a motion is communicated so as to open or close the water sluice.

David Brothers, and Co., Port Quentin—France, 1106.—Instrument to test the strength of thread. Honourable mention.

Dedieu and Co., Lyon—France, 1159.—Manometers. Honourable mention. In this the steam acts upon a disc of metal, motion being communicated to the indicating needle by an eccentric and levers, a coiled spring preventing any play.

P. Renaud, Nantes—France, 1141.—Float for steam boiler, and alarm. Honourable mention.

Lethuillier-Pinel, Rouen—France, 1140.—Magnetic indicators of water level. Honourable mention. In this a magnet, moved by a float inside the boiler, causes a small light steel roller to rise and fall outside a face plate on top of boiler, and indicates correctly every change of level of water.

J. C. Gore and Co., Jamaica Planes—United States, 36.—Belt shifter. Medal awarded. Originality of design; probable utility. A very simple and effective invention. The belt shifter is moved and locked by one motion, thereby preventing the possibility of accidental movement so as to prevent the starting of any machine at an improper time.

S. Elster, Berlin—Prussia, 1395.—Gas-testing apparatus. Medal awarded. Originality of design, good arrangement, and good workmanship.

A. Sacré—Belgium, 277, hydrometer. Honourable mention.

Near and Co., New York City—United States, 27.—Dynamometer, good arrangement, practical utility. Medal awarded. This is a very ingenious machine, but difficult to describe without a drawing: two pulleys are mounted upon a spindle, one being connected with the motive power, the other with the machine to be set in motion, one being loose, the other fast; the former exerts its power upon an inclined plane which acts longitudinally upon two spiral springs, and these indicate their pressure on a scale or counter fixed to the framework of the machine. This counter, besides being actuated by the force and motion of the driving pulley in an uniform manner, is caused to revolve in an increasing ratio as the pressure or force increases, by means of a cone which advances or recedes with the spiral springs, and which gives its motion to the counter by a friction roller.

Bockenhagen—Mecklenburg-Schwerin, 37.—Spirit gauge. Honourable mention.

E. Drewitz—Prussia, 1295.—Alcoholometer for quantity and strength. Honourable mention.

Schaffer and Budenburg—Prussia, 1316.—Manometers; steam-engine fittings. Honourable mention. These manometers act by pressure upon a corrugated plate of metal, and give motion to the needle by a lever and toothed quadrant and pinion; they have proved very effective in practice, and can be relied on for their accuracy.

O. M. Hempel—Prussia, 1404.—Steam-pressure gauge. Honourable mention.

Watremez and Kloth—Prussia, 1325.—Black's safety apparatus to prevent the bursting of boilers. Honourable mention.

D. A. Löhdefink—Hanover, 379.—Manometers. Honourable mention.

J. J. Gutknecht—Switzerland, 154.—Apparatus to measure spirits and water: dry gas meter. Honourable mention,

Waltjen and Co.—Bremen, 6.—Friction balance and oil test. Medal awarded. Good design, practical utility of oil test. This apparatus is intended to determine the description of oil best suited for lubrication of shafts at certain given velocities.

A shaft supported on two bearings is fitted with a sliding friction pulley, driven from a friction disc, placed at right angles to the shaft. The sliding friction pulley is movable from the centre of the disc to its circumference, so as to allow of increasing or diminishing the speed. One end of the shaft is fitted with a worm gearing into a worm wheel, which registers the number of its revolutions. The other extremity of this shaft is fitted with a collar, and upon this collar the balance disc is supported by a segment of a step. The balance is weighted by two pieces of metal of equal weight, suspended from the two ends of a strap which passes over it. On each side of the balance a knob is cast to the circumference, one of which knobs is bored out to receive a cylindrical weight, which screws in and out. The various parts of the balance are so adjusted that its point of gravity falls a little below its centre, and a hand fixed at the lower extremity of the balance shows when it is in a vertical position and accurately balanced. The oil-cup passes through the centre of the step segment to the point of contact with the collar. The apparatus being put in motion, the smallest amount of friction will tend to raise that side of the balance which is fitted with a sliding weight, which is thereupon screwed out so as to increase the weight on that side until the friction is counterbalanced, when the scale marked on the sliding weight will indicate in pounds and ounces the amount of friction on the collars at the given speed with the oil used. On testing various kinds of oil at the same speed, it will be easy to ascertain which quality produces the least amount of friction.

J. Adcock, Dalston—United Kingdom, 1781.—Distance indicator for wheel-carriages. Honourable mention. A small air cylinder is fixed vertically to the axle of the carriage near the wheel, and communicates by means of a non-flexible india-rubber tube, with a second air-chamber; being part of a clockwork which renders the number of revolutions of the wheel. The boss or nave of the wheel is fitted with a curved arm or rod, which after each revolution of the wheel depresses one arm of a bell crank lever, the other arm of the same acting upon and depressing the piston rod, which is attached to the centre of an india-rubber disc with which the cylinder is fitted: on the disc being thus depressed a portion of the air in the cylinder will be forced through the tube to the air-chamber of the clock-work, and inflate the india-rubber disc or bag of the same. The centre of the disc is connected with a pall of a ratchet-wheel, and each time the air is forced into the air-chamber, the pall will rest upon the ratchet-wheel and cause it to move forward one tooth, and thus register by means of the clock-work the distance passed over by a revolution of the wheel. The arm of the nave having passed the arm of the bell-crank lever, the disc in the cylinder will, by its own elasticity, or by means of a spring, rise and again admit the air into the cylinder. The same body of air being passed to and fro between the cylinder and the air-chamber, and no valves being required. The apparatus is at once simple and effective, and not liable to get out of repair.

R. and L. R. Bodmer—United Kingdom, 1801.—Safety-valve.—This being exhibited by a Juror could not be made the subject of an award, but the Jurors wish to record their appreciation of it. The peculiarity of this valve consists in the valve edge being raised by a column of steam or water, entirely independent of the escaping steam; a tube formed in the centre of the valve is connected by means of a pipe with the steam space or water of the boiler; at its upper end this tube is enlarged, and forms a piston of the diameter of the valve; and the valve cap, made in the form of an inverted cylinder open at the bottom, fits on the piston, and rests on the valve seating in the usual manner. When the steam pressure exceeds that to which the cap is weighted, the steam or water, acting upon the end of the inverted cylinder valve cap, will lift the same in proportion to that pressure; but on any sudden accumulation of steam taking place, the valve will at once open to its full extent, and immediately relieve the boiler of its surplus pressure.

With a slight modification, valves on this principle can be constructed with a lifting area of exactly one square inch, less or more, whilst the diameter of the valve may be three, four, six, or more inches.

These valves are particularly adapted for being weighted direct, by means of weights or springs.

F. Normand, Paris—France, 1179.—Improved method of correcting the error of the universal joint in transmitting motion. Medal awarded.—Originality of design, practical success.

J. N. Mauzaize, Sen., Chartres—France, 1197.—Engaging and disengaging gear.

The Reporter of the foregoing articles under Subdivisions II. and V. has preferred giving a short general report, and has added a more detailed description under the head of each, where he considered the articles deserve special notice.

J. Hick, *Reporter*.

PAPERS ON HYDRAULIC ENGINEERING.*

By Samuel McElroy, C.E.

No. 2.—*Distribution*—(continued).

Tuberculation.—In addition to the ordinary process of oxidation to which iron is subject, cast-iron water pipes are peculiarly liable to the production of internal accretions or tubercules, which restrict their calibre and discharge, and involve a chemical action destructive to the metal.

Of these evils, the former is the most important, since the gradual or partial loss of section, by irregular accretions, exerts an influence on the immediate usefulness of the pipes, which exceeds any question of cost in eventual replacement.

We have had frequent occasion to notice the rapid destruction of wrought-iron produced by sea water, in which particular veins and portions of the iron are the most rapidly injured, showing that the relative constituents of the special forging exposed determine the rapidity of this action; and from frequent observation of like action on cast-iron water pipes by fresh water, it is plain that this chemical process, though less formidable in degree in this case, is attributable to the same laws.

We are informed that in the mining pumps of the Pennsylvania coal region, it is not uncommon to have the lower pipes

* Continued from page 336.

entirely destroyed in process of time by a change into plumbago, from water action; and instances are on record in water works experience, where the entire castings of the mains have been gradually transformed, retaining the form, but completely altering the substance, in certain local cases.

Observations were recorded in the 'Edinburgh Philosophical Journal,' in 1822, by Dr. J. Macculloch, on the production of black-lead from cast-iron, under experiments with sea-water, porter, acids, &c.; which have been recently extended by Dr. Crace Calvert, as noticed in the 'London Engineer,' of January 1862, demonstrating the formation of plumbago from cubes of cast-iron.

From 1838 to 1843, in England, Mr. Robert Mallett made investigations of the operations of water on iron, in reference to water-pipes, of which the results are thus stated to the British Association for the Advancement of Science:—

"He found that any sort of iron cast or wrought corrodes when exposed to the action of water holding air in combination, in one or other or some combination of the following forms,—viz. 1. Uniformly, or when the whole surface of the iron is covered uniformly with a coat of rust, requiring to be scraped off, and leaving a smooth, red surface after it. 2. Uniformly with plumbago, where the surface as being uniformly corroded is found in some places covered with plumbagenous matter, leaving a piebald surface of red and black upon it. 3. Locally or only rusted in some places, and free from rust in others. 4. Locally pitted, where the surface is left as in the last case, but the metal is found unequally removed to a greater or less depth. 5. Tubercular, where the whole of the rust which has taken place at every point of the specimen, has been transferred to one or more particular points of its surface, and has there formed large projecting tubercules, leaving the rest bare.

The great elements of difference of corrosion as respects the iron itself appear to be:—

1. The degree of homogeneity of substance of the metal, and especially of its surface

2. The degree of density of the metal, and state of its crystalline arrangement.

3. The amount of uncombined carbon or suspended graphite contained in the iron.

And therefore that the more homogeneous—the denser, harder, and closer grained and the less graphitic—the smaller is the index of corrosion."

From examinations of the Cochituate mains, made by Prof. Horsford in 1853, he expressed the opinion that—

"There has been galvanic action arising in one class of cases from the contact of metals of unlike affinity for oxygen, and generally from a want of homogeneity of the iron, and to this more than any other agency is to be ascribed the rapid formation of accretions."—*Cochituate Water Report*, January 1853.

While the law of this action is universal, and its effects are always to be anticipated, the degree of action is modified by the special conditions of any particular system of mains. Quality of water, rapidity of flow, temperature, and other circumstances, in connexion with the special quality of the castings exposed, may accelerate or retard these formations: and our information as to their existence and effects, however well established as to the law, is somewhat defective in special records, partly because the action is hidden from sight, and partly because, when exposed, it is customary with water works administrations to conceal or deny the existence of defects.

Some of these effects may be thus briefly noticed:—

It was observed at Grenoble, in France, that the cast-iron feed main had reduced its flow on this account, between 1826 and 1833, from 370 to 190 wine gallons per minute.

It was noticed at Cherbourg, that from 1836 and 1838 to 1850, the effective section of the supply main had been reduced to less than one third its original calibre, the accretions being 1·575 to 1·968 inches in height.

In the reports of the water works in England, numerous instances are recorded of the effects of tuberculation, which are also prominently noticed in locomotive boilers, and other kinds of exposed iron work.

In 1852, Mr. E. S. Chesbrough, Engineer of the Cochituate Board, Boston, reports that—

"The rapidity with which the interior surfaces of some of the pipes have been covered with tubercules or rust, has excited a great deal of interest. . . . All the large pipes that have been opened have been partially or entirely covered on their inner surfaces, some with detached tubercules varying from a half to two and a half inches base, with a depth or thickness in the middle of from one-quarter to three-quarters of an inch; and some entirely to an average depth of half an inch, with a rough coating, as if the bases of the tubercules had crowded together. The smaller pipes all exhibit some action of this kind, but generally to a less extent as regards thickness than the larger ones. In one case, however, a four-inch pipe was found covered to a thickness of about one inch."

In 1853, the Cochituate Board remarks—

"The extent to which these accretions have affected the discharge of water from the pipes, by diminishing their area and increasing the friction, has been satisfactorily ascertained by observations made by the City Engineer, with great care, on one of the 30-inch mains across Charles River, and is found to be much greater than was anticipated. The loss of discharge under the common head of six inches was found to be upwards of twenty per cent. of the known discharge of a new main of like diameter. Similar observations on the 30-inch main from the Brooklyn Reservoir, under the ordinary head of 8 feet, gave the same result."

This action at Boston was very carefully recorded for a time, demonstrating a very serious injury to the whole distribution system. The board, however, seems to have consoled itself at last with the theory that the action exhausted itself at a certain stage, and continues to extend the service with cast-iron pipes.

The effective diameter of the 20-inch main of the Jersey City Water Works, recently examined, was found to be less than 18 inches.

Considerable reduction from tubercules is recorded on the Croton mains and smaller pipes.

From the action of the water on the pump valves and other engine castings of the Brooklyn pumping engines, the discolouration of the water at fires, and other evidences, this action is serious on the unprotected Brooklyn distribution.

Similar effects are recorded in various other water works of the United States in confirmation of what may be properly assumed as a law of chemical action, more or less powerful in special localities.

Preventives.—Various efforts have been made to apply washes, paints, and varnishes, by different processes, so as to prevent contact between the water and iron, in castings as well as wrought-iron work. A galvanic action has also been provided by coatings of zinc and other metals, and various enamelling processes have been invented. Among these may be mentioned white-wash of pure lime, a wash of hydraulic cement, linseed oil applied under pressure, a composition of oil and wax, copal and other varnishes, lead and zinc paints, and coal tar varnish or paint. And all of these, including galvanism and enamelling, experience goes to show that they have various special merits as palliatives, but no permanent power as preventives. Paints of all classes need periodical renewal; varnishes and enamels sooner or later peel off or wear off; and galvanism simply delays by destruction in one direction the eventual process of destruction in another. To make either palliative effectual, even for a time, requires careful and expensive workmanship, and the point of final failure is merely a question of time, which question should properly determine the propriety of its use, in connexion with the relative cost of use, in those cases where want of access prevents renewals.

On large dry-dock gates and caissons of wrought-iron, exposed to sea water, without excessive motion, we have found a body-coat of red lead, with super-coats of zinc paint, the most durable and satisfactory; while for the iron work of steamer water-wheels and other parts much exposed, coal tar paint, though requiring frequent renewals, is more easily applied, and probably more effectual. Various experiments which have been made with coal tar varnish in contrast with other coatings, seem to favour it strongly when applied to a hot and clean surface, although its advocates admit its defects when not thus applied. Hence this process has been adopted in several water-supplies in England, and is being introduced into this country to a considerable extent. The large mains at Brooklyn, with those now used for extensions, and the 5-feet mains of the Croton extension, are thus coated. Other water works are following this example, all the pipes required for the Charlestown Water Works, now going under contract, being specified with this protective, in case cast-iron pipes are used at all.

As now applied in this process, the pipes are dipped in a varnish-bath maintained at a temperature of 300° when first cast, or are oiled to prevent rust until they can be coated. The additional cost is about $1·25 to $1·50 per ton. The pipes being laid, renewals in coating are prevented, and its duration will vary with circumstances, being in some cases a matter of years, in others, of months and weeks. Of the mains coated by Dr.

Smith's process at Glasgow, for the Brooklyn works, many of those exposed in the pipe-yard for a few months lost their varnish from the effects of the weather, while others remained in good condition, and all the coatings hitherto applied can only be regarded as palliatives.

While it is fixed and certain, that no engineer is justified in laying unprotected cast-iron pipe, the protections themselves require careful study, and the most faithful application.

Wrought-Iron Cement Pipe.—Among other substitutes which have been adopted for water pipes, those of wrought-iron riveted in proper lengths, and lined and coated with a thick body of hydraulic cement mortar, have been very extensively used in this country within the past fifteen years. The several lengths are put together by butt joints secured by sleeves, filled in with cement to prevent leakage, or by cast-iron hubs protected by mortar from contact with the water. The pipes, by one process in use, are lined with mortar applied under strong pressure, and coated when laid in the trench; and by another process they are both lined and coated under pressure at one operation. In one case the taps are inserted by brazing a tap plate and tap to the outer iron shell before the drill is used; and in another, by the use of cast-iron rings tapped as in ordinary cast pipe.

Without discussing the merits of the several patents which apply to details of manufacture, it is manifest that the pipes themselves embody an important principle of durability by the preservative effect of cement on iron, which excludes air and prevents oxidation and tuberculation, and which continues to increase in solidity and strength with increased age. It is also manifest that any desirable measure of strength may be attained by regulating the quality and thickness of the iron body. The cement lining is not less than one half-inch thick for the smaller diameters of three and four inches, and by pressure is very firmly set to the iron plate. Pipes of this kind can be manufactured and laid with less cost than those of cast-iron, and have several valuable qualifications when properly put down.

Lead Service Pipe.—The use of lead for house service from the street mains, although a matter of common practice, has given rise to elaborate investigations and discussions in Europe and in this country. This use has obtained against the serious objections urged against the material, on account of its ductility, its strength, and its sources of profit to plumbers, and some disadvantages in manufacture or use of its occasional substitutes. In some cities however, as at Hartford, it is directly prohibited.

From the investigations on this subject at Boston in 1848, about the time of introducing the Cochituate supply, it was determined to admit its use. While all the experiments showed that lead is dissolved by water, it was argued that the Cochituate was not more dangerous in this action than the Croton, and that "a coat forms on the lead, which for all practical purposes becomes in process of time impermeable to and insoluble in the water in which it occurs." And this sums up all the chemical discussion in its favour,—viz. that the quantity dissolved is insignificant, and that the process is self-protective in time.

It is plain however, from an examination of the varied analyses and discussions of this matter, that the defence is apologetic at the best; while, on the other hand, the doctrine of cumulative effects, the voluminous testimony as to lead diseases, the extensive prevalence of those which may be directly or indirectly attributed to the effects of lead, as colics, paralysis, neuralgia, rheumatism, &c., and the proof that at Boston and in other localities the coating is not a protective, certainly justify a distrust of this claim of immunity, and a general rejection of the material. To furnish an adequate and safe substitute certainly need not overtax engineering skill.

Appurtenances.—Of these stop-cocks and hydrants are the most important: the former being used to district the supply, for convenience of repairs and access, and the latter for fire purposes, street washing, and other public uses.

Among the various forms of stop-cocks in use, probably the best are those which are built with a globular head acting in part as an air chamber, and with a flaring groove for the gate. In the first case, greater strength is secured in a limited space; and in the second, the gates are prevented from jamming, as the larger ones are apt to do with too narrrow a groove, in working one brass face against another. Face joints are also preferable to lead joints, in obviating the necessity of caulking. Much inconvenience is often caused by improper arrangement of the stop-cock districts, where long distances are attempted to be controlled to save expense in original construction, and it is desirable to condense these districts of control as much as possible.

The ordinary form of fire hydrant in use, as to the tube itself and not as to its case, seems to have been adopted from one city to another, with very little regard to its purpose of operation. The range of ingenuity seems to have rested content with the automatic vent, which drains the tube above the valve when not in use, to prevent frost. In the ordinary tube the valve is operated within, by a rod passing through a stuffing-box in the tube-head, which raises and lowers it, to close or open the hydrant. Generally, a 4-inch hydrant main is attached to a three-inch vertical tube, with a two-and-a-half-inch nozzle, and the effective section of the hydrant is less than one-half the section of the branch main. Hence it follows that in consequence of excessive hydrant friction, the supply of a street main, six-inches in diameter, cannot feed more than two fire engines on the same block, through two hydrants, and our steam fire-engines are obliged to put a suction on the hydrant nozzle to get their supply at all.

Now it is evident, that if there is any propriety in using four-inch branches, there is none in using hydrants throttled down by rude, internal working parts to effective sections of less than one-half the branch calibre; and with the universal introduction of steam fire engines, all the present system of branches and hydrants must be improved. There is no mechanical difficulty whatever in making hydrant tubes with a free delivery equal to that of the branch, and this should always be done.

In all cases where steam fire engines are provided for, the hydrant nozzles may be adapted by the use of a double nozzle, either to the ordinary hose connexion, or a steamer connexion of the full hydrant size; but the best way to arrange them is to make a full-size hydrant nozzle, using a set of reducers for ordinary fire hose. Instances abound in the experience of firemen where most valuable property has been lost, solely on account of excessive friction of hydrants, where time prevented the intervention of engines.

The use of iron cases, both for hydrants and stop-cocks, is an improvement on the ordinary wooden boxes, which should be made universal, as a matter of economy, science, and ornament.

The following table will illustrate the relation of appurtenances to mains adopted in the case of a single prominent supply:—

Aggregate Boston Distribution, January 1, 1862.

Diameters (inches)	40	36	30	24	20	16	12	6	4	Total.
Length of Pipes (feet)	23·082	21·065	31·836	5·778	24·127	7·619	90·625	384·480	104·633	693·240
Stop-cocks ..	4	5	8	10	11	22	163	682	283	1·165
Hydrants ..	..	..	..	..	..	..	..	..	..	1·451

On this work all the wooden boxes which are replaced are Burnetized to prevent decay.

In this rapid sketch, in which the discussion of details is not admissible, we present as to distribution, some of those prominent features which directly affect its cost, durability and usefulness, and which involve systems of practice more or less common and in some cases objectionable, with the hope that inventive genius, prompted by general assent, may mark out the most feasible and satisfactory correctives for our adoption.

(*To be continued.*)

WARMING AND VENTILATION AS ILLUSTRATED AT THE INTERNATIONAL EXHIBITION, 1862.

Perhaps from the absence of any mention in the Official programme of the objects comprised under the above head, and the attendant uncertainty as to the class in which applications for space should be made, the number of contributions connected with systematic warming and ventilation was proved to be very limited. Among the British exhibitors were only to be found the names of Perkins and Rosser (Sylvester); nor were there any illustrations of the practice of Reid, Gurney, Arnot, Haden, Price, and others whose works are numerous throughout the country.

It is particularly to be regretted that foreign engineers and manufacturers should not have been induced to send some specimens of the works in which the Paris Exhibition of 1855 was rich, and which might have been studied with great advantage by their *co-laborateurs* in this country. The ingenuity and science displayed in some of their caloriferes would have been an example to British manufacturers; while the art of sanitary improvement and systematic ventilation would have been much elucidated if MM. Thomas and Laurens, Duvoir Leblanc, Grouvelle, and others had exhibited apparatus, models, or plans. It is to be hoped that any future International Exhibition may comprise a distinct subdivision for the objects assigned to this class.

The whole Exhibition presented only three or four illustrations of the application of systematic ventilation and heating to large structures. These were the Imperial and Royal Military Hospital at Vienna, the designs for a Theatre in Paris, the new buildings of Guy's Hospital in London, and a County Prison at Canterbury.

The system adopted in the Vienna Hospital was illustrated by drawings exhibited in the western annex, Austrian department, Class X., and by a small blowing-machine of the kind employed (No. 630).

The portion of this building shown on the drawings consisted of two stories, each floor comprising two wards of thirty-two and sixteen beds each respectively, placed end to end, with windows on both sides; those on one side looking out over the exterior space; and those on the other into a close corridor running parallel with the length of the wards. This plan will probably be considered as rendering the building greatly dependant for the sanitation of its atmosphere upon artificial or systematic ventilation.

The permanent ventilation of the hospital is effected by *insufflation*, the apparatus employed for forcing in the air being the newly-invented blowing-machine of Dr. Heger.

The fresh air is taken from the exterior at the back of the building, by a small fresh-air shaft of low altitude, provided at the top with a contrivance for directing the descending current, which passes into a subterranean channel in which the blowing-machine is fixed. The machine is worked by a small steam-engine, and is stated to be capable of supplying 7000 cubic metres of air per hour, equivalent to about 40 cubic feet per patient per minute.

In cold weather the air of ventilation is warmed in its passage by clusters of small steam-pipes placed in a chamber in the basement under the centre of each ward; the delivery into the wards being by an open-work pedestal placed in the centre of the ward. Tubes inserted into the pedestals of the ground-floor wards take up to the pedestals on the first floor their due proportion of air. The vitiated air is evolved from the wards through ventiducts contrived in the external walls, having their exterior outlets in the vertical face of the wall at about the level of the ceilings; and openings into them from the wards, both at the floor and near the ceiling. Both the internal and external apertures have regulating valves. The ventilation is independent of the warming, the latter being partially effected by coils of steam-pipes placed in pedestals along the centre of each ward. The plan adopted is reported as being satisfactory to the military authorities. The machine is stated to require only ½ of a horse-power to work it, and to utilise 55 per cent. of the power employed.

The designs for a Lyric and Dramatic Theatre, exhibited by M. Barthélmy (France, Class X., No. 1292), have received honourable mention from the Jurors for the arrangements for warming and ventilating. The plans, which were very comprehensive and elaborate, were however suspended at such a height, and had the specialities of the system of warming and ventilation so slightly indicated, as to leave the impression that the Jurors must have had a much better insight into the ideas of the exhibitor than fell to the lot of any ordinary observer.

Some drawings were exhibited by Mr. S. Egan Rosser—Class X., No. 2399—to illustrate the application of Sylvester's system of warming and ventilation to the new buildings of Guy's Hospital. In this building the winter warming is effected by the air supplied for ventilation. The wards are in pairs, placed side by side, with occasional openings in the division wall for facility of communication. The fresh air is taken from above the level of the highest roofs by a fresh-air tower, which has at its summit an octagonal lantern, within which a cowl, or shield, revolves according to the direction of the wind, to which its open side is always presented. Descending to the basement, the fresh air is carried in capacious channels to the extremities of the building; the several wards on each story receiving an independent supply by caliducts which are carried up in the division-wall between the wards. In the basement, and ranged against the inlets of the vertical caliducts, are tiers of iron pipes, heated in winter by the circulation of hot water, which warm the air in its ascent. The warmed air enters the wards through numerous apertures near the ceiling, and the vitiated air is withdrawn at openings near the floor. All the vitiated air-ducts are collected into a horizontal channel in the roof, which runs the whole length of the building, and discharges into a lofty ventilating shaft about 160 feet in height. The ventilating shaft is warmed by the smoke of the furnaces of the hot-water boilers and those of the warming apparatus, and by tiers of hot-water pipes in the horizontal vitiated air channel. The ventilation is mainly effected by extraction, assisted by the plenum influence of the wind; and has been found to range from 30 cubic feet per patient per minute for the night ventilation in the coldest weather, to 78 feet per minute for day and summer ventilation. There is no restriction upon the opening of the windows, which are freely used in mild weather; and the comfort of open fire-places is also provided in the wards, the smoke-flues from which are also conducted into the main ventilating shaft.

The Kent County Prison at Canterbury, drawings of which were also exhibited by Mr. Rosser, is warmed and ventilated upon the system introduced by the late Mr. Sylvester at the Model Prison, Pentonville, and generally adopted in this country. There are however certain specialities of arrangement which the exhibitor considers improvements. These are—1st, The repartition of the fresh air into district sectional channels for the service of each floor, in which it is warmed by its own series of hot-water pipes, the circulation of which may be regulated or intercepted at pleasure; and 2nd, The increased power of extraction which is gained by bringing the vitiated air down to the basement of the building, and there drawing it into the ventilating shaft, which may thus have a greater working height than when it starts from the roof of the building. The position of the ventilating fire at the bottom is also more convenient and accessible than when it is (as is usual in prisons) placed in the roof.

Of the various kinds of apparatus for heating buildings on a large scale, the only complete full-sized specimens were those shown by Rosser, Staib, and Gervais.

The "Low Temperature Air Warmer," shown by the first of these exhibitors, is calculated to raise the temperature of 2250 cubic feet of air 64° in a minute, with an average consumption of 14 lb. of coal per hour, and is stated to be adequate to the warming of a church or other building containing 150,000 cubic feet of space. The apparatus is of the hot-air class, and is constructed of cast-iron, but the inventor states that by the large development given to the surfaces exposed to the air, as compared with the internal surfaces which receive heat from the fire, the overheating of the air usually incidental to hot air stoves is entirely obviated, while, also, no part of the metal to which the fresh air has access is in contact with the fire. The extension of the exterior surface is accomplished within a very limited space by casting deep parallel laminated ribs or blades upon the exterior of the apparatus—the inner edges only of the blades being exposed to the heat, and their flat sides to the air.

The Cast-Iron Calorifere exhibited by L. F. Staib and Co., of Geneva—Switzerland, Class X., No. 130—shows a remarkable similarity to the foregoing in the principle of its construction; the extension of the exterior surface being however effected by a combination of ribs and angular corrugations. This calorifere has a further resemblance to Rosser's, in the mode in which the smoke is made to descend around the interior fire-box, and in the out-take below the ash-pit. The power of the apparatus is not stated, but it exposes, within a space about 2 ft. 8 in. square and 5 ft. high, a heating surface of about 140 ft. for a fire grate of one foot area, and would, probably, prove in practice a most efficient and economical warming apparatus.

Another calorifere, by the same exhibitor, although intended as a pedestal stove, to be fixed in the apartment to be warmed, may be referred to as combining in an ingenious manner the former principle of construction with the use of smoke tubes. The fire-place is a close cockle or "cloche," pentagonal on plan, with projecting flanges and studs to increase the surface and throw off the heat. This is surmounted with an upper receptacle having recesses on each side, in which sheet iron smoke tubes, that start from its *lower* rim, are partly engaged. The smoke tubes re-unite over the apex of the upper chamber, and the whole is surrounded by a cylindrical case, in which ample provision is made for the ingress and egress of the air. The stove exhibited is stated to be capable of maintaining the temperature of an apartment containing 14,000 cubic feet at 59°; to which it is no doubt fully adequate.

The model of the Pneumatic Heating Stove, shown by R. Zimara, of St. Petersburg, in the Russian department—Class X., No. 316—has attracted some attention from its being an attempt to revive the notion of substituting fire-brick and earthenware for iron, in the construction of large heating apparatus. The model represents an apparatus on a large scale, calculated by the designer to maintain a building containing 130,000 cubic feet at the temperature of 60° to 66° Fahr. under 40° degrees of frost. The warmed air is intended to be admitted at a temperature not exceeding 100° Fahr., the highest temperature in the stove itself being 190°, and the smoke cooled down before escaping to 145°. The apparatus consists of a furnace in fire-brick, occupying a space of about 300 cubic feet. The smoke from the furnace traverses, simultaneously, a horizontal bed of seven earthenware pipes, 9 in. diameter and 9 ft. in length, to a common smoke chamber at the back, whence the smoke returns through a lower bed of the same number of pipes to another chamber behind the furnace; and from thence again, still on the descent, through a third and lowest horizontal bed of pipes to the bottom smoke chamber at the back, and then into the chimney. The air to be warmed is introduced through ducts contrived in the body of brickwork around the furnace, and by a number of inlets under the lowest bed of horizontal smoke pipes; and the warmed air is taken off by arched outlets at the upper part of the chamber, groined into the brick vault which covers the whole of the apparatus. The arrangement of the smoke pipes is good, although by no means novel; and bears a strong resemblance to a system patented a few years back by M. de Jong, which it imitates closely in its inadequate appreciation of the necessary rate of ventilation required in a building of the extent to which such an apparatus would be adapted, and the very insufficient provision for effecting it by means of the ash-pit in draught. The practical difficulties which have prevented the substitution of fire-brick or earthenware for iron in the construction of warming apparatus, are not overcome in M. Zemara's Pneumatic stove. The tendency of the brickwork of the furnace to fall to pieces, of the pipes to crack, and their joints to open, is not counteracted or even attempted to be guarded against; and the result which has hitherto attended all contrivances of this kind—viz., the mixing of the smoke with the air may be regarded as inevitable. In other respects the great bulk of the apparatus, and its cost as compared with the much smaller and more efficient iron caloriferes, would be a serious impediment to its use.

A Calorifere, *à eau chaude et à air libre*, was exhibited by A. Gervais, of Paris (France, No. 1129). This is a combined apparatus for warming air by direct contact, and by hot water circulation. It consists of a cylindric cockle in cast-iron, surmounted by a double bell boiler in copper, with hemispherical envelope in plate iron, confining the smoke around the boiler. An 8-inch sheet iron smoke-pipe rising from the dome makes various turns at right angles in the warm air chamber. The whole apparatus is inclosed in brickwork, the fresh air being admitted to the chamber at the bottom, at the back of the furnace; where it first comes in contact with the sides of the cockle, and then rises to pass over the sheet iron dome and around the smoke-pipes. The boiler has the ordinary flow and return pipe, with a connecting pipe between the two bells. There is little to be said in favour of this apparatus. The cast-iron cylinder is certain to become red hot, while the effect of the dome and smoke pipes in increasing the temperature of the already highly heated air will be small. The construction of the boiler itself may however be adopted with advantage.

Illustrations of heating by hot-water, and of apparatus and parts of apparatus, were exhibited by Perkins, Rosser, Riddle, Weeks, Ormson, Gray, Messenger, Taylor, Gervais, and by the London Warming and Ventilating Company.

The highly ingenious high-pressure Hot-water Apparatus, of Mr. Perkins, may be as well understood from the small full-size specimens which he exhibited—Class X., 2330—as it could be from an inspection of it in its application to the most extensive buildings. The system has been so long before the public, and is so well known, that no detailed description is necessary.

Rosser showed specimens of the low temperature Hot-water Pipes, invented by the late Mr. John Sylvester, in which the conducting power of cast-iron is made use of to obtain a considerably larger surface in the same space than can be done by the ordinary round pipes; as well as presenting those surfaces to the air in a position more favourable for the transfer of their heat. A further extension of the same principle is seen in the hot-water or steam-stove of the same exhibitor, which is simply a vertical cylinder of cast-iron containing hot-water, or steam; from the exterior circumference of which a series of radiating blades project and expose a large surface to the air.

The Apparatus shown by the London Warming and Ventilating Company—Class X., 2411—pushes the same principle to an extreme. The close series of parallel plates which are cast on their hot-water pipes have far too large an extension of the diffusing, as compared with the recipient surfaces, to produce an effect proportioned to the increase in cost; as long as the interior of the pipe is not above the temperature of hot water or common steam. For surfaces in direct contact with a close fire the arrangement would be good.

Mr. Weeks and Mr. Ormson both exhibited hot-water apparatus. The first-named exhibitor (Class IX., No. 2201) showed his well-known vertical tubular boiler, in which a very large surface is exposed to the action of the fire. One would think that the special advantage or defect of these boilers—viz., that of their being quickly heated and quickly cooled, would be less applicable for greenhouses, &c., where they are chiefly used, than a form of boiler which, by containing a larger quantity of water, would give greater permanency of temperature. The tenacity with which the Chelsea hot-house builders hold to this form would seem however to argue that its recommendations are greater than would at first sight appear.

Mr. Ormson—Class IX., No. 2160—also sent a Vertical Tubular boiler, which differs in no essential respect from Weeks's, except that none of its joints are exposed to the fire. Ormson's coil-frame is an elegant modification of a familiar arrangement, and presents a large heating surface in a small compass. The ventilating hot-water apparatus of the same exhibitor, which was to be seen in his very beautiful conservatory, erected in the court of the north-east annex, is simply a series of water-boxes placed at intervals on a line of pipes; the cold air from the exterior being admitted into the house through the boxes, which however, have not their interior surfaces well disposed for warming the air, while their occurrence at frequent intervals must seriously retard the circulation of the water.

Gray's Improved Oval Tubular Boiler—Class IX., No. 2119—is another Chelsea boiler, and we presume is made *oval* for the sake of a difference.

Taylor & Son's Double Chamber Boiler—Class IX., No. 2191—is a modification of the common saddle-boiler, having a return flue from back to front over the furnace, and is made with its recipient surfaces either plain or corrugated. A horizontal tubular boiler, looking like a skeleton of the other, was probably intended to have a division of fire-tile between its upper and lower parts, so as to assimilate the course of the draught to the action of the former boiler. All the London hot-house builders who were exhibitors of hot-water apparatus, seem to have taken to the use of the Sylvester Furnace Door, which they however manufacture in a way that detracts much from its special recommendations.

By far the best of the *horizontal* tubular boilers was that shown by T. G. Messenger, of Loughborough—Class IX., No. 2151.—This boiler is composed of triangular tubes set near together in horizontal beds, and so disposed that nearly $\frac{5}{6}$ of the whole pipe exposed is effective as recipient surface. The horizontal beds of pipe terminate at each end in water-spaces which connect one bed with another. The furnace-bars are hollow, as is usual in the Chelsea boilers, but triangular in section, and therefore better disposed for the retention of the fuel, and for feeding it with air. The return-pipes are connected to the water-box at the back end of the furnace-bars, from which he ascending current moves simultaneously through tiers of pipes at the sides and top of the furnace to the back, returning by a second bed of pipes overlaying the fire to the flow-pipe, which comes out in the front. The only objection to this boiler seems to be the retardation of the circulation in passing through so many turns in the pipes, and the consequent tendency to the generation of steam—a serious inconvenience in hot-water boilers.

Horton's Patent Locomotive Fire-box—Class VIII., No. 1888—would also be well adapted for a hot-water boiler.

Harrison's Cast-Iron Boiler—Class VIII., No. 1877—although more expressly intended for use as a steam-boiler, seems applicable to hot-water apparatus. It may be described as consisting of any number of hollow spheres, with slightly projecting neckings, turned and bored to fit into one another, and held together in rows by iron bolts passing through each range. The rows are set at such an inclination as to allow the particles of steam or heated water to rise without interruption from each lower globe to the next upper one.

Riddell's Slow Combustion Boiler—Class X., No. 2397—seems suitable for small apparatus. It consists of a double cylinder, placed in a vertical position upon a solid bed of fire-brick. The fuel is supplied at a door or lid on the top, the fire being fed with air, and the ashes removed by a small sliding door at the bottom. By moving the latter to the right or left, perfect control over the combustion is attainable.

The Double Bell Boiler of M. A. Gervais has been already referred to. Another by the same exhibitor, styled the "Thermosyphon Boiler," was probably the best article of the kind in the Exhibition. This boiler, which is made of copper, may be described as a saddle boiler, with reverberating chamber at the back, from which the flame works by an internal flue to the front, returning by an upper flue again to the back, where it descends within the body of the boiler to an out-take at the bottom. The furnace, flues, and chambers present an extended heating surface, while preserving a considerable section for the draught.

The Drawings of the Warming Apparatus at St. Augustine's Prison, Canterbury, already referred to—Class X., No. 2399—show boilers on a very similar principle of construction, but having a more fully developed reverberating chamber, and only one internal flue, the smoke completing its circuit outside the boiler, which is of a waggon shape. Both this and the preceding form possess the great advantage of utilising that part of the heat, which with boilers having *through* flues is expended against the brickwork at the back. For extensive apparatus they will be very economical, particularly where long ranges of hot-houses, &c., are to be heated from one boiler.

In connection with hot-water apparatus may be mentioned the new method of joining water pipes, exhibited by V. Delperdange—Belgium, Class IX., No. 310—The joint is formed by a band of vulcanised india-rubber, which is slipped over the beads of the butting ends of the two pipes to be connected, upon which an elastic wrought-iron collar, having on its inside a groove corresponding to the width of the two beads, is tightened by a bolt and nut.

For the removal of condensed water from steam heating apparatus, the Steam Traps of Schäfer and Budenburgh—Class VIII., No. 1316; and of Phillipson—Prussia, Class VIII,, No. 1314—would be found useful. They differ somewhat from the construction hitherto adopted in this country, and appear likely to maintain their action under steam of any pressure. Bowden's Steam Trap, shown Class VIII., No. 1851, was on the ordinary construction.

Among mechanical appliances for effecting forced ventilation, there were exhibited a considerable number of fans, on the centrifugal principle, by various makers, of which none appeared better than Lloyd's Noiseless Fan—Class VIII., No. 1913.

Schiele Patent Ventilators, and Exhaust Fans, manufactured by the North Moor Foundry Company—Class VIII., No. 1948—appeared to possess considerable advantages.

Lemielle's Blowing Machine—France, Class VIII., No. 1135—differs from the ordinary centrifugal machines, in drawing in the air at the opposite side of its periphery to that at which it is discharged. It consists of two cylinders of different diameters placed eccentrically one within the other, the smaller cylinder turning on a fixed axis; the space between the two cylinders being occupied by movable flaps which assume different degrees of inclination as the inner cylinder revolves, and thus acting as pistons or valves in forcing the air forward.

A well constructed Fan, on the centrifugal principle, was to be seen near Lemielle's machine in the western annex. A disc in the vertical centre of the fan separates the inhaling apertures on each side, while the spaces between the blades are preserved of a uniform section throughout.

Dr. Heger claims for his Ventilator, already referred to in speaking of the heating and ventilation of the new Military Hospital at Vienna, that its principle is new. The small machine of this kind, exhibited in the western annex, may be described as a pipe within which a set of flies like those of a smoke-jack are made to revolve transversely to the direction of the pipe, by a strap passing over a pulley on their axis. A set of fixed vanes corresponding to the movable flies is placed on the inhaling side of the machine; the central portion of the tube from the axis to the inner circle of the vanes being occupied by a sort of conical boss, which fills up the dead space and prevents the formation of eddies in the air current.

Howorth's Self-acting Archimedean Screw Ventilators, (Class VIII., No. 1889) are intended to be put in motion by the force of the wind acting upon a turncap, in the neck of which the Archimedean screw is fixed. It is difficult to see what advantage this contrivance possesses over a common cowl, in discharging the air, while like the common cowl its efficacy diminishes as the velocity of the wind decreases. When the screw is turned by machinery, the discharge of air would be more free by the opening in a common cowl than it would generally be through the slits in the revolving lantern.

Of contrivances for facilitating natural ventilation, few possessed any novelty. The glass louvred Window Ventilators of Mr. Ramage—Class X., No. 2333—are in very general use. Mr. McKinnell—Class X., No. 2392—showed several modes of applying his Concentric Ventilators. Mr. W. Cooke—Class X., No. 2379—had a wire gauze folding blind for fixing between the sash of a window and the frame, which, being attached to the upper rail, is drawn down with the sash, and interposes a wire gauze screen excluding dust and deflecting the current of entering air. Also a box for fitting in openings in the wall, containing perforated zinc screens, inclined at various angles.

In conclusion we would recommend, to all concerned in the practice of ventilation, the excellent instrument for determining the velocities of air currents, manufactured by Mr. J. Davis of Derby, and shown in Class XIII., No. 2891.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Meeting at Cambridge*, 1862.

On the Importance of Economising Fuel in Iron-Plated Ships of War. By Edward Ellis Allen.

The object of this paper is to point out the very great importance of economising the consumption of fuel in iron-plated ships of war, and to show how this may best be done. It is a subject which has been sadly neglected, notwithstanding these vessels have to be constructed to carry several hundred tons additional weight, even when only partially protected.

This increase of weight has been met to some extent by reducing the number of days' fuel carried; so that instead of these vessels coaling for fourteen days, which, in the opinion of most persons, is the least they should do, the quantity has been reduced to considerably less than one-half. With bad or indifferent coal this time would be reduced to perhaps four days' consumption when full steaming, *i.e.*, when the engines are working up to, say four times their nominal power. Moreover, the high rate of speed considered desirable for these vessels necessitates a corresponding increase in the power of the machinery, which of course, under any circumstances, involves an increase in the fuel consumed, or, in other words, reduces the time during which a given quantity of fuel will last.

Further, it is highly probable in future wars great despatch will be necessary in moving vessels from one station to another, not only from the fact that for many years to come there will be comparatively few iron-cased vessels in the navy, but also from the increased rapidity with which warlike preparations must be made. This also will tend to increase the quantity of fuel consumed.

Even in time of peace it will be difficult to reconcile ourselves to war steamers going far under sail alone; and when the whole of the working expenses of a large ship of war are taken into account, it may be the more economical course to put her in commission so many weeks later, and then let her steam to her destination. Indeed, it cannot be doubted, that the same causes which have operated in supplanting sailing vessels by steamers will also induce the use of the steam power more and more as time advances.

There are thus several important reasons why every effort should be made to economise the consumption of fuel in the ships of our new iron-plated fleet—viz., Additional weights, increase of speed and distance to be steamed, increased despatch in moving

* Continued from page 351.

from station to station and of time during which steam power will probably be used even under ordinary circumstances, and increase in the cost of coals owing to the continually increasing size, power, and number of steam ships in the Royal Navy.

To these reasons for economising fuel we may add: the universal deficiency of boiler power in ships of the Royal Navy, necessitating a relative increase of space being allowed for this portion of the machinery; as also the fact now generally admitted that much smaller vessels than those first constructed will be necessary in order to constitute an efficient fleet; these small vessels being of course as thickly plated as the very largest, if not more so, on account of their speed being considerably less. From the particulars given in the accompanying table (page 392) it may be stated with sufficient accuracy that in most of our iron-plated ships the weights of the three items, viz., the armour plating, the machinery, and the fuel, are very nearly equal, and that together they constitute about one-third of the total displacement, *i.e.*, in vessels plated amidships only. Marine engines of good construction, when working full power, exert a force, when measured by indicator, considerably above their nominal power; and it is a rule with the Admiralty that all engines supplied to them shall work up to at least four times this nominal power. Now the average consumption of fuel in marine engines of the ordinary but best construction being about 4½ lb. per indicated horse power per hour, it follows that a nominal horse power requires about 4 cwt. of best coals in the day of twenty-four hours, so that a 1000 horse power engine would consume something like 200 tons of coal per day when working full power. Comparing this quantity with that for which stowage is given in the iron-plated ships of the Royal Navy, it will be seen that the best of them carry no more coal than would serve them for about four days' full steaming.

We are nevertheless told, that in all, or nearly all cases, seven days' supply is provided, but this can only be on the supposition that the engines are not intended to work full power the whole of the time; indeed, with the ordinary boilers used on board war steamers, this is not possible, for it is well known that full steam cannot be kept for more than twenty-four hours together.

The very great increase of power necessary to propel any given vessel at an increased speed renders it a matter of some difficulty to obtain a rate of speed in the iron-cased ships such as that believed to be desirable, or rather necessary, by those competent to judge. If a certain power be necessary to drive any given vessel of good form at 10 knots per hour, then to increase the speed of the same vessel to 12 knots will require nearly double that power; to increase it to 14 knots the power must be nearly three times as great; and to increase it to 16 knots the power will require to be more than quadrupled. The estimated speeds of our new ships of war, even in smooth water, are considerably less than those thought necessary at sea by naval men and many others, and the difference is as much as 1½ to 2 knots per hour.

Six of the largest vessels are estimated to attain about 14 knots per hour; five of them about 12 knots; two of them about 11¾ knots per hour; four of them about 11 knots; one about 10¾ knots, and one only 9½ knots; and in the vessels tried even these speeds have not been attained; whereas 15 knots per hour has been very generally assigned as the speed below which our new iron-plated ships of war should not be propelled when at sea. In favour of such a speed we have the opinions of Mr. Scott Russell, Mr. Samuda, Captain Halsted, Commander Oldmixon, Admiral Moorsom, and many others.

With regard to the distance which such vessels should be able to go without recoaling, we have the most distinctly expressed opinion of Mr. Scott Russell and Captain Halsted, as well as those who have commented upon their views, that 5000 miles should be the minimum, whereas none of our ships could, with their ordinary supply of coal, go one-third of that distance.

With respect to the increased cost of coaling the ships of the Royal Navy, it will be found that the charge on this head is now over £300,000 per annum, and in war time more than double the ordinary amount is expended. What shall it be, even in times of

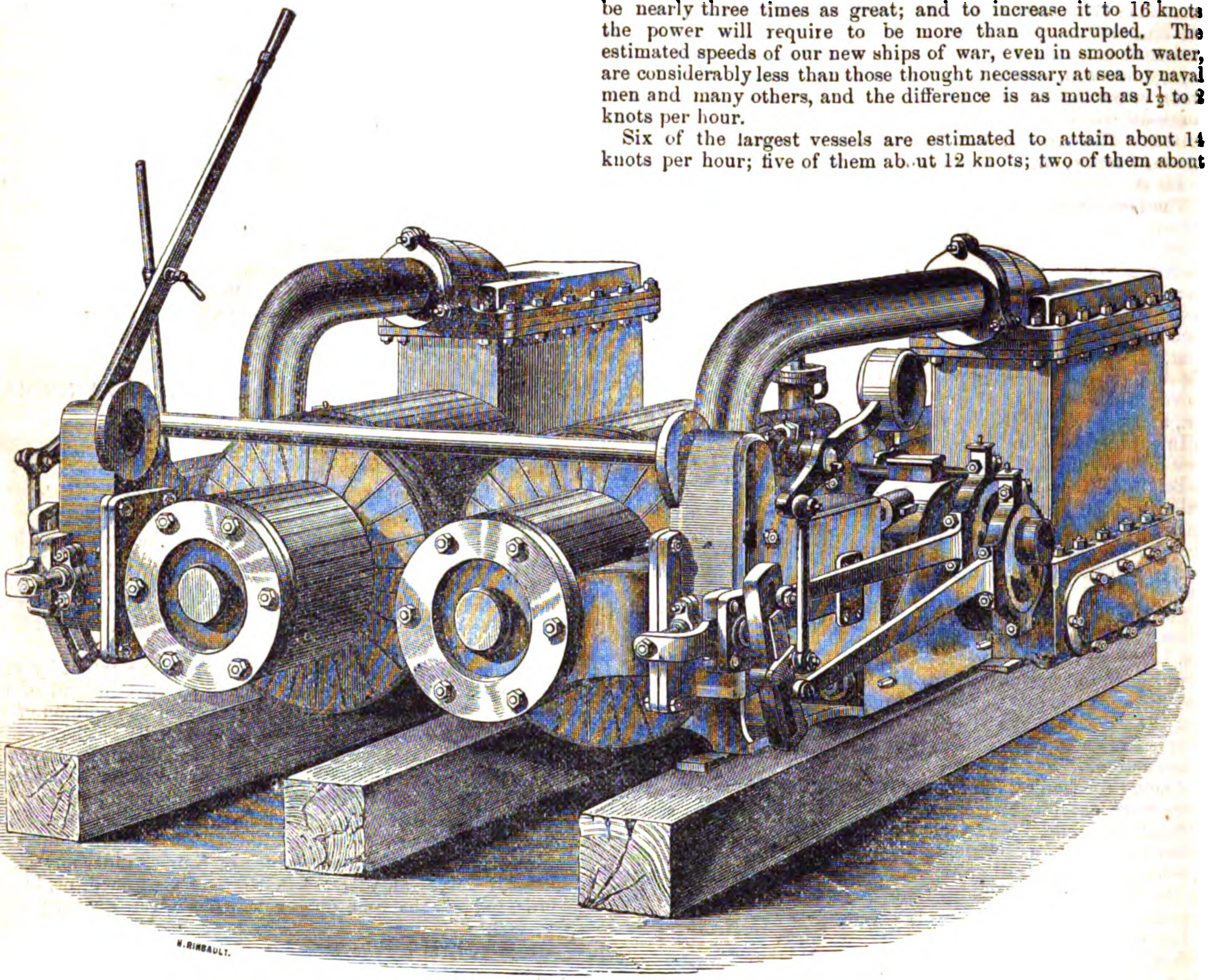


Fig. 1.—E. E. Allen's Patent End-to-End Cylinder Double Piston Rod Engine.—View from Small Cylinder end.

peace, when a fleet of iron-cased ships of the Warrior class shall have been formed? We may indeed view with some alarm the amount of this item in the naval estimates of future years, unless something be done to diminish the consumption of fuel in marine engines.

Regarding the necessity of economising fuel in ships of war, on account of the insufficiency of boiler power at present allowed, it will be only necessary to quote the opinion of the present Surveyor of the Navy, expressed by him when in charge of the steam reserve at Portsmouth, in 1858. He says:—"As far as my experience goes, no ship of any class or with any maker's engines has sufficient boiler space; there is not one of the multitudes I have tried that has steam enough to keep the throttle valve open for two hours. The steam drops directly the vessel goes over 9 knots, and this not in one or two, but in all without exception. . . . Nothing is so wasteful of fuel as too small a boiler: intense firing and incomplete combustion of the fuel is the inevitable result of trying to keep up steam in such a case. . . . Not a step is made in the right direction of obtaining speed and economy until more attention is paid to the proper proportion between the quantity of steam used in the cylinders at each stroke, and the quantity remaining in the boiler."

He says that 600 horse-power boilers should be used where 450 horse-power boilers are now employed, and the ships would go faster, not perhaps rush past the measured mile quicker, but in a chase of four or five hours.

The Committee on Marine Engines, reporting upon this and other evidence, observe:—"From the evidence taken by the committee it appears that in general the boilers supplied to our men-of-war are deficient in generating steam, and that full speed in consequence can only be maintained for a short time. Now the remedy of that defect must necessarily involve the whole question of the amount of space that can be allotted to the boilers; the committee, therefore, consider that they need not enter into further details, and that they do their duty by simply, and without comment, bringing the question before their lordships."

Of the last reason named for encouraging economy of fuel, no better illustration can be given than that of the Enterprise, the first small ship in course of construction by the Admiralty, plated with armour. In this case the employment of ordinary machinery (excepting having surface condensers) not only necessitates the quantity of fuel taken being reduced to a very few days' steaming, but the speed with which we are to be satisfied is an "estimated" one of 9½ knots only. What will this be as an average at sea? Possibly not over 8 knots.

Enough has now been said to show that economising the consumption of fuel in iron-plated ships of war is a subject of the very gravest importance; and although this will be admitted generally, and, perhaps, by none more readily than by the authorities of the Admiralty, it appears practically to have received far less attention than it deserves. It is hardly saying too much when we state that coal is the only item in which weight can be saved.

It has been long known that many vessels in the merchant service have been working now for some years upon just one-half of the fuel consumed in ships of the Royal Navy. In proof of this, although evidence is abundant, it will suffice to give simply the opinion of Mr. Charles Atherton, late Chief Engineer of Woolwich Dockyard, and that of Mr. Andrew Murray, Surveyor to the Board of Trade. Mr. Atherton, in a paper read before the British Association, three years ago, says, "I believe the ordinary consumption of fuel in steam ships of the Royal Navy is fully 50 per cent. in excess of the amount of 2½ lb. which has been practically realised on continuous sea service."

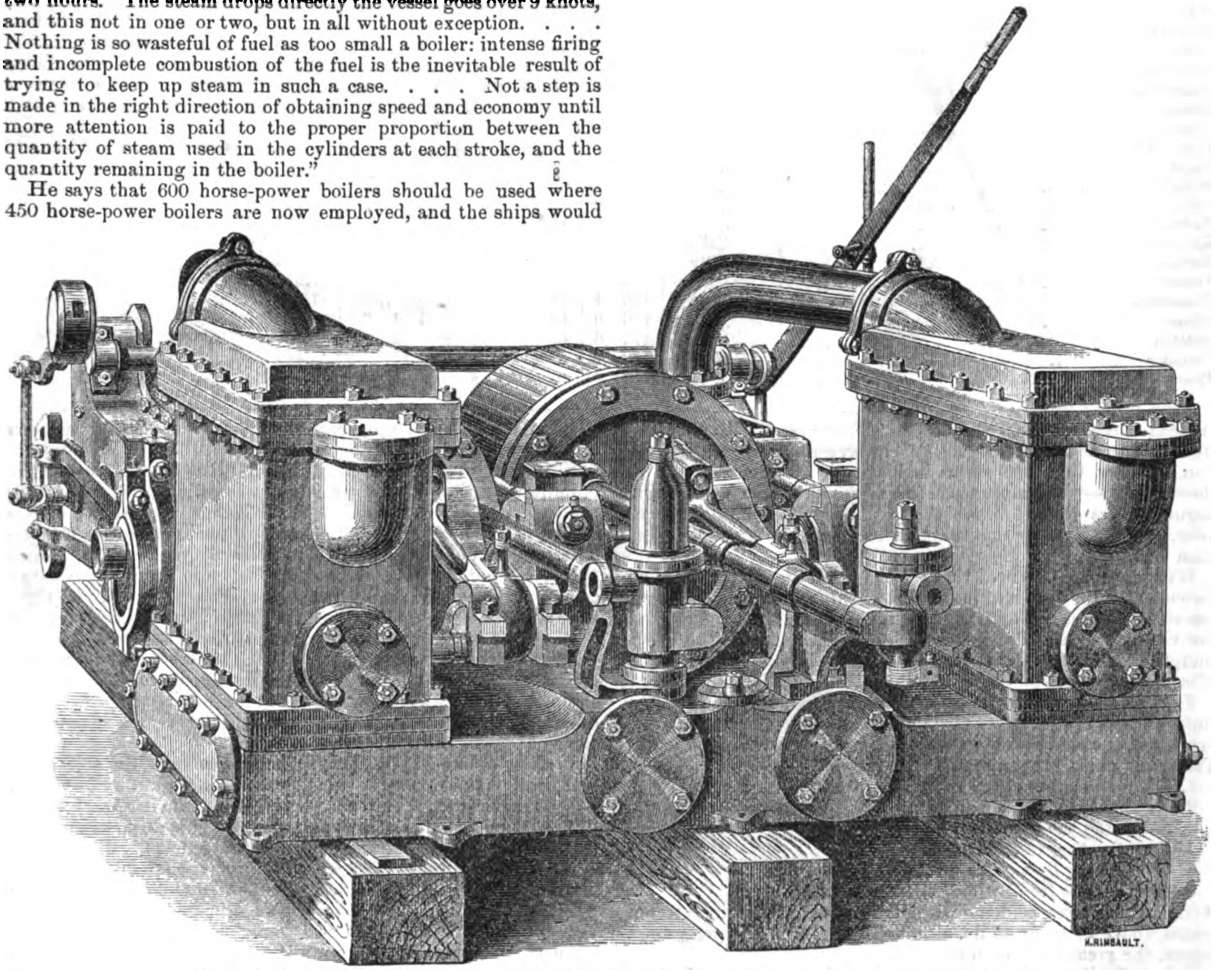


Fig. 2.—E. E. Allen's Patent End-to-End Cylinder Double Piston Rod Engine.—View from Surface Condenser end.

Mr. Murray, in his paper on "Means and Appliances for Economising Fuel in Steam Ships" (read in March, 1860), says:—"It is hoped and believed that the day is not far distant when the average consumption of marine engines will be reduced to nearly one-half of what it now is. In Cornwall, ninety millions of pounds raised one foot high in an hour by a bushel (or 94 lb.) of coal is considered fair work for a good steam engine, which corresponds to nearly 2¼ lb. of coal burnt per indicated horse power per hour. It is not likely that this degree of economy can ever be permanently maintained at sea; but if our marine engines can be

Table of all Iron-Cased Ships and Floating Batteries building or afloat, with assumed weights of their armour plating, and quantity of coals carried, the latter deduced from difference of draught with and without coals.

Name of Vessel.	Afloat, or building, &c.	Iron or Wood.	Wholly or partially cased.	Length. ft. in.	Beam. ft. in.	Mean Draught ready for Service.	Diff. without Coals.	Tonnage.	Nominal H.P.	Assumed Weight of Coals carried.	Assumed Weight of Armour Plates.
Agincourt	Building	Iron	Partially	400 0	59 3½	25 8	1 7	6,621	1,350	1,000	850
Minotaur	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Northumberland	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Achilles	,,	,,	,,	380 0	58 3½	26 3½	1 10½	6,079	1,250	,,	800
Black Prince	Afloat	,,	,,	380 2	58 4	25 11	1 8	6,109	,,	950	,,
Warrior	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Hector	Building	,,	,,	280 0	56 3	24 8	1 0½	4,063	800	450	450
Valiant	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Defence	Afloat	,,	,,	,,	54 2	24 11	1 4	3,720	600	550	,,
Resistance	,,	,,	,,	,,	54 1	,,	,,	3,710	,,	,,	,,
Caledonia	Building	Wood	Wholly	273 0	58 5	25 10½	1 6½	4,045	1,000	650	950
Ocean	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Prince Consort	Afloat	,,	,,	,,	,,	25 11½	1 7½	,,	,,	,,	,,
Royal Alfred	Building	,,	,,	,,	,,	25 10½	1 6½	,,	800	,,	,,
Royal Oak	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
Royal Sovereign	Converting	,,	,,	240 7	62 0½	22 11	1 5	3,963	,,	550	750
Prince Albert	Building	Iron	,,	240 0	48 0	20 0	1 9	2,529	500	230	,,
Favourite	,,	Wood	,,	225 0	46 9	20 5	1 4½	2,186	400	400	
Enterprise	,,	,,	Partially	180 0	36 0	14 7½	1 7½	990	160	100	
Erebus	Afloat	Iron	Wholly	186 8½	48 6	8 9	1 3¼	1,954	200	80	
Terror	,, (Floating Batteries)	,,	,,	186 3	48 8	,,	,,	1,971	,,	,,	
Thunderbolt	,, (Floating Batteries)	,,	,,	186 11	48 5¾	,,	,,	1,973	,,	,,	
Ætna	,, (Floating Batteries)	Wood	,,	186 0	43 11	8 2	1 3	1,588	,,	300	
Glutton	,, (Floating Batteries)	,,	,,	172 8	45 2½	8 9	1 3	1,535	150	60	
Thunder	,, (Floating Batteries)	,,	,,	172 6	43 11	8 11	1 4	1,469	,,	80	
Trusty	,, (Floating Batteries)	,,	,,	173 6¼	45 1¾	8 8	1 3	1,539	,,	60	

induced to content themselves with 3 lb. or even 3½ lb., this will still be a vast improvement on their present average consumption.' What this is he states in his work on Steam Ships, in these words:—"The more usual consumption of modern marine engines varies from 4 lb. to 5 lb. per indicated horse power per hour, and the average consumption of all classes cannot be less than 6 lb."

It may be here observed that the Admiralty returns contain no statement of the consumption of fuel of ships of the Royal Navy; but this omission having been complained of for many years past, the Committee on Marine Engines recommended that the consumption of coal per indicated horse power, as well as the quality of coal and evaporation of water, should be given in future.

The fact of vessels running continuously on half the fuel consumed in Government vessels is now well known, as are also the principles of construction on which this important saving is made. They may shortly be stated as follows:—

1. Proportionate increase of boiler power.
2. Expansion of the steam to, say 5 lb. pressure.
3. Jacketing the cylinders.
4. Superheating the steam.
5. Condensing by surface instead of by jet; and,
6. Heating the feed water.

And all this may be done without increasing the pressure of steam above 20 lb. or 25 lb., although the higher the pressure of steam, the greater the economy of fuel.

It is difficult to assign the exact proportionate value of each of these six modes of economising fuel, as they have seldom, if ever, been so far separated as to admit of correct deductions; but, taken altogether, there is now no doubt that 50 per cent. may be saved in the ordinary consumption of fuel. This saving has been practically effected in several vessels where the principles above stated have been carried out.

In the early part of 1855 the author read two papers at Birmingham on "The Commercial Economy of Expanding Steam in Marine Engines," and described several new forms of engines suited to this purpose, and ever since that time has endeavoured to direct the attention of steam-ship companies and owners, as well as that of the Admiralty, to the subject.

In 1858, he forwarded detailed drawings of engines to the Admiralty, the designs being made with a view to effect a very large saving in fuel. One of these was that of concentric cylinders, with three piston rods and cross head, the two outer rods being carried to a guide block from which the connecting rod was returned to the crank; this arrangement being precisely that adopted in the Swedish gunboats, and for which a medal has been awarded to the maker in the Exhibition.

In the early part of the present year he again adddressed the Admiralty, calling their attention to this subject, and requesting the favour of an examination of the engines constructed on his patent of 1855, by Messrs. J. and G. Rennie, and which may be described as double expansive end-to-end cylinders, the small cylinder being placed at the back of the large one, motion being communicated to the crank by means of double piston rods (Figs. 1, 2, and 3). Even this arrangement has it appears been recently tried on one of the Swedish vessels of war, the results of working being, it is said, very satisfactory. If therefore, the Swedish engineers have not the faculty for designing economical marine engines, they may at least take credit for duly appreciating what others do, and in this respect are considerably in advance of some of the engineers of our own country.

In these several applications to the Government, the object was to show how the expansive principle could, in the author's opinion, be best carried out in ships of war, fulfilling the necessary conditions of such vessels, *i.e.*, of keeping the weights down as much as possible, and the machinery below the water level.

He showed in his papers, that the suggested alterations in marine engines could be made without either adding to the gross weights carried, or to the space occupied in the ships, and that a very considerable saving of coal would be the result; increased capacity of cylinder to allow of full expansion of the steam being, of course, under every possible arrangement absolutely necessary.

One of the forms of marine engines suggested by him in 1855 has lately been adopted in the case of the Poonah's engines, now building by Messrs. Humphrys and Tennant, the small and large cylinders being placed end to end, as above described with reference to the engines made by Messrs. Rennie, but motion being given to the crank shaft by means of a trunk working in the large cylinder (Fig. 4).

For these several forms of double expansive engines may be claimed many advantages, which are shortly these:—

1. Capability of fully expanding the steam without the use of expansion gear.

2. Great uniformity of motion, by reason of the steam from the boiler acting upon a comparatively small area, not pressing upon the large pistons until partially expanded.

3. Saving of considerable weight, on account of the strength of the connecting rods, piston rods, &c. being only necessarily proportioned to the pressure of the initial steam on the small

piston and the expanded steam on the large area, instead of the initial steam on the latter; or rather, upon a considerable extension of it, as in the case of a single acting cylinder designed for great expansion, its *area* must be greatly increased, the stroke not being capable of being lengthened.

4. Considerable saving of steam, owing to the loss in the clearances in the small cylinder being much less than that in a very large cylinder, the loss in the latter case absorbing a large percentage of the steam.

5. The cylinders being in line with each other, no increase in the number of piston rods, connecting rods, or guides is necessary.

6. That practically all the advantages of a long-stroked engine are obtained without increasing the stroke, and which cannot be done, owing to the speed of revolution of direct acting screw engines being necessarily high; and,

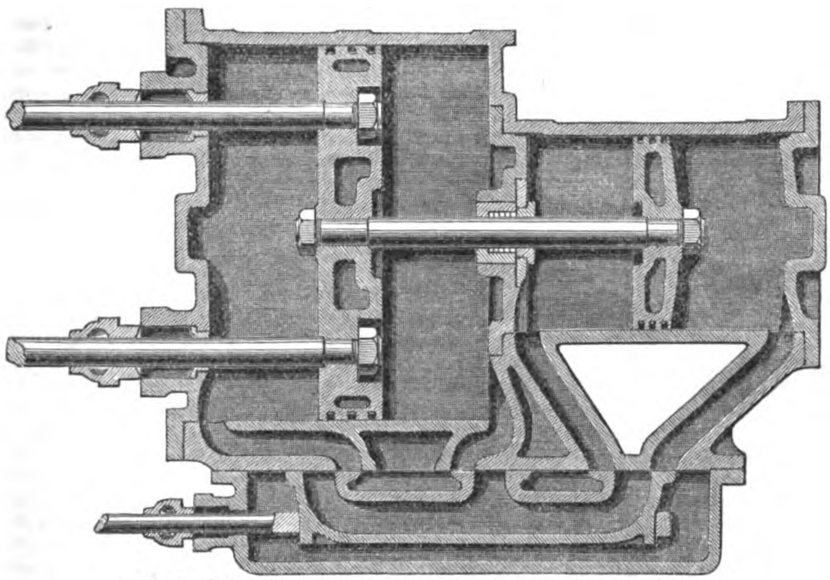


Fig. 3.—End-to-end Cylinder Engine.—Section of Cylinders and Valve.

7. That by fully expanding the steam, a far less quantity suffices for the production of a given power, this allowing of the boilers being reduced a third or a fourth, still leaving a large proportionate increase in boiler power compared with the steam required.

It will be readily admitted on all hands that very considerable difficulties would be found in making ordinary marine engines fully expand their steam, an increase in the capacity of the cylinder of from two to three times being essential.

At present the shape of the cylinders of marine engines approaches to that of those of rivetting machines, the diameter being frequently two and a half times the stroke; whereas in pumping engines, in which economy is studied, the cylinders assume an entirely different form, their length being three times their diameter; as shown in Figs. 5 and 6, which represent cylinders of equal capacity, the former similar in shape to those of the 1350 horse power engines constructing for the largest iron-plated ships, and the latter the cylinder of an ordinary pumping engine. Indeed all engineers admit that, in very short cylinders, *i.e.*, single acting ones, economy is out of the question. It is therefore greatly to be regretted that in our iron-plated ships, even in those of the largest class, the same form of engines has been adopted as was employed fourteen years ago, notwithstanding Mr. Atherton, the late engineer at Woolwich Dockyard, stated some years ago that "double expansive engines ought to be tried," especially as superheating of the steam had been carried out.

Mr. Murray has rather severely remarked upon "the plan adopted by the Government of contracting for their steam machinery with only a few favoured and old established houses;" and states that this, "though perhaps justifiable in other respects, has undoubtedly tended to promote conservatism in marine engines, and to repress innovations and improvements . . . . competition being scarcely roused into action. . . . In the case of those manufacturers . . . . however, who are dependent upon the custom of the great steam shipping companies, and other private owners of steam vessels, who have a strong interest in this question, there exists an active competition, and, consequently, a powerful inducement to improve upon the economical performance of their machinery. We find, accordingly, that it is this class who have taken the lead in the steam reformation which has recently set in."

The practicability of saving so great a percentage of fuel being now so well known, how is it, that the whole of our iron-cased fleet at present in existence or ordered, are doomed to consume double the amount of fuel which is necessary?

In the twenty-six iron-cased ships constructed and constructing, a force of no less than 18,310 nominal horse power is to be employed; and when working full power every day will witness an unnecessary consumption of upwards of 1700 tons of coal, which, on foreign stations, would certainly amount to more than £5000 sterling.

This loss is, however, not what is to be most regretted; but rather the fact that our iron-cased fleet, the largest vessels of which are to cost upwards of £350,000 each, and are provisioned for four months, should only carry coals enough for from four to five days' steaming. It is surely a sad pity that these vessels should have to creep into port every time after steaming say 2000 miles, or else waste days, and perhaps weeks, of valuable time on full commission pay, in attempting to reach their destination by the use of sails. If it be maintained that the quantity of coals carried is sufficient—which the Admiralty authorities would hardly acknowledge—even then, is it not better to increase the armour plating, or the speed of the vessels, by reducing their draught or increasing the power of the engines, rather than carry an unnecessary quantity of expensive fuel?

It is now certain that the speeds of the Warrior and Black Prince are much below what was anticipated: and even if a speed of 14 knots were obtained, under the most favourable circumstances of clean bottom, clean tubes, and fair weather, this would be reduced to about twelve knots at sea, running days together; and this is no less than three knots below the speed that has been considered necessary. Again, if the present quantity of fuel carried be enough, the engine power could be increased some 40 per cent. without increasing the draught of water, and still allow of the same number of days' fuel. This increase of power would increase the speed about one knot and a half per hour, which cannot be regarded as a matter of slight importance.

With these facts before us, the question arises, are we justified in continuing to employ engines of the ordinary kind in our iron-plated ships of war? In considering this matter we must be careful not to confound the excellency of workmanship of government engines, which is all that can be desired, with correctness in the principles upon which such machinery is made and worked.

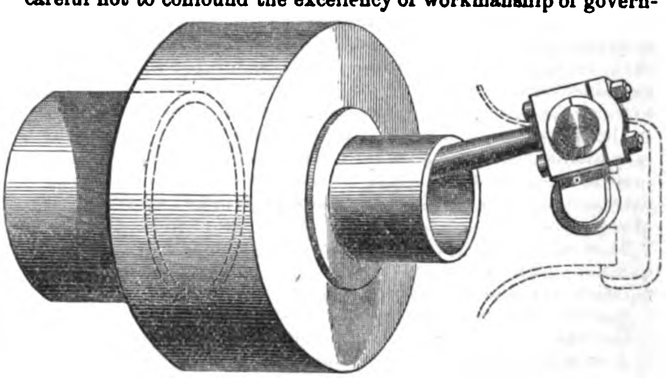


Fig. 4.—E. E. Allen's Patent End-to-end Cylinder Trunk Engine.

The wasteful expenditure of fuel in all vessels having ordinary but first-class machinery, arises of course from the principles upon which it is made and worked being faulty; such as filling the cylinders three-parts or seven-eighths full of steam, and only expanding in the remaining space; condensing by jet; not superheating the steam or heating the feed water; confining the boiler space in proportion to the steam used (although this space is much greater than required under improved conditions); not jacketing the cylinders; and finally, using short-stroked single expansive engines. No amount of excellence in workmanship can ever make up for this total disregard of every principle which experience has shown to be necessary to economical working.

Our present navy consists of vessels in which there is a nominal power of upwards of 142,000 horses, distributed in about the following proportions:—

	Horse power.
Ships in commission	60,000
Do. in ordinary	51,000
Do. used as transports, &c.	13,000
Do. (new iron-plated) and batteries	18,000
Total	142,000

The ultimate extent of our iron-cased fleet, of course, is not as yet known, but taking the very moderate estimate made by Mr. Scott Russell, we have yet engines to provide to the extent of at least 60,000 horse power, making a gross power of 200,000 horses. Assuming that one-half of these vessels are in commission in time of peace, the *daily* consumption of coal when working full steam would be over 15,000 tons at the present rate per indicated horse power. Now ships in commission may be fairly assumed to be one-third of their time under steam, say two days per week, or 100 days in the year. They will probably be half this time under easy steaming, and the remainder three-quarters and full steaming, and will consume from 2½ to 3 cwt. of coal per day, or 14 tons per annum per nominal horse power, or for the whole of the ships in commission about 1,400,000 tons per annum.

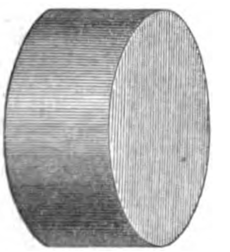


Fig. 5.—Cylinder of Horizontal Marine Engine.

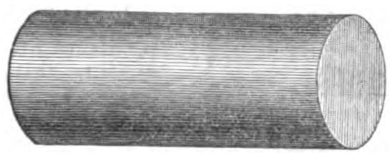


Fig. 6.—Cylinder of Pumping Engine.

This is, then, what we may look forward to in the navy returns in future years of peace, *i. e.*, if the present consumption of fuel be maintained. It is just half this quantity which experience has now fully proved may be saved by a modification in the mode of constructing and working marine engines, and it is to the cost of this quantity, which could be saved, and the advantages arising from its absence in the vessels, that attention is now invited.

Applying the same calculations to the engines of the twenty-six iron-cased vessels made or ordered, or omitting the floating batteries and some of the vessels in ordinary, it appears more than probable that had these vessels been fitted with improved machinery, a money yearly saving would have been made sufficient to purchase at least one iron-cased vessel annually, from saving in the consumption of coal. This gain, it must be remembered, is quite distinct from the other numerous advantages which have been referred to, and of which no estimate can be made; the very existence of the ships being perhaps jeopardised by either want of coal or want of speed.

This saving of fuel, whenever brought about will, without question, give us one or other of the following advantages, in addition to the money saving, viz.—

Increase of armour plating 50 per cent.; or,
Increase of speed to the extent of one knot and a half; or,
Increase of number of days' fuel to double what it now is; or,
Diminished draught to the extent of 8 in. to 12 in., according to the vessel.

Thus enabling us to have armour-plated vessels of comparatively very small tonnage. To all this we must not forget to add the loss of time, expense, and inconvenience of frequent coaling when only five to six days' supply are carried; and again, the cost and labour of trimming the coals, and feeding the furnaces with double the quantity which would be needed with good double expansive engines.

It is hoped that these considerations will induce the Lords of the Admiralty to turn their attention to the advantages of working steam expansively in the vessels of the Royal Navy, not simply as it has hitherto been done, and when the power is proportionately diminished and no saving effected, owing to the machinery not being adapted for expansive working, but constantly and regularly in ordinary working and under proper conditions, when its advantages would be at once experienced.

In conclusion, it is only fair to mention that soon after the appearance of the report of the Committee on Marine Engines, recommending that the number of contractors for Government engines should be increased, and that the best engines should be adopted in ships of the Royal Navy, by whomsoever proposed to be supplied, orders were issued for three pairs of engines designed to work with less fuel than usual. Messrs. John Penn and Son supplied a pair of large trunk engines, with surface condensers; Messrs. Maudslay, a three-cylindered arrangement, also with surface condensers, designed by Mr. Sells; and Messrs. Randolph and Elder, a six-cylindered arrangement, also with surface condensers. Neither of these vessels have as yet been fully tried, the results however being anxiously looked for by engineers.

Considering the nature of these three plans, which, with the exception of the trunk engines, involve considerable complexity, the trunk and three cylinder arrangements being, moreover, single expansive engines, it is very doubtful if the results can be altogether satisfactory; and certainly cannot be so far so as to warrant experiments stopping at the point at which they have now arrived. Trials should at least be given of such other arrangements as appear likely to give favourable results.

The double expansion end-to-end cylinder engines proposed by the author, in 1855, for ships of war, having now been very ably worked out by Messrs. J. and G. Rennie, and, it is understood, been favourably reported upon by the inspecting engineer of the Admiralty, who was instructed to examine them; it is hoped an opportunity will shortly be afforded of testing their suitability for her Majesty's ships; the success of the principle of double expansion being already fully established, and Messrs. Rennie being prepared to guarantee to the Government that the consumption of fuel shall not exceed 2 to 2¼ lb. per indicated horse power per hour, or half the ordinary consumption. To the general introduction, however, of so radical a change in the construction of marine engines for the ships of the Royal Navy, a thorough conviction of the importance of economising the fuel seems essential, and it is hoped this will be found to have been somewhat promoted by the present paper.

On Rifled Guns and Projectiles adapted for Attacking Armour Plate Defences. By T. Aston, M.A.

As it is now an admitted fact that naval warfare will be carried on by iron-clad navies, it has become an imperative necessity that the Navy of England shall henceforth be armed with artillery adapted for attacking the new armour-plate defences which all nations are hastening to adopt. The superiority which defence so suddenly acquired over attack, by simply putting on a coat of armour, threatened to upset not only the theoretical but the practical tactics of modern warfare. The necessity of improving the means of attack, so as to restore as far as possible the disturbed equilibrium, was obvious to every one; and the contest which has been carried on in this country for the last two or three years between the attack of improved artillery and the defence of improved armour-plates, has been watched by all of us with the greatest interest. From a scientific point of view, with which we are on this occasion more immediately concerned, the subject was one which engaged the attention of some of the keenest and most experienced intellects of the country; these on the one hand giving practical aid on the side of defence, those on the other devoting their best energies to restore attack to what must be considered its normal position of superiority. For a long time, for too long a time, the defence people had much the best of it. Under the energetic superintendence of the Plate Committee (who in this matter *de republicâ bene meriti sunt*) armour-plate targets were erected by our able engineers, which at fighting ranges laughed to scorn the utmost efforts of the artillery attack brought against them. Some of the targets combined the resistance of iron with wood, others, constructed with far-seeing ingenuity, depended upon iron alone. The Ordnance Select Committee were challenged to bring forward the best gun their artillery science, aided by all the resources of the royal arsenals and the public purse, was able to provide. The science brought to bear by the Ordnance Select Committee, after exhausting itself in repeated efforts to cover its repeated defeats—efforts that were fruitless for reasons that will be explained—was at length compelled to confess itself vanquished by the armour-plates. But ordnance had other resources which it hoped to have dispensed with, and upon which, in its disappointment, it was glad to fall back. It said to the Committee of Defence, "If you will obligingly set up your armour targets within a shortened range, say, for instance, a Robin Hood bowshot of 200 yards, you shall see what the brute force of the old smooth-bore will do. True it is, that cast-iron will be brought to attack wrought-iron, that a rounded missile will have to punch its way through a flat, and possibly, at times, inclined armour plate. Science, which proved but a broken reed in our hands, must be abandoned, but with a gun big enough, a shot heavy enough, a charge of powder large enough, and a range short enough, the smooth-bore shall smash your target." Of course it would, and so would a battering-ram like those Titus used to smash the gates of Jerusalem. If, therefore, the old smooth-bore with its short range had failed the Ordnance Select Committee, like the service rifled gun, they might have fallen back on the older battering-ram.

Looking at it from a scientific point of view, this retrogression was very humiliating; and it caused the country serious anxiety to hear her Majesty's Ministers state in Parliament, as they did in the last session—on the authority, of course, of their official scientific advisers—that the navy of England, after all the vast expenditure that had been lavished upon it, was at last obliged to be armed with the old smooth-bores, to meet the iron-clad navies of her possible enemies. It was in fact proclaiming England's weakness to other nations, who were more scientifically informed and better armed than she.

In further explanation of what was the actual condition in which this all-important question stood no later than May last, I will quote the statement of an official authority upon the subject, Sir W. Armstrong. It was made by him at a meeting of the United Service Institution, May 20, 1862, in these words:—"It certainly may be said that shells are of no avail against iron-plated ships; but, on the other hand, I may say that neither 68-pounder nor 110-pounder guns, with solid round shot, are effective against such iron vessels. The fact is, what we want is a gun in addition to our 110-pounder rifled gun, especially adapted for breaking through iron plates. That is what we are in want of now." This forced confession was very startling to all of us, who knew that, long ago, France armed her "Gloires" and "Normandies" with rifled 90-pounders, proved to be efficient against iron plates. Such, however, being the state of the question a few months ago, we may proceed to consider, first, the reason why the artillery hitherto employed in the service, including rifled guns and smooth-bores, has always failed to make any impression on the plated defences at ordinary fighting range; and secondly, by what means artillery science has lately reconquered its lost ground. Sir William Armstrong put the case very plainly when he said that shells were of no avail at all against plated ships, and that the solid shot of the 110-pounder rifled gun is not effective against such iron vessels. But late experiments at Shoeburyness, in which the "Warrior" target was pierced and shattered by shell at 600 yards, have proved that the case as put by Sir William Armstrong must have been based on his experience of shells that were not made of the proper form nor of the proper material, and on his experience of rifled guns that were unable to propel their projectiles with the requisite velocity.

Three conditions may be laid down as necessary to enable artillery to attack successfully armour-plate defences. 1st, The projectile must be of the proper form; 2nd, of the proper material; and 3rd, be propelled from a gun able to give it the necessary velocity. The artillery of the Ordnance Select Committee failed because they utterly neglected the first two conditions, and had recourse to the brute force of the smooth-bore for the third. The expression accepted as representing the penetrating power of shot was "velocity squared, multiplied by weight;" but the form of the shot, and the material, were conditions altogether omitted from the expression; and the importance of the omission will be obvious if we take an analogous case, say that of a punching machine employed to perforate wrought-iron plates. What would be the result, if the punch itself, which is made of suitable shape and material, were removed, and a round-headed poker of brittle cast-iron or soft wrought-iron were substituted in its place? The great importance of sufficient velocity is conceded; it is a *sine quâ non* condition. But has there not been great misconception in supposing that the old smooth-bore gives a greater initial velocity than the rifled gun? The results obtained will show how this is. The average initial velocity of the 68-pounder is in round numbers 1600 feet per second, with a charge of powder ¼ the weight of the shot, the length of the shot being of course one calibre. Sir William Armstrong stated that, with a charge of powder ⅛ the weight of the shot, he obtained with his rifled gun an initial velocity of 1740 feet per second; he did not state the length of his projectile. Mr. Whitworth, with a projectile one and a half calibres long, obtains an initial velocity of 1900 feet per second, and with a projectile one calibre long, like that of the smooth-bore, an initial velocity of 2200 feet per second, being greater than that of the smooth-bore in the proportion of 22 : 16. The reason why under nearly similar conditions as to charge and length of projectile, the rifled gun can obtain an initial velocity superior to that of the smooth-bore, must be ascribed to the action of the first condition I ventured to lay down as necessary. The rifled projectile, as compared with the spherical, has a form which is better adapted for flight, and fits more accurately the bore of the gun, so that the gases of explosion exert a greater pressure upon it while propelling it through the barrel. In practice, the initial velocity of the rifled projectile is lower than that of the smooth-bore, because with the rifled gun the charge of powder used is much less, while the projectile is much longer and heavier, and has a greater *vis inertiæ* to be overcome at starting than that of the smooth-bore. If very large charges be used with the rifled guns, and long projectiles, with the view of obtaining increased velocity, the strain becomes too great for the guns to bear. But if rifled guns are fired with charges so low that they are not made to perform half the work they ought to do, then, though the defects of weak construction may not be made patent by the gun being destroyed, they are very plainly manifested by the weak results of their projectiles fired against armour plates. It is proved by well known results that the constructors of the 110-pounder rifled gun now adopted in the service do not dare to make the gun perform its full work, but, on the contrary, they find themselves forced gradually to reduce their charges, until they are beaten by the old smooth-bore they undertook to supersede. The only conclusion that can be drawn from this fact is, that the gun is weak in construction, and the projectile used with it is defective in principle.

The power of the smooth-bore, with its large windage, to fire large charges, and thereby obtain great initial velocities, has procured it many advocates; but Mr. Whitworth's experiments have shown that, if length of projectile be given up, which may be looked upon as the price to be paid for increased velocity, he can get an initial velocity much greater than that of the smooth-bore. But is the result worth the price paid? Not if a more efficient compromise can be obtained. I use the word compromise advisedly, because I think that every one who has had experience in artillery practice will agree with me that the best results are only to be obtained by means of the best conpromise. You cannot have long projectiles and very high velocities without burning too much powder, and taking too much out of your gun, or else making it an unwieldy monster.

The problem we have placed before us now is, how can artillery be best adapted for attacking armour defences? The advocates of the smooth-bore are satisfied with one condition—high velocity. Mr. Whitworth objects, and says:—"If velocity were all that is needed, I can get more than you do, in the proportion of 22 to 16; but to sacrifice all to velocity is a bad compromise to effect a solution of the penetration problem. You set down velocity as greatest possible, form of projectile of no account, material of no account, and after all, can do nothing at an ordinary fighting range, while you wrongly take it as proved that 'shells are of no avail' against iron-plated ships. It will be a far better compromise to be satisfied with a lower velocity, getting however all you can at a fair cost, and combining therewith conditions (1) and (2), proper form, and proper material for the projectile."

Let us now compare the actual results obtained in the way of penetration by the Armstrong 110-pounder, the proposed naval gun, the old 68-pounder smooth-bore, and the two naval Whitworth guns lately fired at Shoeburyness.

Guns.	Range. yards.	Projectile.	Powder Charge.	Penetration into Armour Plate.
Armstrong 110-Pr. (7 inch bore)	200	110 lbs. solid	14 lbs.	1½ to 2 inches.
68-Pr. Smooth Bore	200	68 lbs. solid	16 lbs.	2¼ to 3 inches.
Whitworth 70-Pr. (5¼ inch bore)	200	70 lb. shot and shell	12 lbs.	Through plate and backing.
Whitworth 120-Pr. (7 inch bore)	600	130 lb. shell.	25 lbs.	Through plate and backing.*

The first two results will lead every one to the same conclusion that it is to be presumed they led the Ordnance Select Committee, when they so eagerly re-adopted the smooth-bore, viz., that the Armstrong rifled gun is a worse compromise than the old gun it was intended to supersede. The reason may be inferred from the results to be, that besides neglecting conditions (1) and (2), form and material of projectile, it is very much behind in respect of condition (3), velocity—this is to be attributed to the defective construction of the gun, which cannot fire with safety efficient charges of powder, and to the use of the lead-coated projectiles. Taking all the results, they show themselves to be indisputably in favour of the Whitworth, the old 68-pounder smooth-bore coming second, and the Armstrong rifled gun last.

Let us now examine how they stand in regard to velocity, as shown in the following table, which, like the one given above, is compiled from official sources.

Gun.	Charge.	Velocity.
68-Pr. ...	... 16 lbs. ...	Initial 1600 ft. per second.
Whitworth 70-Pr.	... 12 lbs. ...	Initial 1350 ft. per second.
Whitworth 120-Pr.	... 25 lbs. ...	Terminal at 600 yds. 1260 ft. per sec.
Armstrong 110-Pr.	... 14 lbs. ...	Initial 1210 ft. per second.

With regard to initial velocity, therefore, the order of the guns may be taken, with the charges used, to be, 1st, 68-pounder; 2nd, Whitworth; 3rd, Armstrong. It is worthy of notice, however, that the velocity of the Whitworth 120-pounder, after traversing 600 yards (a good fighting range), was found actually to be 1260 feet; whereas the initial velocity of the Armstrong is only 1210 feet.

The total results in respect of penetration proving themselves to be so decidedly in favour of Whitworth, who combines with condition (3)—viz., sufficient velocity—conditions (1) and (2), proper form and material of projectile, it follows that his must be the best compromise. The slight inferiority in initial velocity of his rifled gun, with its ordinary charges, as compared with the smooth-bore, is more than compensated for by employing a projectile of proper form and material; this is shown by the penetration being through and through both plate and backing in the case of the Whitworth, while it is barely half through the armour plate in the case of the smooth-bore, and not half through in the case of the Armstrong gun.

The form of projectile employed by Mr. Whitworth for penetrating armour-plates, is like the one now before the Section. It has a flat front, the centre being slightly rounded, the middle part of the projectile is rifled hexagonally like the bore of the gun, the front and rear of the projectile are made of the requisite taper to allow the air displaced in front to close in readily behind, a form which gives a great increase of velocity as compared with the form parallel throughout, as I endeavoured to explain to this Section, in a paper I had the honour of reading at its meeting last year.

The material of which the projectile is composed, is what is termed homogeneous iron, combining the toughness of copper with the hardness of steel; it is made hard enough to penetrate the wrought-iron plate, but not so hard as to be brittle and break up when the projectile strikes against its surface. The advantage of the flat front as compared with a pointed front is apparent, when it is considered that when the flat front strikes a plate, the whole resistance it meets with is that offered by the area of the plate covered by the flat front, in a direction in line with the axis of the impinging projectile. It consequently punches out a clean hole with a sudden impact. In the case of a pointed shot, as soon as the point begins to penetrate, the inclined sides begin to push aside the particles of the plate in a lateral direction, and an accumulating lateral resistance is offered by every part of the plate whose particles are disturbed; the passage of the shot is thereby gradually retarded, if not altogether arrested. It has been thought that the flat-fronted projectile will glance from the surface of an inclined plate like a round projectile. This is not found to be the case, as is proved by the plate now shown to the Section, which was completely penetrated by a flat-fronted projectile when inclined at an angle of 37° to the perpendicular.

The Whitworth penetration shell, whose destructive power was shown by its penetrating and shattering the Warrior target at Shoeburyness, has the same form outwardly, and is made of the same material, homogeneous iron, as the flat-fronted solid projectile, which has already been described. A cavity of suitable shape is formed in the projectile, of the size required to contain the bursting charge of ordinary powder. The rear of the shell is entirely closed by a screwed plate or cap. A sufficient thickness of metal, disposed in the required form, is left for the front of the shell. The uncertain complications of percussion fuses, and even the simpler time fuses, are wholly dispensed with. No fuse, or detonating substance of any kind, is used. On firing his shell through iron plates, Mr. Whitworth found that by the force of impact and friction, sufficient heat was generated to fire the bursting charge without any fuse at all. In practice the action upon the powder was found to be even too rapid. To retard its action for the time necessary to enable the shell to effect a complete penetration and then to burst, Mr. Whitworth interposes between the metal of his shell and his bursting powder charge, a substance that is a non-conductor of heat; by preference he incloses the powder in a flannel case, and finds that, by simply diminishing or increasing the thickness of his flannel, he can burst his shell in the armour plate, or in the timber backing, or after it has passed through both. The fragments of the shell now before the Section are those of one which was fired through this armour plate, and which burst and shattered this backing of timber, nine inches thick, placed behind the plate. There is one point in connexion with the Shoeburyness trials that should be particularly noticed, and it is this—that all the previous experiments against iron plates had been confined to the short range of 200 yards; at longer distances the smashing monster smooth-bores cannot be made to hit the mark, whereas Mr. Whitworth has proved that at a good fighting range of 600 yards he can hit his mark to an inch, and can at that distance (and, there is good reason to believe, at twice that distance) send his shells through the "Warrior's" sides. That 600 yards may be fairly called a good fighting range will be admitted, when we remember that the brave "Agamemnon" at Sebastopol fought all the guns of fort Constantine at a range of 500 yards; and the "Albion" signalled, "Well done, 'Agamemnon,' where you lead we will follow." With regard to the 120-pounder gun itself, it should be explained that it was made at Woolwich, under the able superintendence of Mr. Anderson, at Mr. Whitworth's own request, and according to drawings supplied by him. It has the same bore (7 inches) as the Armstrong 110-pounder, so often tried against the "Warrior" target, and found, as Sir W. Armstrong said, "not to be effective." It is a built-up gun, and its hoops are made of coiled iron welded; but that method of manufacture was adopted by Mr. Whitworth in the first built-up gun that he made, and by many other makers of guns many years ago; Mr. Whitworth has since employed, by preference, the homogeneous metal, which he found to answer perfectly for small arms and field guns, as well as for the penetration shells which have been described.

Practical improvements have been made in the process of forging and annealing the metal, which enable it to be worked in masses of any required size, whose quality may be henceforth depended upon with certainty. The Whitworth heavy guns are now being made with both interior tubes and outer hoops of homogeneous metal of the improved manufacture, so that the guns will be constructed throughout of one uniform metal, without any welding at all. Experience justifies the expectation that they will be free from the objections which it is well known are inherent in all welded guns, and be fully able to resist the severe and searching strain which is sure, sooner or later, to disable a gun built up of forged coiled tubes, if it be called upon to do its full work by discharging heavy rifled projectiles at the most efficient velocities.

* These results were recently surpassed, as detailed elsewhere. The 70-pounder sent its shell through 4½-inch plate and backing at 600 yards range, and the 120-pounder sent its shell through 5-inch plate and backing at 800 yards range.

REVIEWS.

The Iron Manufacture of Great Britain. By W. TRURAN, C.E. Second edition, revised by J. ARTHUR PHILLIPS and WILLIAM H. DORMAN, C.E. 4to. London: Spon. 1862. (Second Notice.)

We now resume our notice of this valuable treatise. The author, while bringing large experience and very extensive observation to the treatment of his subject, has confined himself throughout to a practical view of it. He does not much affect theory, and deals with chemistry so far only as is manifestly necessary to a due understanding of the various processes described. We of course cannot expect in this work any account of the more recent productions of the steely irons; but it furnishes a very interesting and instructive history of the general and long established manufacture of iron in every stage. We propose to give an extract or two, referring our readers to the work itself for fuller information.

The influence of damp or dry weather on the produce of the blast furnace is important:—

"The effects produced on the quality of the metal by changes in the atmosphere are both serious and constantly recurring. It is known that the metal produced in winter and spring is, on the whole, superior to that produced in summer and autumn, and that the difference of quality is due to the condition of the atmosphere in these seasons; the immediate cause however is not so well understood.

We have already stated that the introduction of water into blast furnaces is attended with the most prejudicial effects. At certain seasons of the year the atmosphere contains a considerable quantity of water, which is forced into the furnace through the tuyeres along with the blast; at other periods the materials collected for smelting are saturated with rain falling on them, and water is thus also conveyed into the furnace, but through the throat, so that at certain times water is discharged into the furnace at top with the materials, and at bottom with the blast.

* * * * * * *

The quantity of water discharged into the furnace through the tuyere will depend on the consumption of blast and quantity of moisture in the atmosphere. For dark grey pig-iron the consumption is 25 tons of air per ton of metal made. Estimating, then, that the make is 120 tons weekly, the consumption of blast will be 3000 tons. Now, according to the most trustworthy authorities on the composition of atmospheric air, it appears that in ordinarily dry weather it contains 1·42 per cent of moisture. At this rate, then, the water in 3000 tons of air will amount to nearly 43 tons. This, however, refers to comparatively dry air. The generally moist atmosphere of this country contains at periods full twice this per-centage of water; on such occasion, the volume of water discharged into the furnace along with the blast will not fall far short of 100 tons weekly, or from 50 to 60 tons above the quantity discharged into it in favourable seasons.

If to the quantity discharged into the furnace along with the blast there be added the quantity entering with the materials at top, it will be seen that there are periods when, from a superabundance of moisture in the atmosphere, the enormous quantity of 160 tons of water is discharged weekly into a blast furnace, making 120 tons of metal, and that under ordinary circumstances the quantity entering is equal in weight to the make of iron. The deteriorating effects which such volumes of water produce in the quality of the metal are very apparent. With a dry easterly wind, the quality and make will be greatly superior to that obtained when the wind is from any other point of the compass. A sudden shift from east to south-west occasions a deterioration in quality from dark to bright grey, and if the alteration continues, from grey to mottled and white. Thus the importance of a dry atmosphere for blast furnace operations can scarcely be overrated."

In our notice of the former edition (vol. xix. p. 149) we considered at some length Mr. Truran's views as to the merits of the hot blast, and also as to the employment of the heat carried off by the escaped gases, we therefore need not further refer to the portions of his work in which these subjects are dealt with. But our author's views as to the relative size of the throat of the blast furnace are so important as to demand our full notice:—

"The diameter of the throat or filling place is a matter of the greatest importance to the working of the furnace. It influences the make and yield more than any other dimension; and yet it receives little attention in designing the furnace. Local custom is generally considered the safest guide, and yet it is a matter which above all others is likely to cause loss and create difficulty in the working of the furnace.

In the old blast-furnaces the top was generally narrow, the breadth scarcely averaging one-fourth of the diameter of the furnace; and in Staffordshire, Derbyshire, and other districts, furnaces are still in operation with throats bearing this proportion. In other furnaces in these districts a width of one-third of the diameter at the boshes is considered sufficient. The breadth most common in Scotch furnaces erected or altered within the last twenty-five years is one-half the diameter of the furnace—extended, however, in some instances to as much as two-thirds. In the Welsh district the breadth ranges from one to two thirds of the diameter; but the proportion which prevails in the majority of the Welsh furnaces is one-half or nearly so.

Although it is now generally admitted by smelters that with a narrow throat a furnace will not carry as much burden or work as well as with a wider one, the largest throats hitherto constructed have not exceeded 10 feet. This appears to be considered as a maximum width. But if the enlargement of the throat from one-fourth or one-third of the diameter of furnace has been productive of advantage, what is to prevent further enlargement still leading to improved results.

With the narrow-throated furnace formerly employed in smelting, the average yield of coal to each ton of pig-iron was 6 tons. By increasing the diameter of the throat to one-third of that of the furnace, and using a more powerful blast, 4 tons were made sufficient; increasing it again to one-half, the yield diminished to 2¼ tons. We believe that after making every allowance for the operation of other causes, three-fourths of this saving in fuel must be attributed to the enlargement of the throat, and that by continuing the enlargement a further saving might be effected.

In support of this opinion we may adduce the effect produced by a narrow throat at one of the Dowlais furnaces. The diameter of this furnace at the boshes was 18 feet, and it formerly worked with a throat 9 feet in diameter. Repair being necessary, the furnace was blown out, new hearth and boshes put in, and a new lining carried up beyond the boshes, but on approaching the top the curve of the section of the body was quickened, so that the width of the throat was reduced to 6 feet, or one-third of the diameter of the furnace. Prior to the alteration this furnace had been in blast fifteen years; the average make was 90 tons of pig-iron weekly, and consumption 45 cwts. of coal to the ton. After the alteration the make became irregular, varying from 50 to 70 tons; the consumption of coal rose to 70, 80, and even 90 cwts. per ton of pig-iron. The quality of the iron also was excessively bad, and the loss of metal in the dense black scouring cinder produced was very great. The average yield of coal with this narrow throat was near 4 tons, but if the deterioration in the quality of the metal be also taken into account, the consumption may be fairly considered as just twice the quantity which would have sufficed with a wider throat. Yet this proportion of throat is not less than may be seen in numerous furnaces in England.

As more satisfactory results could not be obtained, the materials in the furnace were let down nearly to the boshes, and the upper portion of the lining taken out and placed farther back, and a throat of the original width—9 feet—obtained. With this enlarged throat the make of the furnace has several weeks exceeded 170 tons, and for a period of six months has averaged more than 160 tons, the yield of materials being good.

There was one other circumstance connected with the working of this experiment worth recording. Whenever the furnace was let down and maintained at a depth of 7 or 8 feet, so that the throat was practically enlarged, partaking of the diameter of the furnace at the level of the materials, the yield and make greatly improved. The former would be as low as 50 cwts., while the latter rose to 80 and 85 tons. This circumstance clearly points to the confined throat as to the cause of unsatisfactory results. Other narrow-throated furnaces have yielded similar results under our observation, working better when the surface of the materials has been kept a few feet below the charging plates.

Where narrow throats are in use we need only to refer to the velocity of the upward current to find a sufficient cause for the diminished reducing power of the fuel in the lower regions of the furnace. The volume of gas produced there being the same, the velocity of escape through the throat will be in an inverse ratio to its area, and may be calculated with sufficient accuracy to show the beneficial effects which must arise from larger throats. * * * * * * *

The consumption of fuel in the throat by the rapid draught explains the superior produce and yield when the materials are let down a few feet. The expansion of the furnace at the lower level affords a larger area for the ascending column of gases; they consequently pass through the upper stratum of materials at a reduced velocity, and escape through the narrow throat unimpeded by the materials.

But a reduction of the velocity of the current of escaping gases below the minimum above stated—2830 feet per minute—would doubtless be attended with beneficial results. A portion of the fuel now consumed in the throat would remain available for smelting, and the yield of carbon to iron might eventually be reduced considerably below 2 lb. of carbon to 1 lb. of iron. We observe, from a drawing of the Baerum charcoal furnace in Norway, that the throat is two-thirds of the largest diameter. The yield of charcoal is a little more than 1 lb. per lb. of iron. May not the superior reducing power of this furnace be partly attributed to the large throat? for in many other respects the mechanical arrangements are inferior to those in use in this country. * * * * * *

We are of opinion that the time is not distant when the contracted top will be altogether abandoned, and the interior wall of the furnace be built vertically from the boshes upwards. By such a construction a minimum temperature would be maintained at the surface and throughout the upper stratum of the materials. The velocity of the issuing gases would be reduced to about 600 feet per minute—a draught too slow for the combustion of any portion of the fuel in the upper regions; consequently the yield of coal would improve. The diameter remaining constant, the capacity also would be largely increased, and the make, with a corresponding increase of blast, would be augmented in the same ratio. Furnaces of 275 cubic yards capacity would be enlarged to 340, and those of a smaller capacity in a similar proportion."

In a section "On the use of Raw Coal in Blast Furnaces," Mr. Truran expresses the conviction that the enlargement of the throat of the furnace would enable all the coals now employed in iron smelting to be used without being previously coked. Attributing to the high temperature in the throat, consequent on its generally small area, the liability of bituminous coals to cake, and of semi-anthracites to split and crumble when first introduced into the furnace, the author considers that with a throat of equal or even larger diameter than that of the furnace at the boshes the kinds of coal at present generally coked might with advantage be used raw, and that even compressed peat might be successfully employed:—

"If reference be made to the proportion which the throat bears to the diameter of the furnace, it will be seen that for every 100 feet of horizontal area in the furnaces in the bituminous district the throat has an area of 16 feet; in the semi-bituminous and semi-anthracite the proportion is increased to 25 feet; in the anthracite to 44 feet. Furnaces with a proportion of 25 feet are unable to smelt advantageously with a coal deficient in bituminous matter, unless previously coked; but when the proportion is increased to 44 feet the pure anthracite itself is employed raw. We have only to go from Hirwain to the Neath Valley to see the beneficial effects on the coal which would follow from an inconsiderable enlargement of the throat.

We have hitherto advocated an increase of the diameter of the throat to equal that of the boshes, which would make the upper portion of the furnace cylindrical; but with anthracite we cannot proceed too cautiously in communicating an increase of temperature. We have no question but that in furnaces for smelting with this coal the enlargement may be beneficially extended until the throat is one-fourth, or one-third, greater in diameter than the boshes. The result of this will be that the velocity of the issuing column of gases will be reduced, and a minimum temperature maintained. The area then allowed for the escape will be four times that now provided.

By a large class of persons engaged in the iron trade it is supposed that anthracite cannot be advantageously used unless with a heated blast. This is an error, and it arose from the defective blowing-machinery originally employed. To show how insufficient the first blasts were, we may mention that there is a patent extant for using a cold blast of more than 2½ lb. to the square inch with this coal. With a cold blast of this and greater densities large quantities of cold-blast iron have been smelted. But while furnaces having the contraction at top are employed for smelting, the hot blast will be the most economical in the yield of coal. The diminished volume of blast employed, consequent on the caloric thrown into the furnace, causes a diminished draught, and reduced temperature at top.

The saving attendant upon the advantageous use of raw coal, together with the economy in the consumption of the coal itself, consequent on the reduction of temperature of the furnace throat, will reduce the cost of smelting fully one-half. In the bituminous coal districts of Monmouthshire, the Midland Counties, and Scotland, the conversion of the coal into coke is attended with such waste that from 3½ to 4 tons of coal are required for each ton of foundry-iron produced. The proportion of carbon ranges from 76 per cent. in the inferior bituminous varieties, to 92 per cent. in the anthracite. The present system of coking is attended with the combustion of from 10 to 50 per cent. of this carbon. Since the proportion of carbon determines the value of the coal for smelting purposes, the retention and combustion of the entire quantity in the furnace will be attended with a proportionate generation of heat.

The suggested form of furnace will permit of raw coal being used, and, by economising the coke and retaining the entire quantity of carbon for combustion in the hearth, it will render 20 cwt. of raw coal more effective than 3½ tons converted into coke, and afterwards consumed in furnaces of the present form.

The widening the top of the furnace, so as to insure a reduced temperature, will be highly advantageous to smelting with compressed peat. Large tracts of this valuable fuel exist in the vicinity of deposits of the richest iron ores, but hitherto all attempts to use it in the blast furnace have failed. The best specimens contain large quantities of volatile matter, and, unless previously well dried, injurious quantities of water. The rapid evolution of these in the blast furnace of the present form causes a greater or less destruction of the coal, while, from the high temperature maintained, a portion of the carbon is consumed. In the same proportion as the coal is weakened and carbon consumed are its smelting powers reduced, and the yield per ton of iron augmented. And from the moisture and generally large per-centage of ash, the increased consumption becomes fatal to the economy of smelting with this fuel. The large residuum of ash requires for its fusion a corresponding quantity of limestone. Hence the quality of the iron is contaminated by the excess of earthy matter present.

With the improved form of furnace the diminished temperature at top would favour the retention of carbon. The fuel also, being subjected to a great pressure long before its temperature is elevated to a red heat, the cohesion of its particles will be insured, and its ability to stand a blast of the requisite density will be little inferior to that of charcoal.

Under favourable circumstances we have no doubt but 30 cwt. of well-dried peat will smelt a ton of pig-iron."

The volume concludes with a very interesting section, headed "Sundry Notes on Iron Making." Among other matters a very clear and instructive account is given of the production of the fibrous or laminated forms of wrought-iron, and also of a third form presenting a fracture neither fibrous nor laminated:—

"Plates made from piles of No. 2 bars, laid alternately along and across, are nearly devoid of this laminated fracture. For its production the bloom requires to be rolled between cylindrical rolls offering no opposition to the extension of the plate in any direction. If rolled from cross-built piles plates are nearly alike devoid of the fibrous and laminated structure. Thus, we are enabled to judge from the fracture of the iron the manner in which a boiler plate has been manufactured.

The greater value, for numerous purposes, of iron rolled from piles having a portion of the bars laid at a right angle to the others, is not generally understood either by the manufacturer or consumer. Such iron is harder, denser, and possesses greater tensile strength than iron otherwise prepared. Fibre is generally considered an indication of strength, and in the ordinary way of manufacturing, the quantity of fibre developed does determine the value of the iron. For it can only be produced by repeated rollings and the expulsion of the extraneous matter combined with the iron. But while the presence of fibre is an indication of superior quality, we cannot accept it as a measure whereby to estimate the quality of bar iron generally. Iron may be of an excellent quality and yet possess no fibre. If the fibrous character determined the strength of the iron, steel, the purest form in which iron exists in commerce, instead of being the strongest, would rank as the weakest. Iron manufactured from cross-laid piles possesses many of the properties of steel. It is hard, the structural arrangement of the iron is more dense, and the specific gravity is superior to that of iron rolled from piles built in the ordinary way. The strength is increased in the same, or a greater, ratio than the specific gravity. Hence, for boiler plates and other purposes, iron manufactured in this manner, though devoid of either fibre or laminæ, possesses a greater tensile strength, and consequently should have the preference.

The superior density of the iron thus made is easily explained. In the ordinary way of rolling the extension is in one direction only; the original fibres are lengthened at each rolling, and no resistance is offered longitudinally to the degree of extension. In the bar manufactured from the cross pile the pressure exerted by the rolls acts endways on the portion placed across the pile, compressing the iron to one-third of its former length. The density appears to be greater than is due only to the pressure on the cross-piled portion, and is probably the effect of the interlacing of the fibres in the bar when at the half-finished stage. The difference in the iron produced from ordinary piles and that produced from cross piles is very similar to the difference observed in iron drawn out by a continuous hammering in one direction, and that produced by alternate extension and compression by turning the end. To produce a dense solid iron the upsetting is absolutely necessary.

In the puddling forge the good effect of the upsetting on the bloom is fully acknowledged. If the quality of the iron is thus early improved by pressure in this direction, it is very evident that a repetition of the upsetting process at each subsequent rolling will result in a corresponding improvement. The upsetting in the mills, however, is best performed, as we have shown, by so disposing the greater portion of the iron that it may be thus acted on by the rolls.

Fibre is produced by rolling or hammering the iron when hot, and by no other means. But the fibrous character of malleable iron may be destroyed while hot by altering the direction of elongation, and while cold by hammering, concussion, and vibration."

The following are the views of our author on the mixture of wrought-iron scraps with cast-iron by fusion, and on the effect of repeated re-meltings:—

"The tenacity of cast-iron of a low specific gravity, and consequent inferior quality, may be improved by remelting and incorporating in it wrought-iron scraps of a superior tenacity. But the improvement in quality by this treatment nearly disappears when the cast-iron is of a high specific gravity. And of the improvement occurring to irons of low quality, debased by the presence of an excess of carbon, by far the largest portion is due to the increase of density and consequent greater purity which follows on the partial oxydation of the volume of carbon during the operation,

The superior strength of air-furnace castings is generally acknowledged by iron founders; but the common explanation of its being due to a greater homogeneity, consequent on the remelting of the crude iron, is we consider altogether erroneous, and has arisen from a deficiency of experimental researches on the subject. We have found that the simple operation of remelting invariably increases the density and tenacity of crude irons of grey quality, the improvement being greatest with those containing the largest volume of carbon; and that a second remelting results in a further increase of these qualities, which continue to augment with successive remeltings until the iron has attained a high degree of refinement and increased its tensile strength by fully one-half. The number of remeltings necessary to the development of the tensile powers of the metal, varies with, and is directly proportionate to the volume of carbon to be liberated, but may be largely reduced by prolonging the period during which the molten iron is exposed to the decarburising influence of the reverberated gases. With white irons from blast furnaces consuming a minimum quantity of fuel, the improvement is not so marked. Containing a lesser volume of carbon, with a greater quantity of metalloids more difficult of oxydation, the act of remelting is attended with a larger waste of metal in proportion to the volume of impurity removed. Since, therefore, the maximum tenacity is not attained with a single remelting, and microscopic examination fails to detect any irregularity in the structural arrangement of the blast-furnace iron, we conclude that the superiority of air-furnace castings is principally due to the greater purity of the metal which necessarily results from remelting.

But while maximum tenacity is attained only by remelting and mechanical subsidation, the operation results in a corresponding deprivation of fluidity, and the iron so treated, after the third or fourth fusion, is not adapted for small castings, or the filling of sharp angles in larger ones. And with a succession of remeltings, all cast-irons, especially the hot blast varieties, and such as have been produced from a burden composed wholly or partly of hematite, are subject to unequal contraction in cooling, sinkings on the surface, and, where the pieces are angular and of large dimensions, they are rarely solid throughout."

The original work is too well known for much recommendation to be necessary. Whatever improvements may be introduced from time to time, Mr. Truran's authentic record of the iron manufacture of this country as observed by him will always possess much interest and value.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

President's Inaugural Address.

At the opening meeting of the session of the Royal Institute of British Architects, on Monday, the 3rd ult.,

The President, W. TITE, Esq., M. P., delivered the usual introductory address, and congratulated the Institute therein upon its continued flourishing condition and prospects. Reviewing the occurrences during the past session, he lamented the loss of its patron, his late Royal Highness the Prince Consort, whose powerful influence had ever been used, to the best of his ability, for the promotion of art and science. To him was owing the idea of the International Exhibition, so recently closed. As to the manner in which that building had been carried out by the engineer to whom it was entrusted, it was deeply to be deplored that it tended little to the credit of British architecture. "As a shed," "tolerably well lighted," and "suited for the display of the goods in it," it had answered its purpose. But the arrangements of the plan were far from satisfactory, and in every sense of architectural or artistic treatment it was seriously defective. As President, therefore, of the Institute of British Architects, he disclaimed, for the profession, that any judgment as to the present condition of English architecture should be founded upon it.

A very satisfactory circumstance during the past year was the invitation, by desire of her Majesty herself, to several of the members of their Institute to consider and report upon the proposed memorial to Prince Albert, by which act the profession had been duly recognised; and he confidently felt that those to whom the preparation of the designs had been entrusted would do justice to the opportunity. He took occasion to warn the profession that in these days of progress they must not allow themselves to be trammelled by servile adherence to precedent, but that they must seize and adapt to their own uses the advantages offered by the numerous new materials and discoveries of the present day, since otherwise they could not hope to influence the public as they undoubtedly ought. Upon the question, how this influence was to be exercised so as to promote art education, some observations were made; and the lectures by Mr. Smirke and Mr. Scott, at the Royal Academy, and those delivered at this Institute, valuable in their way, were considered necessarily to have but a limited effect; and he thought it desirable that popularly written courses of lectures should be given at but small cost, for the purpose of diffusing taste, and educating the public in the principles of art, but particularly for the sake of workmen and those who have to execute designs, and whose deficiency in the appreciation of their spirit, architects have so constantly to deplore.

The extensive municipal alterations in foreign cities, *e. g.* Paris, Brussels, &c., were, if not paralleled, to a great extent proposed to be so in London at the present time. The Thames Embankment was one scheme of great magnitude and importance, and it was much to be hoped that it would be carried out in a manner that might embellish the metropolis. The several new bridges were reviewed and considered to be generally, however scientific, wanting in architectural truth and beauty, while several were absolutely ugly. The numerous private buildings lately erected in the City were commended for their many various architectural merits, which far more than counterbalanced any defects of detail which some certainly present, and they were contrasted generally in a very favourable light with most of the public buildings that have been erected.

The deaths of several members of the Institute during the year were announced with regret, as also that of Mr. James Walker, the eminent engineer, and others of that body; and after some remarks upon sundry arrangements of the business of the Institute, concluded an address, which was listened to with marked attention and applause throughout.

Mr. Digby Wyatt, Fellow, in the absence of Mr. T. L. Donaldson, Fellow, then read a short memoir, composed by the latter, of Monsieur Charles Frederic Nepveu, architect, of Versailles, deceased, whose devotion to his patron, King Louis Philippe, after his fall, was contrasted with his somewhat sturdy maintenance of his own views in his previous relations with that king, in a manner which greatly redounded to his credit.

November 17.—A paper read consisted of "*Some Remarks on Colour and Coloured Decoration*," by T. HAYTER LEWIS, Fellow.

Prefacing that theories of colour were all of moderate date, while practical excellence in its treatment was almost exclusively to be found in the works of ancient masters, "ignorant even of the prism," the author reviewed the treatises of Chevreul, Field, Sir G. Wilkinson, Redgrave, Owen Jones, and others, and considered that they contained much valuable information, but no *rules* for the safe guidance of the colourist, for such, when attempted to be educed, were found to be constantly demolished by the variety in nature; neither could art be confined in such bondage. He had himself given much time to the analysis of the facts stated by the above writers, and made many curious experiments, which were detailed. In the course of these he had been much struck by the strong neutrality of nature colouring, and its sparing use of the positive colours. Referring to the idea that it is necessary to maintain a relationship between the colouring and the material on which it is applied, he had no faith in it, and did not find that it had been attended to by the old masters, who used colour lavishly, even covering with plaster and painting marble, stone, and wood, *e. g.* Girgenti, Fountains Abbey, &c. The first thing in decoration is to help out the design, not seizing bare surfaces as mere grounds for colour; then to consider how far the actual materials can be used to give the key-note, as they generally may in skilful hands; and it is the architect who alone can and should be entrusted to decorate his own structures. To cover every portion with colour, as in the Sainte-Chapelle, Paris, is not so satisfactory. In the cathedral of Spires the plain stone columns are left, with better effect, to give repose to the rest of the wall-surface, which is gorgeously painted. In such compositions it is desirable that the glass should be painted as well; the want of this is painfully felt at Monreale and in St. Mark's; it is a mistake to think that the light transmitted through them will interfere with paintings on the walls. We may look for good precedents for our practice to Palermo, Monreale, the Baptistery at Florence, &c., where gold and marble mosaics, the finest material for decoration, are profusely and admirably employed, together with frescoes; and it should be noticed how the richness is increased from the floor upwards, and not, as in modern rooms, from the ceiling downwards, and how, as in the halls at Palermo, Venice, and Rome, the paintings are fitted and framed *into* the walls, instead of being hung upon them as if for sale. The importance of painting decorations being made to suit the building, and, in fact, to be designed by an architect, may be seen by the contrast between the old mosaics of St. Mark and those of the Renaissance painters in the nave; but then the architect must study and become competent to undertake it as were the men of old.

With regard to external decoration in colour, buildings in towns, it was said, called for a different treatment to those in the country; and as time and climate seriously affect applied colour, the natural tints of materials are the safer to use; and we have numerous examples of every age of their employment in this manner. These were briefly reviewed, and the subject commended to the careful consideration of the meeting, which was then adjourned to the 1st of December, when a paper will be read by George Edmund Street, Fellow, "On the Church of St. Michael, Penkivel, Cornwall, and its Restoration."

THE SOLID-BAR LINK-MOTION.

TO THE EDITOR OF THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

SIR,—Having had the pleasure of seeing this modification of Link-motion applied to marine engines in the Exhibition, I have waited with some degree of curiosity to see who would come forward and claim the invention as his own. In your Journal of this month I perceive Mr. Nasmyth appropriates the invention, and relates the circumstances of its introduction by him in 1852. Perhaps others may do so also; but with all deference to Mr. Nasmyth, I beg to inform you (and may I ask a place in the columns of your Journal to inform its readers) that in the capacity of Locomotive Engineer for the Ardrossan Railway Co., I contrived, modelled, and constructed, in 1851, a Solid-bar Link Motion for a locomotive (the "King Coil"), which I rebuilt on the Company's premises. I had this engine running early in 1852, and need scarcely add it gave entire satisfaction.

I am, &c.,

WILLIAM ROBERTSON.

92, Mid Abbey Street, Dublin,
November 25, 1862.

CLASSIFIED LIST OF PATENTS SEALED IN NOV. 1862.

1440 Johnson, J. H.—Purification of oils (a com.)—May 13
1455 Deacon, H.—Manufacture of colours—May 14
2380 Newton, W. E.—Producing light (a com.)—August 27
2176 Newton, W. E.—Lubricating compounds (a com.)—July 31
1383 Cochrane, C.—Manufacture of aluminate of soda and potash—June 27
1385 Peyrouse, L. De la.—Treating fatty substances, resins, &c.—May 8

1484 Lamiable, A. A.—Cementing cast and wrought-iron to obtain cast-steel—May 16
1314 Herdman, E., A. F., and J.—Manufacture of wrought-iron, steel, or combined wrought-iron and steel plates—May 3
1312 Snowden, T.—Manufacture of steel tyres, hoops, and cylinders, &c. (a com.)—May 3

1699 Parsons, P. M.—Ordnance—June 5
1335 Burley, R.—Ordnance—May 5
2445 Cowan, B. F.—Cannon and other fire-arms—September 4
1544 Needham, J.—Breech-loading fire-arms, &c.—May 22
2506 Richards, W.—Fire-arms and cartridges—September 11

1399 Brooman, R. A.—Apparatus for superheating steam (a com.)—May 2
1337 Roscoe, J.—Lubricator for steam engines—May 5
2077 Meriton, T.—Steam engine governors and speed regulators—July 22
2145 Colburn, Z.—Steam pumping engines—July 29
1576 Huddart, G. A.—Superheating steam—May 26
2343 Monson, C.—Repeating rotary engine—August 22
1605 Hirst, J., and Taylor, E. O.—Evaporating water and other fluids—May 28
1830 Adamson, D., and Leigh, L.—Steam boilers, &c.—June 20

1598 Simpson, J.—Apparatus for producing mouldings—May 28
1368 Combe, J.—Drawing into slivers, flax, hemp, jute, &c.—May 7
1291 Huntington, W., and Huntington, T.—Manufacture of bread—May 2
1289 Douchain, C. P. A.—Letting in or shutting off water, &c.—May 1
1344 Mills, R.—Washing machines—May 6
1347 Chenaillier, F.—Concentrating liquids—May 6
1309 Ormerod, E., and Schiele, C.—Cutting or dressing stones—May 3
1351 Bourdon, E.—Blowing fans—May 7
1708 Newton, A. V.—Knitting machinery (a com.)—June 6
1495 Newton, A. V.—Machinery applicable to cutting out boot and shoe soles (a com.)—May 16
1468 Sissons, W.—Machinery for driving piles by means of steam hammers—May 15
1547 Childs, A. B.—Wringing machines (a com.)—May 22
1432 Ardrey, S. B., and Beckett, S.—Manufacturing spindles—May 13
1409 House, J.—Crushing or reducing substances—May 10
1404 Moore, R.—Apparatus for indicating the presence of liquids, gases, &c.—May 10
1517 Newton, A. V.—Splitting leather (a com.)—May 19
1494 Newton, A. V.—Machinery applicable to the cutting of leather, &c. (a com.)—May 16
1378 Southwood, W.—Pulverising ores—May 8
1472 Wright, J.—Machinery for digging, excavating, &c. (a com.)—May 15
1421 Firman, H.—Washing and cleansing textile fabrics, &c. (a com.)—May 12
1447 Southwood, W.—Manufacturing nails—May 13

1492 Stocken, F.—Carriages—May 16
1341 Adcock, J.—Apparatus for measuring distances travelled by wheel carriages—May 5
1307 Juhel, H.—Wheels (a com.)—May 3
1539 Oxley, J.—Making wheels—May 22

1443 Clark, W.—Generating motion in fluids, applicable for raising water (a com.)—May 13

1359 De Berville, C. V. F.—Coupling bar—May 7
1467 Dicker, J.—Apparatus for delivery of bags from railway trains—May 15
1300 Whitworth, C. F.—Apparatuses for signalling on railways—May 2
1365 Johnson, J., and Chapman, A.—Apparatus for preventing collisions on railways—May 7
1372 Marchal, D., and De Wiart, A. C.—Method of preventing effects of vibration or jar on the permanent way of railways, &c.—May 7
138 D'Aubreville, L.—Metallic cross sleepers for railways (a com.)—May 9

1466 Jouvin, J. P.—Preserving iron plated vessels—May 15
1360 Colomb, P. H.—Signalling—May 7
1301 Paul, M.—Windlasses and capstans—May 2
1448 Latham, R. M.—Steering apparatus (a com.)—May 13
1424 Cartwright, H.—Propelling and steering screw steam vessels—May 12
1425 Hutchinson, W. N.—Screw propelled ships—May 12
1477 Watney, A.—Constructing ships, vessels, and other structures intended to resist shot—May 15
1595 Hudson, C. H.—Defensive armour—May 27
1381 Lungley, C.—Apparatus for manœuvring ships and vessels—May 8
1527 Kennedy, J.—Ship propellers—May 20
1405 Moore, R.—Structure of ships and other vessels—May 10
1493 Sharpe, B.—Construction of ships and vessels, masts and spars—May 16

1369 Bousfield, G. T.—Tilling by means of a digging locomotive (a com.)—May 7
1373 McCann, J.—Drying, cooling, and cleaning grain—May 7
1355 Ransome, J. E., Copping, W., and Lansdell, L.—Harrows—May 6

1287 Swallow, J., and Allinson, J.—Carpet fabric—May 1
1348 Clarke, J., and Richmond, J.—Looms—May 6
1345 Morel, A.—Heckling machines—May 6
1321 Mellodew, J., and Mellodew, F., Kesselmeyer, C. W.—Looms—May 3
1323 Heyworth, J.—Looms—May 3
1394 Fawcett, T.—Plaited fabrics for shirt fronts—May 9
1457 Whittaker, E., and Clarke, J.—Preparing cotton, &c. to be spun—May 14
1566 Harrison, W., and Harrison, J., and Oddie, and Parkinson, W.—Machinery for winding, sizing, &c.—May 26
1565 Harrison, J., and Parkinson, R.—Rollers for preparing, spinning, &c.—May 26
1406 Cooke, J. T.—Battens used in weaving—May 10
1427 Ashworth, H.—Opening and carding cotton, &c.—May 12
1554 McGregor, P.—Spinning and doubling cotton, &c.—May 23
1655 King, J., and Partington, J.—Looms—June 2
1501 Broadley, J.—Weaving—May 17

2328 Callebaut, C.—Sewing machines—August 20

1390 Mace, T. K.—Guards or protectors for hats—May 9
1400 Haseler, G. C.—Lockets, and application of parkesine as a substitute for glass—May 10
1331 Brindley, F. B.—Flasks, decanters, bottles, &c.—May 5
1607 Johnson, J. H.—Tinned lead pipes (a com.)—May 28
1367 Brooman, R. A.—Swings (a com.)—May 7
1351 Greaves, W.—Stirrup bars—May 6
1311 Herdevin, J. M., and Julien, J. A.—Sluice cocks—May 3
1358 Clark, W.—Buckle or fastening (a com.)—May 6
1382 Grimes, G. C.—Cigar lights—May 8
1325 Williams, A.—Form or seat, capable of being converted into a table—May 5
1488 Davies, G.—Ribs for umbrellas and parasols (a com.)—May 16
2172 Ransom, J. and E.—Mounting mill stones—July 31
2526 Newton, A.—Sleeking, creasing, and raising leather (a com.)—September 13
1412 Cristofini, J. B.—Tents—May 10
1469 Birkbeck, G. H.—Apparatus for consuming smoke (a com.)—May 15
1416 Milnes, J.—Apparatus for exercising the human body—May 12
1616 Perks, W.—Metallic sash bars—May 29
1403 Clark, W.—Application of a vegetable fibre, in the manufacture of felted fabrics, &c. (a com.)—May 10
1551 Roberts, W., and Gre nacre, T.—Cocks or valves—May 22
1500 Hogg, J.—Book cover—May 17
2488 Hands, F.—Composition for black ornaments—September 10
1507 Gore, J. C.—Belt shippers—May 17
1456 Smith, A.—Balances for weighing letters, &c.—May 14
1911 Newton, W.—Apparatus for picking or gathering cotton (a com.)—June 30
2093 Keene, C.—Apparatus for raising and lowering canvas on easels—July 23
2345 Ritchie, E. S.—Mariner's compass—August 22
1801 Newton, W. E.—Electrical brushes (a com.)—June 18
1480 Haselton, G.—Churns (a com.)—May 16
2418 Nickson, J., and Waddingham, T.—Foundation or ground-work for plaster for ceilings, &c.—September 1
1438 Wormull, A.—Trepanning instruments—May 13
1398 Bolton, F. J.—Telegraphing—May 9
1827 Fabbricotti, B.—Polishing and grinding belt formed of leather (a com.)—June 21
1426 Neale, C. J.—Apparatuses for measuring and registering corn, &c.—May 12
1429 Freeland, A. B.—Treatment of hops—May 12
1631 Burt, H. P.—Protecting wooden posts from decay—May 30
1474 Tress, C.—Manufacture of hats, helmets, bonnets, or capes—May 15
1702 Hadfield, G.—Manufacture of casks or barrels—June 5
1810 Wigzell, M.—Bolts and other fastenings for shipbuilding, &c.—June 19
1545 Turnbull, S., and F.—Manufacture of floor cloths—May 22
1415 Walker, H.—Handles for crochet needles, &c.—May 12
1608 Blackmore, W., and Lamb, H.—Burning limestone and generating steam—May 28
1542 Bastida, E. de La—Production of designs in relievo, &c. (a com.)—May 22
1602 Martindale, R.—Manufacture of globes and glasses—May 22
1654 Templar, B.—Apparatus for registering and indicating billiards and other games—June 2
1754 Jackson, M.—Shield for the gums—June 12
1528 Petrie, W.—Vessels for boiling chemical products, &c.—May 20
1557 Wiley, W. E.—Manufacture of penholders or pencil cases, &c.—May 23
1525 Fewtrell, E.—Manufacture of metal tubes—May 20
1583 Virloy, M. A.—Drying and carbonising wood, peat, and other fuel—May 21
1585 Ireland, J.—Forming mould for card cylinders—May 27
1591 Duffus, J.—Apparatus for measuring piece goods or webs—May 27
1760 Tyler, C. A.—Holder for holding dinner and other plates and dishes—June 13
1637 Gilbey, A.—Packing cases or boxes for holding bottles—May 31
1640 Smallwood, W. T.—Water closets—May 31
1600 Cohen, C.—Walking, umbrella, and other like sticks—May 28